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IMPACT OF ICT ON ECONOMIC GROWTH : CASE OF OECD AND MENA COUNTRIES

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Abstract

This article examines the direct effects of Information and Communication Technologies (ICT) on economic growth in the presence of four important indicators: the rates of Internet, telephone, and mobile usage, as well as the proportion of technologically-related imports in total imports. In order to achieve our stated objectives, we undertake a rigorous evaluation of the interaction impact between the ICT factors, human capital, and financial development for the four specifications that are under consideration. A comparison analysis between the OECD countries and those of the MENA area was conducted between 2010 and 2023, employing the generalized moment's method in dynamic panels.

Our findings demonstrate that the impact of ICT is predominantly influenced by financial and human capital growth. This study reveals that OECD countries have been more proactive and effective than MENA countries in embracing ICT to foster economic growth. Examining the case of MENA countries provides comprehensive insight for policymakers regarding the relevance of ICT in boosting economic growth through the advantages of technology expansion.

JEL classification : O_{32}, O_{33}, O_{47}, O_{57}.

Key words: Information and Communication Technologies, Economic Growth, Human Capital, Financial Development, OECD and MENA countries, Dynamic Panel, GMM.

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Introduction

The global economy is undergoing significant and irreversible transformations, marking the advent of a new era defined by immaterial resources. These include investments in knowledge production and dissemination, encompassing research and development, education and training, as well as information and communication technologies (ICT). This is why the knowledge economy, also referred to as the knowledge-based economy, is increasingly becoming a dominant force in the global economy. As demonstrated by Durand (2000), knowledge can be defined as a structured set of information that has been assimilated and integrated into a set of reference frameworks. This allows a company to conduct its activities and act in a specific context by mobilizing different, partial, and contradictory interpretations.

Subsequently, the preceding years have demonstrated that the world has entered a new phase of information, knowledge, and learning. This phase is characterized by the proliferation of instruments, rules, processes, protocols, skills, and languages that fall under the umbrella term "information and communication technologies." Indeed, information and communication technologies (ICTs) represent a significant driver of economic and social activity in developed countries, as well as in emerging and developing countries. These processes encompass the collection, processing, storage, and presentation of data. They are the source of a profound socio-cultural transformation and represent a crucial component in the advancement and expansion of economic sectors. Information and communication technologies (ICTs) encompass all techniques utilized for the processing and transmission of information, including computers, multimedia, and the Internet. It is evident that these tools facilitate the transmission and sharing of information in the contemporary era. These changes have a significant impact on various aspects of modern life, including communications, the financial and commercial sectors, and, most profoundly, the governance of companies and the way we live.

The rapid diffusion and pervasive presence of these technologies have eliminated spatio-temporal constraints and cultural barriers, thereby contributing to the emergence of an ICT-based knowledge economy. In this context, we refer to the digital economy, in which companies are confronted with the necessity of maintaining continuous access to reliable and pertinent information from a multitude of sources, both internal and external. The objective is

to enable its members to direct their activities and encourage innovation, a determining factor of sustainability, in a context of international openness and globalization.

The aim of this study is to make a contribution to the existing body of knowledge regarding the direct impact of information and communication technology (ICT) on economic growth. In order to achieve this objective, we conduct a comparative analysis of Organisation for Economic Co-operation and Development (OECD) countries and Middle East and North Africa (MENA) countries during the period 2010-2023. In order to achieve our objective, we analyze the interaction effect between information and communication technology (ICT) variables and human capital, on the one hand, and financial development, on the other.

This paper is structured into three sections. The initial section presents a review of the literature on information and communication technology (ICT), with a particular focus on its contribution to economic growth. The second part presents an empirical validation of the impact of ICT on economic growth, employing a dynamic panel data model developed by Blundel and Bond (1998). In conclusion, we present some potential avenues for further research and development.

1. Literature review

The relationship between information and communication technology (ICT) and economic growth has been a topic of considerable debate since the 1980s. During this period, technical progress was viewed as a key driver of economic growth, as evidenced by the work of prominent economists such as Romer (1986, 1990), Grossman and Helpman (1991), and Aghion and Howitt (1992). This line of inquiry has grown considerably over the past few decades, with a particular focus on the role of information and communication technology (ICT) in the productivity surge observed in the United States in 1990. In this context, Oliner and Sichel (2000) demonstrate that, during the period between 1995 and 1999, information and communication technology (ICT) contributed 1.5% to the growth of the US economy and 2.6% to the labor productivity of US firms. In a separate study, Dewan and Kraemer (2000) evaluated two distinct production functions. The first model incorporates information and communication technology (ICT) as an input, whereas the second model does not. The authors estimate a panel data model comprising 36 nations, including 22 developed and 14 developing countries, over the period 1985-1993. The authors identify notable discrepancies in the

structure of returns to capital investment between the two groups under examination. It is proposed that the impact of ICT on developed countries is more pronounced.

In their study, Roller and Waverman (2001) examine the influence of telecommunications infrastructure on economic growth in 21 OECD countries over the period 1971-1990. A microeconomic model was constructed, incorporating a variable describing investment in telecommunications. The authors conclude that approximately one-third of the increase in total output can be attributed to ICT. Additionally, Oulton (2002) demonstrates that the contribution of information and communication technology (ICT) to gross domestic product (GDP) growth in the United Kingdom increased from 13.5 percent during the period 1979-1989 to 20.7 percent during the period 1989-1998. Furthermore, ICT contributed to capital formation to the tune of 55% during the decade of 1989-1998 and 90% during the years 1994-1998. Similarly, Papaioannou and Dimelis (2007) employ a dynamic panel data model estimated via the GMM method in first differences for a sample of 22 developed and 20 developing countries. The findings indicate that an increase in the ICT capital stock is associated with an improvement in labor productivity. The findings indicate that the ICT capital stock exerts a positive influence on labor productivity, with more pronounced growth observed in developed countries (Saba et al., 2023).

Sassi and Goaied (2013) identify the impact of the interaction between financial development and ICT diffusion on economic growth in 17 MENA countries over the period 1960-2009. Based on their dynamic panel data estimates via the system GMM method, the two authors provide evidence that ICT has a positive impact on economic growth in this region. It can be reasonably concluded that the impact of financial development on growth is enhanced by a better developed ICT infrastructure.

In their study, Garcia-Muniz and Vicente (2014) examine the capacity of the ICT sector to disseminate technology and stimulate innovation. The authors employ data extracted from input-output tables of 59 products corresponding to the years 2000, 2005 and 2007. The authors present evidence that the ICT sector in European countries plays a pivotal role in the dissemination of information throughout the economic network. Furthermore, information and communication technology (ICT) is regarded as a conduit for technological externalities, which contribute to economic growth in South Korea. In a similar vein, Hong (2017) analyses the relationship between economic growth and the Korean ICT industry during the period 1988-

2013. The results of the causality test in the Granger sense indicate that private investment in research and development has a more pronounced effect on economic growth than that recorded by the public sector. Nevertheless, Asongu and Le Roux (2017) challenge the notion that ICT can mitigate the potentially detrimental impact of environmental degradation on human development. They employ a TOBIT model, utilising the instrumental variables method, to analyse data from 49 sub-Saharan African countries between 2000 and 2012. Their findings suggest that ICT fosters inclusive human development.

In Lee and al. (2018) study, authors identify the primary drivers of technological innovation in the ICT industry and the socioeconomic factors that influence them. A fixed-effects panel data model was estimated for 40 countries over the period 1999-2013. The authors posit that the advancement of information and communication technology (ICT) is shaped by a multitude of factors, including the development of network infrastructure, the quality of education, the extent of international trade, and the influence of socioeconomic factors. In a study conducted by Niebel (2018), the effects of information and communication technology (ICT) diffusion on economic growth in 59 emerging and developed countries were examined over the course of five years, from 1995 to 2010. The findings indicate that the former group does not derive sufficient benefit from ICT to match the performance achieved by the latter.

Additionally, Radosevic and Yoruk (2018) developed a composite indicator that reflects a range of factors. The two authors demonstrate, based on a sample of 42 countries, that in contrast to high-income countries, technological activities in middle-income countries are not reflected in income levels. In their 2019 study, Tchamyou et al. investigate the impact of information and communication technology (ICT) on income inequality through the lens of financial development. The sample comprises 48 countries in Africa, and the study period is from 1996 to 2014. The findings indicate that the impact of mobile phone penetration and financial inclusion on income inequality is contingent upon the level of financial development in these countries (Awad and Albaity, 2022).

Nevertheless, Amri et al. (2019) investigate the relationship between CO2 emissions, total factor productivity as a measure of income, and ICT. The ARDL technique, as proposed by Pesaran et al. (2001), was employed to test the aforementioned hypotheses in the context of Tunisia over the period 1975-2014. With regard to the results, it can be stated that there is no significant impact of ICT on CO_2 emissions and sustainable development. Asongu and

Odhiambo (2020) present a study that elucidates the interconnections between inequality, information and communication technology (ICT), and inclusive education in 44 sub-Saharan African countries over the period 2000-2012. The authors posit that while ICT enhances inclusive education, this is only observable when a specific threshold has been reached. In a study published in 2021, Cheng and al. estimated the impact of information and communication technology (ICT) on economic growth in 72 countries over the period 2000-2015. The results derived from a system Generalized Method of Moments (GMM) model demonstrate that the diffusion of information and communication technology (ICT) enhances economic growth in high-income countries. Nevertheless, the impact remains inconclusive for low-income countries. Additionally, the expansion of the mobile sector has been found to have a positive effect on economic growth, while the growth in internet access or the number of secure internet servers has been observed to have no impact on growth.

In their 2022 study, Kallel et al. examine the impact of the proliferation of information and communication technologies (ICT) on Tunisian economic growth between 1997 and 2015. A sectoral index of ICT diffusion is developed, and the short-term and long-term effects are distinguished. Two principal conclusions are derived from the application of a panel-ARDL model. In the long term, the diffusion of information and communication technologies (ICT) has a positive effect on economic growth in Tunisia. In the short term, the authors identify a negative impact, which can be attributed to a notable bias in investment. These findings have significant implications for policy, both for those who invest and for those who create policy. In conclusion, the effect of ICT on economic growth remains unclear (Global Risks Report, 2024). Accordingly, the following section presents the findings of an empirical study based on a comparative analysis between OECD and MENA countries.

Kurniawati (2022) examines the causal relationship between information communication technology (ICT) and economic growth in high-income and middle-income Asian countries. This study utilises a high-quality data from 25 Asian countries from 2000 to 2018. It presents the robustness results by employing panel cointegration and estimation procedures to account for the endogeneity and cross-sectional dependence issues. The results illustrate that high-income Asian countries have achieved positive and significant economic development from high Internet penetration. Additionally, the middle-income countries have started to benefit

from ICT Internet. The findings show that the telephone line and mobile phone penetration is highly capable of promoting economic growth in middle-income Asian countries.

The OECD Digital Economy Outlook (2024) provides new insights on key technologies that underpin the digital technology ecosystem and their impacts. Using big data and machine-learning techniques, Volume 1 provides new estimates of the growth rate of the ecosystem's core – the information and communications technology (ICT) sector. It then looks toward the technology frontier with perspectives on the future of artificial intelligence (AI) and how it can be shaped into a positive force. Volume 1 also analyses how people, firms and governments are adopting digital technologies, offering insights into the scale and scope of digital divides and how to boost equal opportunity and inclusion. To that end, it looks at the critical need for next generation wireless networks to provide unlimited connectivity everywhere. Moving beyond the hype of immersive technologies, Volume 1 examines the proven ability of virtual reality (VR) to scale, while identifying its opportunities and risks. Finally, it shines a spotlight on mental health in digital environments, including those most at risk.

The 2024 Digital Economy Report highlights the critical necessity for environmentally sustainable and inclusive digitalization strategies. Digital technology and infrastructure are heavily reliant on raw materials, and the production and disposal of an increasing number of devices, coupled with the growing demands for water and energy, are exerting a detrimental impact on the planet. For instance, the production and utilization of digital devices, data centers, and information and communications technology (ICT) networks are estimated to account for a significant portion, ranging from 6% to 12%, of global electricity consumption.

2. ICT effects on economic growth: Empirical Strategy, Conceptual Data, and Results

2. 1. Problematic

The aim of this article is to examine the immediate impact of information and communication technology (ICT) on economic growth in the Middle East and North Africa (MENA) region[1] and the Organisation for Economic Co-operation and Development (OECD) countries[2]. Four indicators of ICTs are employed in this study: internet, telephone, and cell phone usage rates, as well as the share of imports of goods with technological content in total imports. To achieve the study's objectives and enhance the reliability of the findings, the interaction effect between the four ICT variables and human capital on the one hand, and financial development on the other, is interpreted.

2. 2. Procedure

In the initial phase of the investigation, the direct impact of information and communication technology (ICT) on economic growth is examined. This is achieved by measuring the ICT variables using a set of indicators, including the rates of internet, telephone and cell phone use, as well as the share of imports of goods with technological content in total imports. In order to address the aforementioned issue, four distinct scenarios are considered. Subsequently, the interaction effect between the ICT and human capital variables on the one hand and financial development on the other is examined.

A dynamic panel data model is estimated using the GMM method in systems, as developed by Blundell and Bond (1998). The variables are annual and encompass the period from 2010 to 2023. The values were extracted from the World Bank database, specifically the World Development Indicators (WDI) 2024.

[1] Algeria, Bahrain, Egypt, Iran, Iraq, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Syria, Tunisia, United Arab Emirates.
[2] Austria, Belgium, Canada, Denmark, Estonia, France, Germany, Greece, Hungary, Italy, Japan, Poland, Portugal, Sweden, Spain, Switzerland, United Kingdom, USA.

2. 3. Model presentation

The model to be estimated is written as follows:

$$TX\_PIB_{i,t} = \alpha_0 + \lambda_0 TX\_PIB_{i,t-1} + \beta_1 INV_{i,t} + \beta_2 DF_{i,t} + \beta_3 DEP_{i,t} + \beta_4 OUV_{i,t} + \beta_5 INF_{i,t} + \beta_6 CAPH_{i,t} + \beta_7 ICT_{i,t} + v_i + u_i + \varepsilon_{i,t}$$

TX_PIB*:* Rate of growth of real GDP.

DF*:* Credit to the private sector as a proportion of GDP, is often used as a proxy for financial development.

INV*:* The investment rate is defined as the proportion of gross fixed capital formation in gross domestic product (GDP).

INF*:* The rate of inflation is defined as the percentage change in the price level of goods and services over a specified period of time.

CAPH*:* The level of human capital, measured by secondary school enrolment.

OUV*:* The trade exposure rate is defined as the sum of exports and imports in relation to GDP.

DEP*:* The proportion of government expenditure as a percentage of gross domestic product (GDP).

ICT*:* The indicators of new information technologies are as follows: the rate of internet use (INTER), telephone use (TELE), cell phone use (MOB) and the share of imports of goods with technological content in total imports (ICT_IMPORT).

v_i : Country-specific effect.

u_i : Year-specific effects.

$\varepsilon_{i,t}$: Error term.

The dependent variable is defined in terms of $TX\_PIB_{i,t}$. The lagged dependent variable is represented by $TX\_PIB_{i,t-1}$. α_0 is a constant term, while λ_0 and β_i represent the coefficients to be

estimated. The set of independent variables comprises DF, INV, INF, CAPH, OUV, DEP and ICT. v_i represents the country-specific effect, u_i denotes the year-specific effects, and $\varepsilon_{i,t}$ signifies the error term.

In selecting the variables for analysis, we have drawn upon the work of Sapprasert (2007), Niebel (2018), Cheng et al. (2021) and Saba et al. (2023).

2. 4. Study of econometric tests

An examination of the correlation matrix for the MENA region (Table 1) reveals weak positive correlations between the economic growth rate and the investment rate (p-value 0.0766), ICT imports (p-value 0.0181), the trade openness rate (p-value 0.077), and fixed-line telephony registration (p-value 0.0652). Conversely, there are negative and statistically significant correlations between growth and the inflation rate (p-value 0.05). The results presented in Table 2 indicate that, for OECD countries, there is a weak positive correlation between economic growth and government spending (p-value 0.0417), ICT imports (p-value 0.001), the inflation rate (p-value 0.0089), the investment rate (p-value 0.0887), the openness rate (p-value 0.0083), and the fixed-line enrollment rate (p-value 0.051). These correlations are statistically significant. Conversely, there are negative and statistically significant correlations between growth and the inflation rate (p-value 0.05). The results presented in Table 2 indicate that, for OECD countries, there is a weak positive correlation between economic growth and government spending (p-value 0.0417), ICT imports (p-value 0.001), the inflation rate (p-value 0.0089), the investment rate (p-value 0.0887), the openness rate (p-value 0.0083), and the fixed-line enrollment rate (p-value 0.051). These correlations are statistically significant.

The results presented in Tables 5 and 6 provide evidence that the models are well specified. The hypothesis that there is no second-order serial correlation between the residuals cannot be rejected at the 5% significance level (p-value greater than 10%). Similarly, the results demonstrate that the instruments are valid, as indicated by the Sargan test, which indicates a good specification of the models (p-value greater than 5%).

Table 1: Correlation Matrix, MENA Countries

Variables/ p-values	TX_PIB	CAPH	DEP	DF	ICT_IMPORT	INF	INTERNET	INV
TX_PIB	1							

CAPH	-0,18979	1						
P-value	0,3151	-----						
DEP	-0,028844	-0,59356	1					
P-value	0,8797	0,0005	-----					
DF	-0,046681	0,156302	-0,36479	1				
P-value	0,8065	0,4095	0,0475	-----				
ICT_IMPORT	0,122754	0,247004	-0,27038	0,279204	1			
P-value	0,0181	0,1882	0,1484	0,1351	-----			
INF	-0,012174	-0,39192	0,268447	-0,53087	-0,01995	1		
P-value	0,0491	0,0322	0,1515	0,0025	0,9167	-----		
INTERNET	-0,05948	0,829632	-0,69042	0,458168	0,233347	-0,61158	1	
P-value	0,7549	0	0	0,0109	0,2146	0,0003	-----	
INV	0,25345	0,386864	-0,55847	0,499348	-0,2728	-0,38179	0,52517	
P-value	0,0766	0,0347	0,0013	0,005	0,1447	0,0374	0,0029	-----
MOBILE	0,10475	0,707527	-0,60858	0,512563	0,348999	-0,63671	0,874579	0,2831
P-value	0,0817	0	0,0004	0,0038	0,0587	0,0002	0	0,12
OUV	0,005332	0,532031	-0,5473	0,545238	0,136566	-0,55985	0,767595	0,3262
P-value	0,0777	0,0025	0,0017	0,0018	0,4718	0,0013	0	0,07
TELEPH	0,260053	0,086537	-0,60657	0,194432	0,425545	0,279921	0,102	0,049
P-value	0,0652	0,6493	0,0004	0,3032	0,0191	0,1341	0,5917	0,79

Source: Table made by the author.

Table 2: Correlation Matrix, OECD Countries

Variables/ p-values	TX_PIB	CAPH	DEP	DF	ICT_IMPORT	INFL	INTERNET
TX_PIB	1						
p-value	-----						
CAPH	0,0415	1					
p-value	0,6419	-----					
DEP	0,10422	0,483548	1				
p-value	0,0417	0	-----				
DF	0,0888	0,057508	-0,10115	1			
p-value	0,3189	0,5191	0,2559	-----			
ICT_IMPORT	0,145601	-0,24451	-0,12563	0,057739	1		
p-value	0,001	0,0054	0,1577	0,5174	-----		
INFL	0,230418	0,032697	0,033981	-0,16788	0,233995	1	
p-value	0,0089	0,7141	0,7034	0,0582	0,0079	-----	
INTERNET	0,161893	0,306962	0,291893	0,275658	0,251542	0,102262	1
p-value	0,0679	0,0004	0,0008	0,0016	0,0042	0,2507	-----
INV	0,116938	0,236374	0,110897	-0,08345	0,271247	0,238221	0,603273
p-value	0,0887	0,0072	0,2127	0,349	0,002	0,0068	0
MOBILE	0,02052	-0,27119	-0,15561	-0,10691	0,013864	0,011078	-0,04878
p-value	0,8182	0,002	0,0794	0,2297	0,8766	0,9012	0,5845
OUV	0,190749	0,218957	0,171436	-0,60795	0,008479	0,193085	0,181567
p-value	0,0083	0,013	0,053	0	0,9243	0,029	0,0403
TELEPH	0,102	-0,25159	-0,06531	0,187456	-0,31387	-0,20699	-0,02172
p-value	0,0519	0,0042	0,4639	0,0341	0,0003	0,0191	0,8078

Source: Table made by the author.

2. 5. Descriptive analysis of variables

Table 3 on descriptive statistics for the MENA region reveals that the average growth rate is -0.515, with a range from a minimum of -32.24 to a maximum of +121.78. Indeed, the economic growth rate appears to be the most volatile variable, exhibiting the highest coefficient of variation (+25.32). Conversely, human capital appears to be the most stable variable, exhibiting the lowest standard deviation (+0.125). The variables exhibiting a positive (negative) skewness coefficient indicate the presence of right (left) shifted distributions. Consequently, the rates for economic growth, ICT imports, and fixed-line enrollment exhibit a right-skewed distribution function. The remaining variables are characterised by symmetric distribution functions.

The results demonstrate that the economic growth rate, ICT imports, the fixed-line telephone subscription rate and the inflation rate exhibit kurtosis coefficients exceeding three. This is why their distribution functions are flatter than those of a normal distribution. With the exception of the variables pertaining to the mobile and fixed telephone registration rate and the commercial opening rate, the remaining variables appear to exhibit a distribution that does not align with a normal distribution, as evidenced by p-values in the Jarque-Bera test that are less than 0.01.

With regard to the OECD region (Table 4), the average growth rate is -0.374, with a range extending from a low of -16.78 to a high of +13.07. This variable exhibits the greatest volatility, with the highest coefficient of variation (+18.01). Nevertheless, the internet subscription rate appears to exhibit the least volatility, with a coefficient of variation of +0.134. The distribution function for human capital is right-skewed. The remaining variables exhibit a symmetric distribution. Additionally, the results indicate that the distribution functions of human capital and government spending are less peaked than a normal distribution. Conversely, the distribution functions of the cell phone enrollment rate, the investment rate, and the inflation rate exhibit a degree of kurtosis that is comparable to that of the normal distribution. Furthermore, all variables appear to exhibit a distribution that does not align with the normal distribution. The p-values derived from the Jarque-Bera test are less than 10%, with the exception of the mobile and fixed-line telephone subscription rates.

Table 3: Descriptive Statistics: MENA Countries

	Mean	CV	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
TX_PIB	-0,515	25,329	121,780	-32,238	13,045	6,423	63,579	19972,960	0,000
CAPH	91,004	0,125	107,583	52,532	11,366	-0,774	3,818	7,281	0,026
DEP	70,194	0,337	131,997	24,450	23,675	0,537	2,572	6,844	0,033
DF	54,926	0,572	138,858	5,414	31,439	0,113	1,909	5,484	0,064
ICT_IMPORT	4,949	0,504	17,188	0,001	2,494	2,110	10,230	280,376	0,000
INF	5,579	1,850	84,864	-3,749	10,323	4,672	31,473	4639,850	0,000
INTERNET	61,079	0,442	100,000	5,000	26,968	-0,230	1,899	7,770	0,021
INV	23,061	0,377	43,074	2,845	8,698	-0,026	2,898	0,057	0,972
MOBILE	122,638	0,312	212,639	42,525	38,323	0,353	2,614	3,756	0,153
OUV	101,009	0,477	239,666	0,000	48,197	0,408	3,087	3,895	0,143
TELEPH	15,381	0,538	38,818	5,548	8,268	1,247	4,275	45,466	0,000

Source: Table made by the author

Table 4: Descriptive Statistics: OECD Countries

	Mean	CV	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
TX_PIB	-0,37436	18,0192	13,07196	-16,7801	6,745667	-0,50408	2,778101	7,592523	0,022455
CAPH	113,7051	0,156803	163,9347	80,32146	17,82931	1,257564	3,824591	45,82972	0
DEP	19,98617	0,169816	26,74524	11,10199	3,393967	-0,45014	3,743202	10,78929	0,004541
DF	110,9702	0,390488	215,9451	32,3851	43,33254	0,15501	2,002917	7,995441	0,018357
ICT_IMPORT	7,803698	0,397875	17,47813	3,118018	3,104897	0,647913	2,734059	13,85331	0,000981
INFL	1,294863	0,99273	5,652145	-1,73604	1,285449	0,390815	3,05857	4,863819	0,087869
INTERNET	81,072	0,13498	98,04643	51,65	10,9431	-0,75592	2,796547	17,54963	0,000155
INV	21,58783	0,173542	30,24391	11,89228	3,746405	-0,52432	2,953285	8,722944	0,01276
MOBILE	120,2481	0,141785	162,3071	77,7089	17,04937	0,119862	3,101936	0,537214	0,764444
OUV	86,00237	0,464559	170,7599	23,37613	39,95318	0,654414	2,527807	15,32666	0,00047
TELEPH	40,54207	0,280204	63,85413	12,67974	11,36006	-0,24479	2,672335	2,747506	0,253155

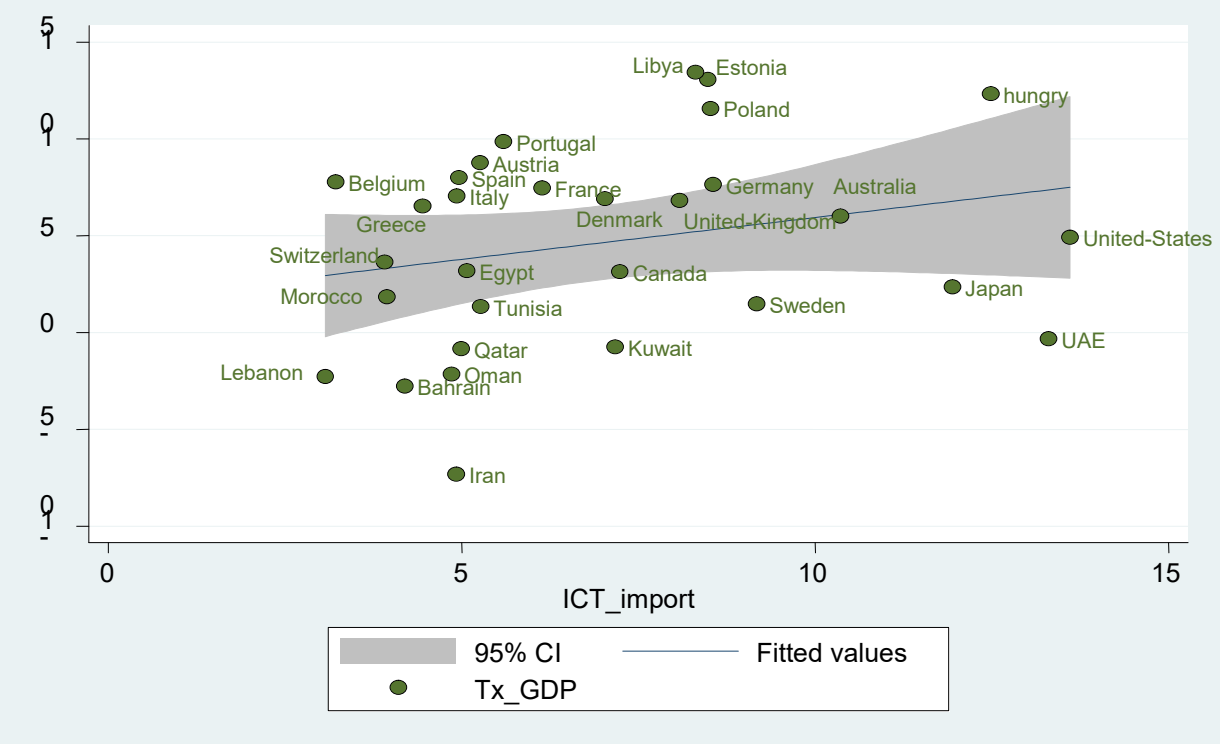
Source: Table made by the author

2. 6. Graphical analysis

The following graphs present an analysis of the correlation between economic growth rates and the factors that influence them. Figure 1 illustrates a positive correlation between imports of technology goods and economic growth, as indicated by an upward slope (the blue line). A number of countries, including the United States, Japan, Hungary, and Australia, have both high economic growth rates and high levels of imports of technology goods. Conversely,

Lebanon, Bahrain, Oman, and Iran exhibit comparatively low economic growth rates and minimal imports of technology goods.

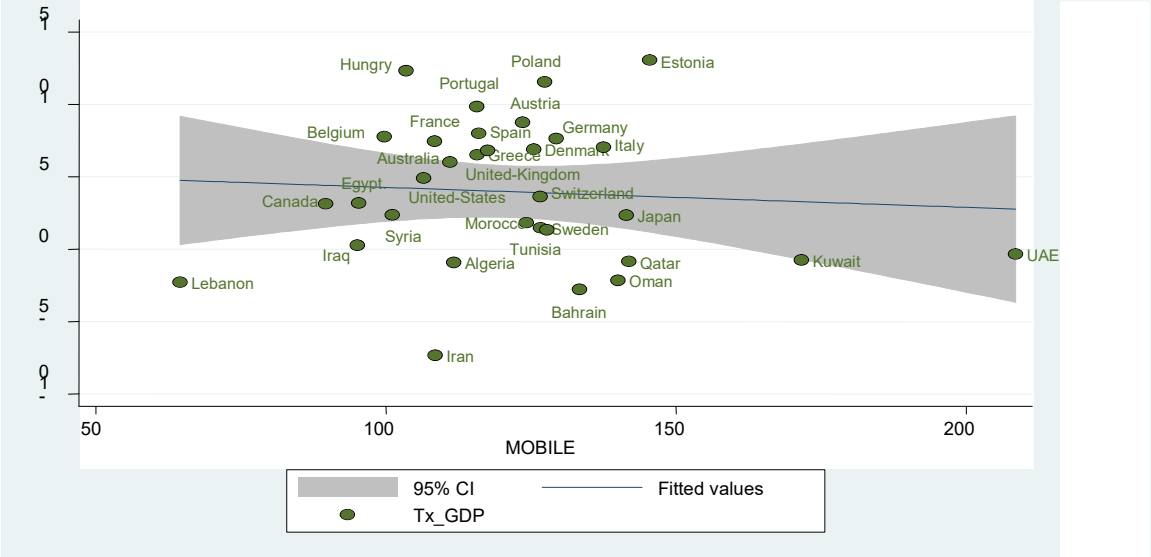
Figure 1: Correlation between the import of technological goods and the growth rate



Source: Table made by the author.

Figure 2 illustrates a negligible correlation between cell phone enrollment and economic growth, as indicated by a flat slope. The data indicates that the United Arab Emirates and Kuwait exhibit both significant economic growth rates and cell phone enrollment rates. Conversely, the values observed in Lebanon and Iraq are relatively low.

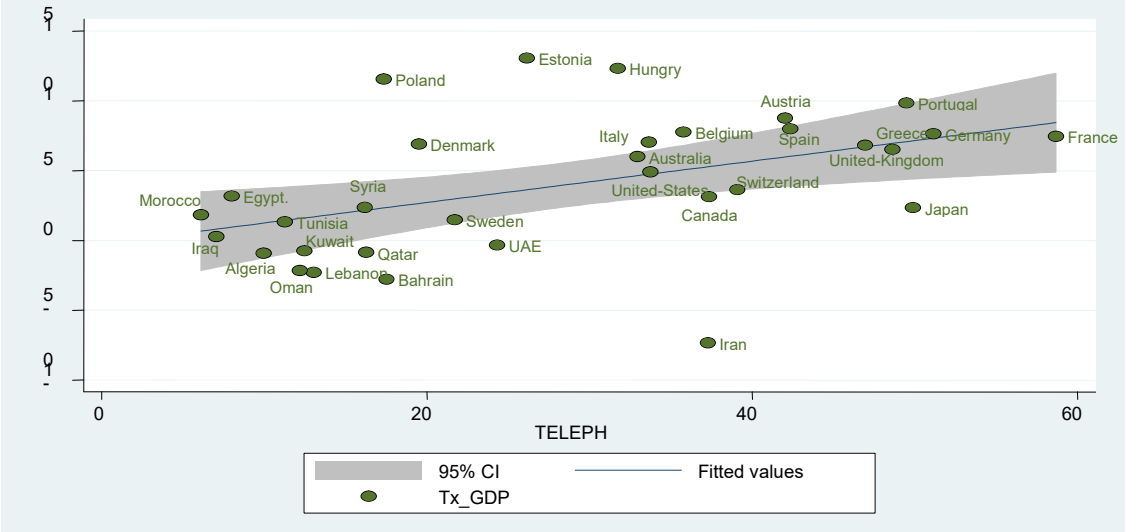
Figure 2: Correlation between the number of mobile phone subscribers and the growth rate



Source: Table made by the author.

Figure 3 illustrates a positive correlation between the fixed-line telephone enrolment rate and economic growth, with an upward slope. Significant rates are observed in the cases of France, Japan, Portugal and Greece. In contrast, the rates observed in Iraq, Morocco and Algeria are relatively low.

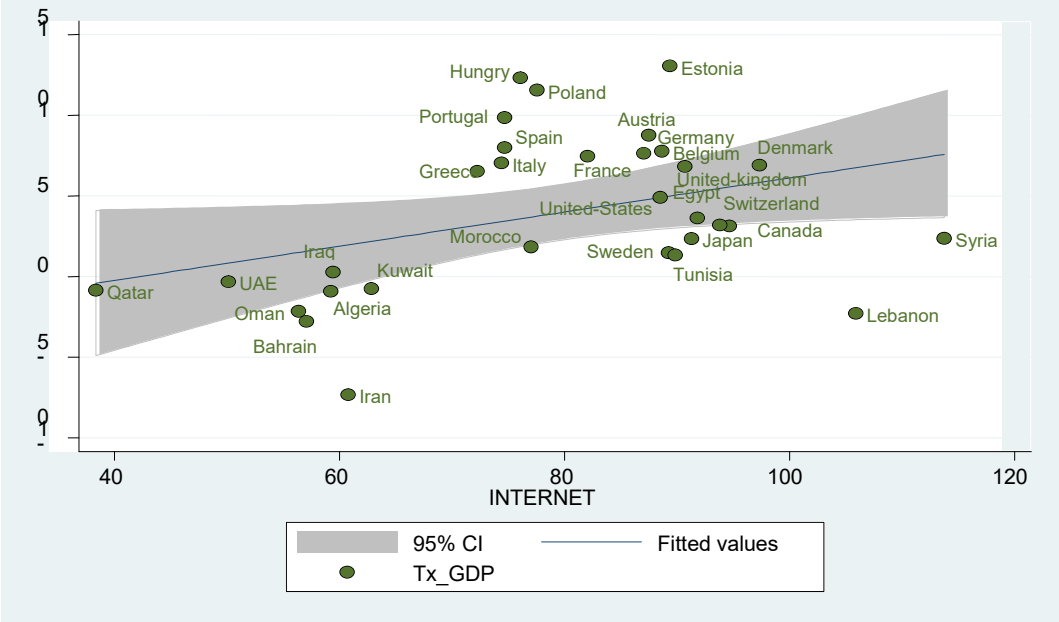
Figure 3: Correlation between the number of fixed phone subscribers and the growth rate



Source: Table made by the author.

The data presented in figure 4 illustrates a positive correlation between the internet enrolment rate and economic growth, as evidenced by an upward slope. The United States, Switzerland, and Denmark all exhibit relatively high rates. Conversely, the cases of Qatar and the United Arab Emirates illustrate that both variables are at negligible levels.

Figure 4: Correlation between internet registration and growth rate



Source: Table made by the author.

3. Econometric results and economic interpretations

3.1. Direct effect of ICT

The econometric estimations yielded four scenarios, which are presented in Tables 5 and 6. In addition to the conventional macroeconomic factors that influence economic growth, we incorporated the variables of interest, namely "telephony," "ICT import," "mobile," and "internet". The objective of this analysis is to ascertain the impact of output per capita lagged one period in order to determine the dynamic behaviour. The results confirm a positive and significant relationship for the different specifications in both regions. This finding indicates that an increase in real GDP per capita over time is associated with a corresponding increase in the material resources available to the inhabitants. They are instrumental to economic success through the generation of labour and capital income, which in turn gives rise to an

increase in consumption and subsequently an increase in economic growth. Despite the homogeneity of the variables employed, our findings do not corroborate the principle of conditional convergence put forth by Baro and Sala-I-Martin (1997).

Indeed, the various macroeconomic variables exert a considerable influence on economic growth. With regard to the variable of trade openness, the four scenarios yield a positive impact on economic growth of approximately 1%. The respective probabilities are 0.005, 0.007, and 0.001 in the OECD region and 0.000 for all MENA country specifications. The findings indicate that economies with a closed trade regime tend to exhibit lower growth rates than those that are more open to external trade. The impact is approximately 1% for both regions and for all four scenarios. Consequently, greater trade openness facilitates the transfer of technological knowledge. This phenomenon is elucidated by Pissarides (1997), who posits that openness to trade fosters a symbiotic relationship between innovative industrialised countries (the northern countries) and less developed countries (the southern countries).

With regard to the variable representing human capital, the estimated coefficients are positive and relatively low in both groups. The results are statistically significant at the 1% level in all four scenarios pertaining to the MENA countries. With the exception of specification 2, the aforementioned coefficients are significant at approximately 1% (scenarios 1 and 2) and 5% (scenario 3) for the OECD region. It is therefore imperative to foster human capital development while simultaneously promoting entrepreneurship within the ICT sector, encompassing telephone, mobile, and internet-related endeavours.

In the MENA region and for all four scenarios, the inflation rate demonstrates a positive and statistically insignificant effect, with probabilities exceeding 0.1 (Table 6). This outcome demonstrates that exceedingly high rates of inflation are inimical to economic growth, due to the considerable uncertainty that acts as a deterrent to investors. Furthermore, the OECD finds that the effect of the inflation rate is positive but insignificant for scenarios 2 and 4, which have respective probabilities of 0.196 and 0.174. Therefore, it can be concluded that the inflation rate has no impact on economic growth, given that the countries in question experience low inflation rates. Conversely, specifications 1 and 3 demonstrate a positive and statistically significant impact on economic growth.

The results of the analysis demonstrate that government spending in MENA countries has a positive and statistically significant impact on economic growth, with an estimated effect of approximately 1 percent. However, the results for the OECD indicate a negative and insignificant impact for specifications 1 and 3. Therefore, it can be concluded that government spending on investment has a positive effect on economic growth, as evidenced by the results of the two positive-effect specifications (Scenarios 2 and 4) presented in Table 5. With regard to the investment rate, the results indicate a positive impact of 1 percent on economic growth across all OECD specifications. In the case of the MENA countries, the results indicate that this variable (INV) exhibits statistically insignificant effects for the four cases under consideration, with the respective probabilities being 0.998, 0.893, 0.975 and 0.783.

Conversely, the evidence suggests that financial development exerts a negative and statistically significant impact on growth in MENA countries, with the probabilities equal to (0.015), (0.011), (0.002) and (0.079). Therefore, the contribution of the financial sector to capital accumulation is inadequate. In the majority of countries, policymakers provide funding for non-productive projects that dominate the majority of banking systems. The results of the study indicate that, for all four scenarios examined, the effect of financial development on economic growth remains positive and significant. This outcome is undoubtedly substantiated by the relatively advanced stage of financial market development observed in OECD countries.

The incorporation of the variables "Mobile" and "Telephone" in scenarios 2 and 4 results in the variable (INV) becoming positive and insignificant when the probabilities are equal to 0.893 and 0.783 (MENA region). This result appears to be consistent with the economic theory that investment is regarded as a catalyst for economic growth.

With regard to the influence of information and communication technology (ICT) variables on economic growth in the Middle East and North Africa (MENA) region, the results indicate positive, though statistically insignificant, values for scenarios 1 and 2. Conversely, scenario 4 shows negative, though also statistically insignificant, values. The most significant impact is evident in the variable pertaining to the import of technological goods, which demonstrates a positive and statistically significant effect of approximately 10% (Specification 3, p-value = 0.064). Indeed, this outcome appears to be a reasonable interpretation of the data, given that

foreign trade exerts a direct influence on the growth of these countries, in contrast to mobile telephony, fixed telephony, or the internet, which exert a comparatively slower effect on growth (Sassi and Goaed, 2013). In the case of the Organisation for Economic Co-operation and Development (OECD), the effect of all the variables mapping information and communication technologies (ICTs) is positive and significant, with the exception of the variable of mobile telephony. The results indicate a negative and insignificant effect (Table 5, scenario 3, p-value = 0.393). Therefore, it can be concluded that information and communication technologies (ICTs) act as a significant catalyst for economic growth within the Organisation for Economic Co-operation and Development (OECD) member countries. They facilitate access to information, efficient resource allocation, economic integration, employment and productivity gains (Stanley et al., 2018).

The following section presents a more detailed examination of the interaction effects between information and communication technology (ICT) and human capital, on the one hand, and financial development, on the other.

Table 5 : Results of the direct effect of ICT on economic growth OECD Countries			
	Specification 1	**Specification 2**	**Specification 3**
L.log_PIB	0.65795924***	0.45860808***	0.62895286***
	(0.000)	(0.000)	(0.000)
INV	0.04306925***	0.03816176***	0.02437469***
	(0.000)	(0.000)	(0.006)
DF	0.00748837***	0.00443157***	0.00500772***
	(0.000)	(0.003)	(0.009)
DEP	-0.00308071	0.00963988*	-0.01657980
	(0.852)	(0.0522)	(0.331)
OUV	0.01153158***	0.01015649***	0.00846262***
	(0.005)	(0.007)	(0.007)
INFL	0.02430964***	0.01199993	0.01475921**
	(0.000)	(0.196)	(0.018)
CAPH	0.00288184***	0.00090124	0.00174110**
	(0.000)	(0.213)	(0.014)
TELEPH	0.00464410***		
	(0.000)		
ICT_import		0.04059132***	
		(0.000)	
MOBILE			-0.00133189
			(0.393)
INTERNET			
Observations	156	156	156
Number of instruments	19	19	19
AR2	0.60119	0.650754	0.630612
Sarganp	0.655	0.465	0.254

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***, ** and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively. The p-value is provided in parent
the second-order serial correlation tests between the residuals. The term 'Sarganp' refers to the p-value of the instrument validit
stage Generalized Method of Moments (GMM) method with Stata's xtbond2 command.

Table 6 : Results of the Direct Effect of ICT on Economic Growth MENA Countries				
	Specification 1	**Specification 2**	**Specification 3**	**Specification 4**
L.log_PIB	0.44940776***	0.45919773***	0.41576306***	0.43578314***
	(0.000)	(0.000)	(0.000)	(0.000)
INV	-0.00000195	0.00012532	-0.00002738	0.00030770
	(0.998)	(0.893)	(0.975)	(0.783)
DF	-0.00214800**	-0.00216984**	-0.00248394***	-0.00180108*
	(0.015)	(0.011)	(0.002)	(0.079)
DEP	0.00079913***	0.00079023***	0.00076467***	0.00066916**
	(0.001)	(0.005)	(0.002)	(0.012)
OUV	0.00282030***	0.00279647***	0.00292093***	0.00270971***
	(0.000)	(0.000)	(0.000)	(0.000)
INFL	0.00050338	0.00054944	0.00047227	0.00048407
	(0.194)	(0.165)	(0.227)	(0.272)
CAPH	0.00374996***	0.00378047***	0.00580885***	0.00347013**
	(0.003)	(0.003)	(0.000)	(0.014)
INTERNET	0.00027806			
	(0.766)			
MOBILE		0.00001576		
		(0.954)		
ICT_import			0.00404449*	
			(0.064)	
TELEPH				-0.00023511
				(0.890)
Observations	73	73	73	73
Number of instruments	10	10	10	10
AR2	0.0629	0.0675	0.0705	0.0962
Sarganp	0.8356	0.8396	0.8704	0.8152

Note: Author's estimates. Values in parentheses are p-values. ***, ** and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively.

3.2. Interaction between ICT and Human Capital

In order to account for a potential interaction between human capital and the variables describing ICT, an interaction variable between human capital and ICT is added to the basic equation. The estimation results are presented in Tables 7 and 8. In the case of OECD countries (Table 7), the estimates indicate that the interaction variables are positive and statistically significant in scenarios 2 and 4. This result demonstrates that the existing human capital enhances the impact of information and communication technology (ICT) on economic growth. In other words, the impact of importing technology-based goods and utilising the Internet on economic growth is contingent upon the level of human capital in OECD countries. The results indicate that the variables associated with the interaction between human capital and information and communication technology (ICT) have a negligible impact on the economies of MENA countries (Table 8). This outcome can be

attributed to the insufficient level of human capital in the region, which hinders the assimilation of foreign technology and consequently impedes economic growth.

In order to ascertain the impact of information and communication technology (ICT) on economic growth, it is necessary to establish that the level of human capital has reached a certain threshold ($d(GROWTH)/d(TIC) = \hat{\beta}_2 + \hat{\beta}_1 * CAPH$). In order to calculate the impact of ICT on economic growth, it is necessary to ensure that the interaction variable (CAPH*ICT) is statistically significant at a minimum threshold of 10%, and that the ICT variable has a sign opposite to that displayed by the interaction variable. This is not the case for the two regions under consideration, and thus the impact of ICT on economic growth cannot be demonstrated.

Table 7 : Results of the effect of the interaction between ICT and human capital on economic growth

OECD Countries

	Specification 1	Specification 2	Specification 3	Specification 4
L.log_PIB	0.50329620***	0.38121228***	0.39354655***	0.42543767***
	(0.000)	(0.000)	(0.000)	(0.000)
INV	0.01485125	0.02469527***	0.01963856***	0.01788468*
	(0.253)	(0.000)	(0.000)	(0.081)
DF	-0.00067585	0.00149987***	0.00021978	0.00117687
	(0.789)	(0.001)	(0.924)	(0.325)
DEP	0.02359518	0.00586679	0.01546909*	0.01615075
	(0.239)	(0.422)	(0.086)	(0.246)
OUV	0.00523804	0.00247696**	0.00575927***	0.00631087**
	(0.130)	(0.046)	(0.000)	(0.036)
INFL	0.04488830***	0.03762411***	0.04080753***	0.03679533***
	(0.000)	(0.000)	(0.000)	(0.000)
CAPH	-0.00234194	0.01188694***	0.00246926	-0.01092272
	(0.747)	(0.003)	(0.834)	(0.447)
TELEPH	-0.00759548			
	(0.721)			
TELEPH_ CAPH	0.00009750			
	(0.554)			
ICT_import		0.10633362***		
		(0.003)		
ICT_import_ CAPH		0.00073392**		
		(0.017)		
MOBILE			0.00616007	
			(0.553)	
MOBILE_CAPH			-0.00003495	
			(0.730)	
INTERNET				0.01659737***
				(0.000)
INTERNET_CAPH				0.0014415***
				(0.000)
Observations	156	156	156	147
Number of instruments	19	19	19	19
AR2	0.50177	0.40495	0.60227	0.60159
Sarganp	0.132	1.000	0.251	0.409

Note: Author's estimates. Values in parentheses are p-values. ***, ** and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively.

Table 8: Results of the Effect of the Interaction between ICT and Human Capital on Economic Growth

	MENA Countries			
	Specification 1	**Specification 2**	**Specification 3**	**Specification 4**
L.log_PIB	0.20035357*	1.64022487**	-0.25533853	0.26596576**
	(0.0832)	(0.046)	(0.835)	(0.025)
INV	0.00469763	-0.00432503	0.00115451	-0.00089648
	(0.349)	(0.686)	(0.917)	(0.434)
DF	-0.00673167	0.00136592	-0.00166893	-0.00025058
	(0.338)	(0.851)	(0.568)	(0.805)
DEP	-0.00043366	0.00108239	0.00078124	0.00091597***
	(0.600)	(0.378)	(0.535)	(0.000)
OUV	0.00362297***	0.00265307	0.00399457**	0.00292694***
	(0.000)	(0.107)	(0.019)	(0.000)
INFL	-0.00052052	-0.00185077	-0.00022934	0.00007173
	(0.812)	(0.630)	(0.903)	(0.872)
CAPH	0.03709784*	-0.02119188	0.01351439	0.00687657***
	(0.064)	(0.399)	(0.429)	(0.007)
INTERNET	0.06657191			
	(0.155)			
INTERNET_ CAPH	-0.00066018			
	(0.155)			
MOBILE		-0.01669969		
		(0.229)		
MOBILE_ CAPH		0.00016506		
		(0.244)		
ICT_import			-0.03756972	
			(0.763)	
ICT_import_ CAPH			0.00029166	
			(0.813)	
TELEPH				0.01190383
				(0.299)
TELEPH_ CAPH				-0.00012220
				(0.312)
Observations	73	73	73	73
Number of instruments	10	10	10	10
AR2	0.836	0.182	0.373	0.9206
Sarganp	0.133	0.210	0.0550	0.0716

Note: Author's estimates. Values in parentheses are p-values. ***, ** and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively.

3.3. Interaction effect between ICT and financial development

An examination of Table 9 for the OECD region reveals that the interaction variables between ICT and financial development exert a positive and statistically significant influence, with the exception of scenario 2, wherein a negative relationship is observed between the interaction variable ICT_Import and financial development, which remains insignificant (p-value = 0.969). Similarly, for countries in the Middle East and North Africa (MENA), Table 10 demonstrates that this identical interaction variable is also statistically insignificant (scenario 4, p-value = 0.169). The results challenge the hypothesis that ICT can stimulate economic growth through the financial development channel. In other words, the impact of ICT on economic growth is contingent upon the extent of financial development in the two regions under examination. At a specific level of financial advancement, the impact of information and communication technology (ICT) becomes positive. It is demonstrated that the utilisation of fixed-line telephony in the MENA region exerts an influence on economic growth, contingent upon the attainment of a financial development threshold of 88%[3] (Table 10, Scenario 3).

[3] Limit= -0.01515413 /0.00017465.

Table 9: Results on the Effect of the Interaction between ICT and Financial Development on Economic Growth

	OECD Countries			
	Specification 1	**Specification 2**	**Specification 3**	**Specification 4**
L.log_PIB	0.23815619***	0.18857081***	0.48906002***	0.57922481***
	(0.000)	(0.007)	(0.000)	(0.000)
INV	0.02475332***	0.02650729***	0.00309694	0.02683265**
	(0.000)	(0.000)	(0.779)	(0.027)
DEP	0.00571853	0.02820815***	0.00170005	-0.01176763
	(0.663)	(0.000)	(0.877)	(0.472)
OUV	0.00393070	0.00867626***	0.00258828	0.00664028**
	(0.142)	(0.000)	(0.259)	(0.045)
INFL	0.03915277***	0.03420564***	0.04520954***	0.02420702***
	(0.000)	(0.000)	(0.000)	(0.000)
CAPH	-0.00463388	0.00610365***	0.00528925*	0.00164902***
	(0.207)	(0.000)	(0.085)	(0.005)
DF	0.00296303**	0.00265029	-0.00387885	0.01269441***
	(0.032)	(0.328)	(0.230)	(0.001)
TELEPH	0.00884353*			
	(0.082)			
DF_TELEPH	0.00005126*			
	(0.091)			
ICT_import		-0.04137753		
		(0.188)		
DF_ICT_import		-0.00000656		
		(0.969)		
INTERNET			0.00759160*	
			(0.068)	
DF_INTERNET			0.00007605**	
			(0.042)	
MOBILE				0.00742333***
				(0.001)
DF_MOBILE				0.0000665[1]***
				(0.002)
Observations	156	156	147	156
Number of instruments	19	19	19	19
AR2	0.296	0.753	0.9379	0.0803
Sarganp	0.986	1.000	0.141	0.364

Note: Author's estimates. Values in parentheses are p-values. ***, ** and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively.

Table 10: Results on the Effect of the Interaction between ICT and Financial Development on Economic Growth				
	MENA Countries			
	Specification 1	**Specification 2**	**Specification 3**	**Specification 4**
L.log_PIB	0.09310462	0.49345623***	0.40538639**	0.31976122*
	(0.670)	(0.007)	(0.048)	(0.087)
INV	-0.00081032	0.00206398	-0.00148033	-0.00025297
	(0.725)	(0.258)	(0.383)	(0.862)
DF	0.00589402	0.00742891*	-0.00339754**	-0.00189116
	(0.156)	(0.063)	(0.040)	(0.262)
DEP	0.00059300	0.00013354	0.00072023**	0.00077802**
	(0.119)	(0.785)	(0.046)	(0.028)
OUV	0.00295760***	0.00291572***	0.00307634***	0.00303487***
	(0.000)	(0.000)	(0.000)	(0.000)
INFL	-0.00099230	-0.00067182	-0.00014353	-0.00019094
	(0.200)	(0.406)	(0.847)	(0.770)
CAPH	0.00701271***	0.00078793	0.00267978	0.00463595**
	(0.001)	(0.687)	(0.101)	(0.027)
INTERNET	0.00318467			
	(0.188)			
DF_INTERNET	0.00010789**			
	(0.048)			
MOBILE		0.00348263*		
		(0.052)		
DF_MOBILE		0.00004504*		
		(0.068)		
TELEPH			-0.01515413**	
			(0.029)	
DF_TELEPH			0.00017465**	
			(0.018)	
ICT_import				0.00796486
				(0.345)
DF_ICT_import				0.00014540
				(0.169)
Observations	73	73	73	73
Number of instruments	10	10	10	10
AR2	0.0172	0.152	0.7285	0.223
Sarganp	0.198	0.514	0.93	0.90482

Note: Author's estimates. Values in parentheses are p-values. ***, ** and * correspond to statistical significance at the 1%, 5% and 10% levels, respectively.

Conclusion

The role of new Information and Communication Technologies (ICT) in development processes and territorial dynamics is currently a topic of considerable debate. This debate concerns both the mastery of information and the reduction in spatial distances. In theoretical discourse, the knowledge economy is a constant point of reference in economic and political debates (Global Risks Report, 2024). In practice, the initial delay in terms of equipment, infrastructure and resources represents a significant obstacle to growth and economic development. Information and communication technologies (ICTs) can be defined as a generic technology and a means of accelerating productivity. They are therefore able to compensate for the delay in growth. This interaction is associated with the growth in the proportion of intangible capital and the extensive utilisation of novel information and communication technologies. Education, training and research and development are pivotal elements of knowledge that have enabled developed countries to transition into a new growth regime.

In this regard, information and communication technologies (ICTs) enhance productivity and improve efficiency at the individual, organisational, sectoral and macroeconomic levels. Furthermore, they can have advantageous effects on the economy, including the transfer of knowledge at an accelerated pace and greater transparency. Information and communication technologies (ICTs) play a pivotal role in facilitating international trade in goods and services. They facilitate a more optimal distribution of resources between disparate sectors, thereby ensuring a greater availability of products for consumption. A reduction in costs creates new opportunities for international trade and facilitates greater involvement of developing countries in the information economy. Furthermore, there has been an increase in the transfer of production and investment from developed to developing countries, in addition to the aforementioned rise in trade.

In light of the empirical evidence, it can be posited that the advent of ICTs, in addition to offering a potential avenue for technological advancement, is likely to exert a considerable influence on the growth of our countries in the forthcoming years, particularly in terms of financial expansion. Furthermore, the consolidation of ICT infrastructures is crucial for enhancing the productivity of networks and the quality of connections. This may be achieved

through the implementation of an attractive policy for the private sector, including foreign direct investment, and also through the execution of large-scale projects at the community level such as the provision of optical fibre and satellite services. It is evident that this commitment facilitates the advancement of value-added services and the expeditious dissemination of nascent technologies.

Our study proposes the implementation of incentive policies and regulatory measures that facilitate the growth of the digital finance sector (e-banking, mobile money, blockchain technology, etc.) with the objective of fully leveraging the potential of ICT for the advancement of financial services. It is of the utmost importance to cultivate human capital and facilitate the establishment of businesses in the ICT sector with the objective of developing financial services on cell phones or via the Internet. Such an approach will have a beneficial impact on financial development.

In conclusion, this article has sought to demonstrate how information and communication technologies (ICTs) have the potential to facilitate accelerated growth, facilitate the realization of positive externalities, and enable MENA countries to approach the performance levels achieved by Organization for Economic Co-operation and Development (OECD) countries. The initial lag in terms of equipment, infrastructure, and resources may, in theory, constitute a significant disadvantage in terms of the ability to compete in the global marketplace.

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