Politická ekonomie
2024, Volume 72, Issue 3
https://doi.org/10.18267/j.polek.1409
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VŠE / PRAGUE UNIVERSITY OF ECONOMICS AND BUSINESS

The Impacts of ICT on Economic Growth in the MENA Countries: Does Institutional Matter?

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Abstract

This study investigates the effects of information and communications technology (ICT) on economic growth. Our study focuses on 16 MENA countries from 1995 to 2018. We examine not only the impact of ICT usage and investment but also the moderating role of the quality of national institutions shaping this relationship. The results obtained using the panel ARDL method suggest that while ICT usage drives economic growth, ICT investment alone has a limited effect. Moreover, our research confirms that higher-quality institutions boost the impact of ICT use and investment on economic expansion. These results are essential for policymakers who want to boost ICT's contribution to GDP growth.

Keywords: ICT usage, ICT investment, institutional quality, economic growth, panel regression, MENA

JEL Classification: E02, O43, O53, O47, C23

Citation: Abu Alfoul, M. N., Tajaddini, R., Gholipour, H. F., Bashar, O., Jamaani, F.: The Impacts of ICT on Economic Growth in the MENA Countries: Does Institutional Matter? Politická ekonomie, 2024, 72(3), 446–477, https://doi.org/10.18267/j.polek.1409

1. Introduction

Information and communications technology (ICT) plays a crucial role in driving economic growth and transforming information into a powerful tool for development. In 2019, the world invested over $421 billion in ICT products and services, and more than half the global population had access to the internet (International Telecommunication Union, 2020). Over the last few decades, ICT has become a fundamental element of economic growth and policy-making, enabling governments to collect, process and disseminate data effectively (Toader *et al.*, 2018). This research paper provides a comprehensive definition of information and communications technology (ICT) and identifies its constituent elements. According to Walter's (1985) research, information and communications technology (ICT) encompasses the collection, preservation, retrieval, processing, estimation and transmission of data using computer, digital and/or electronics-based methods. To put it differently, ICT encompasses the gathering, processing, storage and dissemination of various forms of data, such as text, audio, video and images, facilitated by computers and telecommunications technology. These advancements have helped shape the world we live in today (Niebel, 2018).

While previous research has investigated the impact of ICT and institutional quality on economic growth, few studies have explored the interplay between these variables and their combined effect on growth. Much of the research into ICT and economic growth has been conducted in developed countries, leaving a gap in understanding this relationship in developing countries, especially in the Middle East and North Africa (MENA) region.

The theories of economic growth (Romer, 1990; Sala-i-Martin and Barro, 1995; Barro, 1996) all concur that ICT has the potential to drive economic growth by enabling progress and innovation in various industries. The widespread use of the internet allows for seamless sharing of information and ideas, encouraging competition and creating new products, processes and business models. Moreover, a sound institutional framework can encourage innovation and improve a country's macroeconomic competitiveness, thereby leading to human and capital investments, boosting the innovation capacity of businesses and ultimately resulting in economic prosperity (see Mauro, 1995; Porta *et al.*, 1998; Acemoglu, 2003; Delgado *et al.*, 2012). While the literature predicts a positive effect of ICT on economic growth, research has produced conflicting results – with some studies showing a positive impact (Vu, 2011; Sassi and Goaied, 2013; Edquist *et al.*, 2018; Pradhan *et al.*, 2018) and others revealing mixed or negative results (Yousefi, 2011; Ishida, 2015; Aldashev and Batkeyev, 2021; Cheng *et al.*, 2021).

The purpose of this study is to understand the connection between ICT investment and usage[1] and the economic growth of countries in the MENA region. It also examines the influence of institutional quality on this relationship. To the best of our knowledge, limited studies have explored the impact of institutional quality on the relationship between ICT and economic growth (see Jin and Cho, 2015; Wamboye *et al.*, 2015). Thus, the main objectives of our study are twofold.

Firstly, previous studies have limited their examination of institutional quality to a maximum of one, two or an average of six indicators and their effect on ICT and economic growth (*e.g.*, Jin and Cho, 2015; Wamboye *et al.*, 2015). In this study, we adopt the definition of "institutional quality" by Kaufmann *et al*. (2011), which emphasizes the effectiveness of government policies and the ability to implement sound policies that benefit the community. Our study contributes to the literature by analysing the impact of all institutional indicators measured by the Worldwide Governance Indicators (WGI) on the relationship among ICT usage, investment and economic growth.

The WGI includes the following aspects of institutional quality: control of corruption (*CC*), government effectiveness (*GE*), rule of law (*RL*), regulatory quality (*RQ*), political stability and absence of violence (*PV*) and voice and accountability (*VA*). Unfortunately, the scores of the MENA countries rank among the lowest globally in terms of institutional quality. However, there are some exceptions, as seen in Figure A.1 in the Appendix, where countries such as Israel, Oman, Qatar and the United Arab Emirates demonstrate relatively high performance.

Many economies in the MENA region are characterized by low income, high levels of poverty and unemployment and unequal distribution of resources. Acemoglu and Robinson (2012) link this widespread discontent to corrupt and ineffective governments. In these economies, a small group of elites controls and utilize resources for its own benefit, hindering social progress. These elites often hold sway over critical industries, leading to an uncompetitive and stagnant private sector, ultimately causing slow growth in the MENA economies. This study's second objective is to examine the effect of institutional quality on the relationship between ICT usage, investment and economic growth in the context of corruption and poor institutional quality, which are prevalent in the MENA region.

The use of technology and the quality of institutions are crucial elements in securing long-term competitiveness. Our study draws upon the national competitive advantage theory, which posits that these factors play a significant role in economic growth. The theory suggests that a country's economy cannot flourish and compete in a context of poor institutional quality.

1 ICT usage includes individuals who utilize the internet, households that have internet connectivity, encompassing various devices such as computers, mobile phones and public mobile telephone service subscriptions. ICT investment is private and government expenditure on telecommunications equipment and installations.

However, there has been limited research into the relationship among ICT and institutional quality indicators in developing countries such as those in the MENA region.

This study employs a panel dataset encompassing 16 countries in the MENA region for the time frame from 1995 to 2018. By utilizing the panel autoregressive distributed lag (ARDL) method, the results show that institutional quality indicators significantly influence the relationship between ICT and economic growth.

The paper proceeds as follows: Section 2 reviews the literature on the ICT-growth nexus, institutional quality and the interaction between ICT and institutional quality on economic growth. It then presents the research hypotheses. Section 3 explains the data and the estimation method. Section 4 presents and discusses the results. Section 5 concludes the paper.

2. Literature Review and Hypothesis Development

2.1 ICT and economic growth

As Romer and Solow theorized, the engine of long-term economic growth is driven by technology (Solow, 1956; Romer, 1986, 1990). Romer (1990) showed that collaboration between public and private investments could enhance ideas and bring forth novel products, fuelling economic growth. This concept was verified by the neo-Schumpeterian models of Aghion *et al.* (1998) and colleagues, who concurred that improved and new products and processes, such as ICT, can increase productivity and ultimately lead to a rise in capital investment and GDP. Hence, technology acts as a catalyst, propelling economic growth forward.

Several empirical studies have examined the impact of ICT on economic growth in developed countries. Some studies indicate that ICT can significantly improve economic growth (Evangelista *et al.*, 2014; Edquist *et al.*, 2018; Pradhan *et al.*, 2018). The findings of a recent study conducted by Cheng *et al.* (2021) suggested that while the expansion of Information and communications technology (ICT) has a positive impact on economic growth in high-income countries, its effect on middle and low-income countries is less clear. The study revealed that while the growth of mobile technology positively affects economic growth in these countries, an increase in internet usage does not produce the same result.

Few researchers have examined the relationship between ICT and growth in developing countries. For example, Sassi and Goaied (2013) found that ICT usage and investment had a significant effect on economic growth in the MENA region from 1996 to 2010. Applying an ARDL model to historical data from South Africa, Salahuddin and Gow (2016) revealed a positive and significant long-run relationship between internet usage and economic growth. Vu (2011, 2013), Wamboye *et al.* (2015) and Dedrick *et al.* (2013) have also identified similar associations.

Conversely, there is another stream of literature that suggests mixed or negative effects of ICT developments on economic growth. This is because ICT penetration reduces employment of unskilled workers and leads to unfavourable effects on economic growth (Aghion *et al.*, 1998; Vu, 2011; Yousefi, 2011; Ishida, 2015). Thus, based on the above empirical results, our first hypothesis is as follows:

> $\boldsymbol{H_1}$: *ICT usage and investment positively (or negatively) affect economic growth in the MENA region*, *ceteris paribus.*

2.2 Interaction between ICT and institutional quality to stimulate growth

The relationship between ICT and economic growth is not straightforward. According to Wang *et al.* (1999), the interaction between technological innovation and economic growth creates a "virtuous circle". A growing body of literature suggests that a country's governance institutions play a role in shaping the association between technology and economic growth. The concept of national competitive advantage, or national competence, proposes that national institutions act as a moderator in economic growth. National competence refers to a country's ability to grow and compete, and it is assessed using various factors such as fiscal policy, microeconomic environment, political institutions, social infrastructure, monetary policy, government policies and the social infrastructure, as described by (Delgado *et al.*, 2012).

The theory of national competence focuses on how political institutions and institutional quality influence the efficiency of labour and capital. Institutions play a crucial role in a country's macroeconomic competitiveness. Previous studies in macroeconomics have demonstrated a correlation between institutional quality and economic growth (Acemoglu, 2003; Kaufmann *et al.*, 2009; Kaufmann and Fellow, 2011; Kaufmann *et al.*, 2011). Specifically, economic growth is connected to the rule of law (Porta *et al.*, 1998), anti-corruption efforts (Mauro, 1995) and democracy (Helliwell, 1994). Acemoglu (2003) suggested that institutions are a critical factor in driving economic growth, and countries that have strong institutions and support human and capital investment are more likely to experience economic prosperity.

Existing scholarly research indicates that the level of formal institutional quality plays a crucial role in influencing the extent to which ICT is adopted and utilized. Countries that possess superior institutional quality are more inclined to possess superior ICT infrastructure and are more likely to reap greater advantages from the implementation of ICT. Conversely, countries with inferior institutional quality may not witness comparable levels of ICT advancement (Entele, 2021; Gyamfi *et al.*, 2022; Adeleye *et al.*, 2023). For example, Entele's (2021) research indicates that there exists a significant relationship between the quality and performance of formal

institutions and their impact on ICT. This, in turn, has a direct influence on the economic growth rate. In addition, Adeleye *et al.* (2023) conducted a study that examined the relationship between institutional quality index (IQI) and ICT in the context of inclusive growth, utilizing a sample of 193 countries spanning the years 2010–2019. Their findings indicated a positive relationship between institutional quality and ICT adoption, and inclusive growth. Adam (2020) discovered compelling evidence that highlights the substantial influence exerted by the development of ICT and the quality of institutions as mediators in the context of e-government's impact on corruption. Recently, Gyamfi *et al.* (2022) conducted an analysis on the impact of economic growth, institutional quality and ICT on carbon dioxide (CO_2) emissions in the emerging industrialized countries known as the E7 group, for the period spanning from 1995 to 2016. The researchers discovered that economic globalization and the consumption of renewable energy are associated with a decrease in CO_2 emissions. Conversely, the use of ICT, the quality of institutions and the consumption of fossil fuels contribute to environmental degradation. In general, existing literature indicates that the level of formal institutional quality plays a significant role in the adoption and utilization of ICT. Countries that possess superior institutional quality are more prone to possess superior ICT infrastructure and are more likely to derive greater advantages from the implementation of ICT. Conversely, countries with inferior institutional quality may not witness comparable levels of ICT advancement. ICT has the potential to exert significant effects on the quality and performance of institutions, thereby directly affecting the rate of economic growth.

Few studies have explored the impact of institutional factors on the relationship between ICT and economic growth (*e.g.*, Jin and Cho, 2015; Wamboye *et al.*, 2015). The present study examines the influence of all World Bank's WGI on economic growth. The effect of institutional quality in the MENA countries cannot be accurately assessed by only considering one or two institutional indicators. To accurately determine the impact on economic growth, it is necessary to take into account all relevant institutional indicators together. This is particularly relevant in the MENA region, which suffers from poor institutional quality across all aspects. Therefore, our second hypothesis proposes as follows:

> ***H*$_2$**: *Higher institutional quality enhances the effectiveness of ICT usage and investment*, *which in turn increases the economic growth in the MENA region*, *ceteris paribus.*

Nevertheless, a crucial inquiry emerges regarding the manner in which various dimensions of institutional quality, represented by World Governance Indicators (WGIs) such as control of corruption (*CC*), government effectiveness (*GE*), rule of law (*RL*), regulatory quality (*RQ*), political stability and absence of violence (*PV*) and voice and accountability (*VA*), influence the association between ICT and economic growth. We present the following discussion.

Control of corruption

Corruption has a detrimental impact on economic growth as it distorts market mechanisms, leads to inefficient allocation of resources and hinders investment (Gyimah-Brempong, 2002). Implementation of more effective measures to combat corruption leads to a decrease in rent-seeking activities, instances of bribery and embezzlement, thereby fostering an equitable business environment (Abed and Gupta, 2002). In the realm of ICT, mitigation of corruption serves to foster equitable competition, enhance transparency and establish accountability within the sector (Ndou, 2004). The aforementioned factors serve to bolster confidence within the digital ecosystem, foster engagement from private sector entities, attract foreign direct investment and stimulate entrepreneurial endeavours. Consequently, this phenomenon results in heightened adoption of ICT, fostering innovation and productivity, thereby propelling economic growth (Yunis *et al*., 2018).

Government effectiveness

Government effectiveness is a measure of the government's ability to effectively execute policies, deliver public services and create a favourable environment for economic endeavours (Andrews, 2010). When government agencies demonstrate effectiveness, they are capable of efficiently distributing resources, making investments in infrastructure and implementing laws that facilitate adoption and utilization of ICT (Adam and Alhassan, 2021). Consequently, this phenomenon serves as a catalyst for increased investment in the ICT sector, thereby enabling its substantial contribution to overall economic growth.

Rule of law

The principle of the rule of law establishes a consistent and secure legal structure that safeguards property rights, enforces contractual obligations and assures fundamental rights for people and enterprises (Jamaani and Ahmed, 2021). Robust adherence to the rule of law fosters a sense of assurance and reliance among investors, thereby incentivizing their engagement in the allocation of resources towards ICT infrastructure and its associated sectors (Sassi and Ali, 2017). Thus, the presence of a comprehensive and strong legal framework plays a crucial role in fostering the advancement of electronic commerce, internet transactions and digital platforms, thereby potentially stimulating economic growth.

Regulatory quality

Regulatory quality pertains to the degree of clarity, productiveness and effectiveness exhibited by regulations and their enforcement mechanisms (Sinatoko Djibo *et al*., 2023). Enhancement of regulatory quality leads to a reduction in bureaucratic burdens, hazards associated with

corruption and uncertainties in the regulatory environment (Daude and Stein, 2007). This facilitates a favourable environment for investment in ICT, as it enables businesses to operate with reduced obstacles and decreased costs associated with complying with regulations (Adams and Akobeng, 2021). Improved regulatory quality plays a crucial role in promoting the adoption of ICT, fostering innovation and enabling businesses to effectively utilize digital technologies to enhance productivity, thereby making a significant contribution to overall economic growth (Ozekhome, 2022).

Political stability and absence of violence

The presence of political stability and the absence of violence are essential factors that contribute to a country's long-term economic growth (Feng, 1997). Countries characterized by stable political environments tend to entice a greater influx of investment, particularly within the ICT sector (Adams and Akobeng, 2021). Political stability is a crucial factor that ensures continuation of governance and mitigates potential risks arising from political turmoil, changes in leadership or internal conflicts (Lake and Rothchild, 1996). The presence of a tranquil setting fosters adoption of, investment in and entrepreneurial activities related to ICT, thereby resulting in elevated rates of economic growth (Duruji *et al*., 2015).

Voice and accountability

Voice and accountability pertain to the capacity of individuals to exert influence over public policies, ensure governmental responsibility and engage in decision-making processes (Siddiqi *et al*., 2009). When the general populace are granted the opportunity to express their opinions and when effective systems of oversight are in place, governments tend to exhibit greater levels of responsiveness to demands of the public, demonstrate transparency and display reduced susceptibility to engaging in corrupt practices (Waheduzzaman and Khandaker, 2022). This promotes a setting that is favourable for ICT adoption, investment and development (Arredondo-Trapero *et al*., 2019). Moreover, the presence of ICT tools has the potential to augment engagement of individuals in society, streamline acquisition of knowledge and foster openness and responsibility, thereby bolstering economic advancement (Arredondo-Trapero *et al*., 2019).

In brief, establishment of improved corruption control, government effectiveness, rule of law, regulatory quality, political stability, absence of violence and continuity and voice and accountability jointly foster an environment that is conducive to a correlation between the use of ICT, investment in ICT and economic growth. When these elements happen to exist, they effectively mitigate significant obstacles and facilitate economic growth via the following channels.

Investment and entrepreneurship

Enhanced management of corruption, efficacy of government and quality of regulations contribute to mitigation of uncertainties, corruption vulnerabilities and administrative obstacles that impede investment and entrepreneurial activities in the field of ICT (Luu, 2023). This phenomenon serves as a catalyst for both domestic and international investors to allocate their resources towards the ICT sector, resulting in a surge of capital inflows, generation of employment opportunities and fostering economic expansion (Acaravci *et al*., 2023)**.**

Technological innovation and diffusion

The presence of the rule of law, regulatory quality and political stability creates a conducive and reliable atmosphere for advancement and widespread adoption of technology (Korres and Polychronopoulos, 2011). The presence of well-defined and enforceable legal frameworks plays a crucial role in safeguarding intellectual property rights, thereby creating a favourable environment that encourages businesses to allocate resources towards research and development endeavours. This facilitates the development of novel technologies in ICT services, goods and solutions, which may then be embraced and incorporated by enterprises spanning various industries (Rahman *et al*., 2019). The advances in technology that ensue contribute to enhancement of efficiency, effectiveness and competition, which drives economic growth.

Market development and access

Development of robust ICT markets is influenced by factors such as political stability, absence of violence and presence of voice and accountability (Fajgenbaum and Loser) . ICT infrastructure investments and development of communications networks, internet access and digital platforms are facilitated by stable political environments (Gurstein, 2003). This facilitates expansion of market access for businesses, with a special emphasis on small and medium-sized enterprises (SMEs), thereby allowing them to extend their presence to broader customer segments, explore untapped markets and participate in electronic commerce activities (Tarutė and Gatautis, 2014). Utilization of ICT platforms for market expansion results in heightened levels of trade, improvements in productiveness and overall economic growth.

Digital inclusion and human capital development

Promotion of digital inclusion and growth of human capital are significantly influenced by the presence of voice and accountability (Yilmaz and Koyuncu, 2019). When individuals are afforded the opportunity to engage in ICT-related decision-making processes and exercise their agency, governmental entities are more inclined to allocate resources and attention towards policies that aim to reduce the digital divide, enhance digital literacy and ensure equitable

access to ICT resources (Rashid, 2016; Arredondo-Trapero *et al*., 2019). This phenomenon results in a workforce that possesses higher levels of skill and connectivity, thereby augmenting effectiveness, employment prospects and overall economic expansion.

Efficient governance and public service delivery

Enhanced management of corruption increased governmental efficacy and enhanced citizen participation and transparency together contribute to effective governance and enhanced provision of public services through utilization of ICT mechanisms (Waheduzzaman and Khandaker, 2022). Electronic platforms and initiatives related to e-government have the capacity to augment transparency, mitigate bureaucratic inconsistencies and facilitate provision of citizen-centric services (Zhang and Kimathi, 2022). The aforementioned factors contribute to cultivation of public confidence, optimization of public governance and streamlining of the execution of ICT policies and initiatives, ultimately leading to economic advancement (Alhassan and Adam, 2021).

In summary, the multifaceted nature of the relationship between ICT and economic growth is influenced by various factors such as improved control of corruption, government effectiveness, rule of law, regulatory quality, political stability, absence of violence, voice and accountability. All of these variables contribute to the creation of a conducive environment that facilitates ICT adoption, investment, innovation, market development, digital inclusion and efficient governance of ICT. Through identification and resolution of obstacles and creation of favourable circumstances, individuals and organizations are able to unleash the full capabilities of ICT in order to enhance productivity, promote competitiveness and facilitate long-term, environmentally responsible economic development. Drawing from the preceding discourse, a set of sub-hypotheses has been formulated as follows:

***H*$_3$**: *Higher control of corruption enhances the effectiveness of ICT usage and investment*, *which in turn increases the economic growth in the MENA region*, *ceteris paribus.*

***H*$_4$**: *Higher government effectiveness enhances the effectiveness of ICT usage and investment*, *which in turn increases the economic growth in the MENA region*, *ceteris paribus.*

***H*$_5$**: *Higher rule of law enhances the effectiveness of ICT usage and investment*, *which in turn increases the economic growth in the MENA region*, *ceteris paribus.*

***H*$_6$**: *Higher regulatory quality enhances the effectiveness of ICT usage and investment*, *which in turn increases the economic growth in the MENA region*, *ceteris paribus.*

***H*$_7$**: *Higher political stability and absence of violence enhance the effectiveness of ICT usage and investment*, *which in turn increases the economic growth in the MENA region, ceteris paribus.*

***H*$_8$**: *Higher voice and accountability enhance the effectiveness of ICT usage and investment*, *which in turn increases the economic growth in the MENA region*, *ceteris paribus.*

3. Data and Estimation Method

3.1 Data

This paper analyses a panel data sample featuring 16 MENA countries from 1995 to 2018. The countries included in the study are Algeria, Bahrain, Egypt, Iran, Israel, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Tunisia, Turkey and the United Arab Emirates.[2] The study measures economic growth using the dependent variable of real GDP growth (*RGDPG*). Three proxies are used to assess the ICT usage variables: the percentage of the population using the internet (*USAGE*), the proportion of households with home internet access (*ACCESS*) and the number of mobile cellular subscriptions per 100 people (*MOB*). Additionally, capital investment in telecommunications (*INV*), which encompasses the expenditures on telecommunications equipment such as internet cables, hardware, cellular networks, computer software and initial installations, is used to measure ICT investment.[3]

The six indicators for institutions that make up the moderator variables are *CC*, *GE*, *RL*, *RQ*, *PV* a *VA*. To complement these, we also consider the average of the institutional quality indicators (*INS*). The data for these indicators are sourced from the World Bank's WGI, which gathers information from 32 different sources, such as research institutes, non-governmental organizations and private sector companies. The scores for these indicators range from approximately −2.5 to 2.5, with −2.5 representing the worst institutional quality and 2.5 signifying the best institutional quality. These indicators have been widely utilized in research exploring the relationship between institutions and economic growth, as seen in studies by, *e.g.*, Alfoul (2022), Gholipour and Farzanegan (2018) or Islam and McGillivray (2020).

The control variables in the present study include labour force as a percentage of the population (*LF*) as a measure of labour (*L*) and gross fixed capital formation as a percentage of GDP (*GFCF*) as a measure of capital (*K*). Furthermore, trade openness captures the total value of exports and imports as a percentage of GDP (*TRADE*). The Arab Spring (*DSPRING*) is also considered as it may have affected economic growth in the MENA countries during the study period. A dummy variable for the Arab Spring is created, taking a value of 1 for the years 2011 and beyond and 0 for the years prior to 2011. The data sources and definitions of these variables can be found in Table A.1 in the Appendix.

2 The list of countries is according to the World Bank's (2019) categorisation. Please see World Bank (2020).

3 In our study the term "ICT usage" refers to the actual application and incorporation of information and communications technology into various economic activities, while "ICT investment" refers to the allocation of resources towards acquiring and implementing such technology.

3.2 Estimation method

This study utilizes the panel ARDL approach, which is estimated as follows:

$$\begin{aligned}\Delta RGDPG_{i,t} = {} & p_i(RGDPG_{i,t-j} - \theta_{i,1}\ln ICT_{i,t-1} - \theta_{i,2}\, INS_{i,t-1} - \theta_{i,3}\left(\ln ICT_{i,t-1} \times INS_{i,t-1}\right) \\ & - \theta_{i,4}\ln GFCF_{i,t-1} - \theta_{i,5}\ln LF_{i,t-1} - \theta_{i,6}\ln TRADE_{i,t-1} - \theta_{i,7}\, DSPRING_{i,t-1} \\ & + \sum_{j=1}^{p-1}\sigma^*_{i,j}\Delta RGDPG_{i,t-j} + \sum_{j=0}^{q-1}\gamma^*_{i,j}\Delta\ln ICT_{i,t-j} \\ & + \sum_{j=0}^{q-1}\lambda^*_{i,j}\,\Delta INS_{i,t-j} + \sum_{j=0}^{q-1}\mu^*_{i,j}\,\Delta\left(\ln ICT_{i,t-j} \times INS_{i,t-j}\right)_{i,t-j} + \sum_{j=0}^{q-1}\beta^*_{i,j}\Delta\ln GFCF_{i,t-j} \\ & + \sum_{j=0}^{q-1}\alpha^*_{i,j}\,\Delta\ln LF_{i,t-j} + \sum_{j=0}^{q-1}\varphi^*_{i,j}\,\Delta\ln TRADE_{i,t-j} + \sum_{j=0}^{q-1}\psi^*_{i,j}\,\Delta DSPRING_{i,t-j} \\ & + u_{it} \end{aligned} \tag{1}$$

where $i = 1$ to 16 and $t = 1995$ to 2018. The real GDP growth is represented by the dependent variable $RGDPG_{i,t}$, the set of variables of interest by $ICT_{i,t}$, the set of institutional quality indicators by $INS_{i,t}$, and the control variables by $GFCF_{i,t}$, $LF_{i,t}$ and $TRADE_{i,t}$. The effect of the Arab Spring is considered in the model by the dummy variable $DSPRING_{i,t}$. The long-run coefficients are represented by θ_s. The descriptive statistics and correlation matrix can be found in Table A.2 in the Appendix. Due to the significant correlation among these variables, it is important to mention that the institutional indicators and ICT variables are added to the regression one by one (Busse and Hefeker, 2007).

4. Empirical Results

As for the ARDL estimation, the first step is to apply the panel unit root test to assess the stationarity of the variables. Given that our dataset is an unbalanced panel, with some missing observations on the ICT variables, the Im–Pesaran–Shin (IPS) unit root test of Im *et al.* (2003) is utilized. Next, panel cointegration tests are conducted to investigate the long-term equilibrium relationships among the variables.

The data in Table A.3 in the Appendix indicate that the series being studied exhibits mixed orders of stationarity. As this is one of the necessary criteria for applying a cointegration test, the next step is to determine whether there is a long-term relationship between the variables. The results of the panel cointegration test indicate that there is, in fact, a long-term equilibrium relationship between the dependent variable (economic growth) and the explanatory variables. These results strongly support the existence of a long-term relationship between economic growth and the explanatory variables. [4]

4 For the purpose of conserving space, the tables have been excluded from the primary text of this study. The cointegration results tables are available upon request.

The long-term relationships between the variables are estimated using the panel ARDL method, as proposed by Pesaran *et al.* (1999). Four different variants of a long-run equation are estimated, where the growth rate of real GDP is explained by the variables *USAGE*, *ACCESS*, *MOB*, *INV* and control variables.

The results of the panel ARDL estimator for each of the ICT variables, *USAGE*, *ACCESS*, *MOB* and *INV*, can be found in Tables 1, 2, 3 and 4, respectively. The tables provide the estimates for the coefficients of the long-run and error correction terms (ECT). The coefficients of the ECT in all four specifications are negative, which indicates that the variables demonstrate a tendency towards long-run equilibrium.

The study results indicate that the proxy variables for ICT usage have a statistically significant and positive effect on economic growth in MENA countries. This can be seen in columns 1–7 of Tables 1, 2 and 3. For instance, the magnitude of the effect ranges from 0.569 for *USAGE*, to 0.091 for *ACCESS* and 0.035 for *MOB*. It is noteworthy that the coefficients of *USAGE* have a greater impact on economic growth in most of the models. This means that the role of internet users is more prominent in the MENA region compared to the role of internet access and mobile phones, as reported by Mim and Jeguirim (2021) and Sassi and Goaied (2013). These authors have also noted a larger impact of *USAGE* compared to *ACCESS* and *MOB* in MENA countries. The results of the present study further highlight the importance of internet users in the ICT sector in the MENA region.

The positive impact of ICT usage on economic growth lends empirical support to the predictions of various economic growth theories. These theories posit that technology is the key factor of long-term economic growth, as seen in the models developed by Solow (1956) and Romer (1986, 1990). These theories propose that the improvement in productivity resulting from investment in ICT will, directly and indirectly, drive an increase in capital investment, thereby leading to growth in GDP (Thompson Jr. and Garbacz, 2007). Similarly, Vu (2011) found a statistically significant relationship between ICT and economic growth and that using personal computers, mobile-cellular telecommunications and the internet positively affects economic growth.

Conversely, the results suggest that ICT investment does not have a significant and direct impact on economic growth in the MENA region, which means that the MENA region does not benefit from ICT investment, as seen in most of the estimations in Table 4. This finding aligns with the conclusions of previous studies, such as those by Dedrick *et al.* (2013) and Niebel (2018), which showed that developing and emerging countries do not benefit as much from ICT investment as developed countries. This lack of significant impact on economic growth suggests that MENA countries, like many other developing countries, are not reaping the benefits of ICT investment in terms of increased productivity and GDP growth. Furthermore, the insignificant findings

of *INV* indicate that the MENA region is not achieving the "leapfrogging effect" as suggested by Steinmueller (2001), where developing countries can skip certain steps and achieve higher economic growth rates through effective ICT investment.

The significant impact of ICT on economic growth supports, to some extent, the first hypothesis of this study. We show that ICT usage, but not ICT investment, directly improves and accelerates economic growth in MENA countries.

The findings regarding the effect of institutional indicators on economic growth in the MENA countries are mixed. While some indicators, such as *GE* and *RL*, have a positive and significant effect on *RGDPG* in almost all models (as seen in columns 3 and 4 of Tables 1, 2 and 3), others exhibit negative or insignificant results. These inconsistent results support the notion that institutional indicators cannot solely explain economic growth in isolation. These results are in line with those obtained by Glaeser *et al.* (2004) and Méon and Sekkat (2008), who found that the relationship between institutional quality and economic growth is either insignificant or negative in developing countries. This is also in line with the findings of Hausmann *et al.* (2008), who concluded that improving institutional quality in isolation may not necessarily result in economic growth, as demonstrated in their growth diagnostics of Brazil and the Dominican Republic.

Our findings highlight the important role of institutional indicators in economic growth in the MENA region. The positive and significant relationships between economic growth and the institutional indicators of *GE* and *RL* indicate that these indicators can drive economic growth in the MENA region. This supports the findings of the World Bank (2019) report[5], which implied that MENA region must reform its judicial systems and legal structures to promote the rule of law and transparency in order to improve economic growth. The World Bank report also highlighted the importance of government effectiveness in implementing policies that can attract new investors to the region. By improving institutional quality, the region can provide a secure and predictable environment for investment, leading to increased economic growth.

Regarding the moderating impact of institutional quality indicators on the association among ICT usage and economic growth, our findings show that the interaction terms between *CC* and the ICT usage variables have a positive impact on economic growth. This means that countries with low levels of corruption experience stronger economic growth, better infrastructure and better internet usage (Lio *et al.*, 2011). This is because such countries can better take advantage of technology adoption and thus experience growth in their information infrastructure and usage (Oruame, 2008). Our findings also show that there is a positive and significant interaction impact between the ICT usage variables and *PV* on economic growth, which aligns with the findings

5 Vice President for the Middle East and North Africa Region at the World Bank Group. Please see Belhaj (2019).

of Sadowsky (1993) that political stability is crucial for attracting foreign direct investment in data network infrastructure. However, greater political instability increases the risk of investment, especially in the ICT sector and this imbalance in the infrastructure can reduce the effectiveness of ICT usage and access (Meso *et al.*, 2006).

Table 1: ARDL estimation of internet usage and economic growth

	Dependent variable: *RGDPG*						
Explanatory variables	***GOV*** **(1)**	***CC*** **(2)**	***GE*** **(3)**	***RL*** **(4)**	***RQ*** **(5)**	***PV*** **(6)**	***VA*** **(7)**
$\ln USAGE_{i,t}$	0.196** (2.341)	0.569*** (6.589)	0.185*** (2.630)	0.022 (0.317)	0.283*** (4.050)	0.172** (2.337)	0.059 (0.627)
$GOV_{i,t}$	0.417** (0.546)	0.196 (0.334)	2.395*** (3.829)	1.449*** (4.693)	0.879 (1.355)	−0.330 (−1.077)	1.694*** (3.404)
$\ln USAGE_{i,t} \times GOV_{i,t}$	0.218*** (2.974)	0.277** (2.048)	0.289* (1.734)	0.126 (1.543)	0.153** (1.949)	0.128** (2.307)	0.239* (1.795)
$\ln LF_{i,t}$	5.410*** (3.020)	14.937*** (7.960)	0.649 (1.177)	1.015*** (2.921)	6.354*** (4.365)	5.057*** (2.618)	0.223 (0.419)
$\ln GFCF_{i,t}$	0.453 (0.813)	7.003*** (23.043)	0.397 (0.576)	0.824* (1.761)	−0.178 (−0.323)	0.316 (0.465)	1.869*** (3.171)
$\ln TRADE_{i,t}$	−0.572 (−0.847)	2.879*** (8.069)	0.039 (0.080)	0.554* (1.711)	−0.877 (−1.295)	−0.685 (−0.936)	0.747* (1.735)
$DSPRING_{i,t}$	−1.844*** (−10.739)	−0.182 (−1.376)	−1.538*** (−6.499)	−1.045*** (−6.499)	−1.821*** (−11.529)	−1.908*** (−9.814)	−1.082*** (−3.950)
Error correction term (ECT)	−0.9294*** (−6.7584)	−0.8471*** (−4.5680)	−0.7590*** (−8.0932)	−0.8257*** (−4.6502)	−1.005*** (−6.5208)	−0.9274*** (−6.9855)	−0.7512*** (−8.8754)
Observations	349	347	363	335	349	349	363
Number of lags (ARDL)	(2, 1, 1, 1, 1, 1, 1)	(1, 2, 2, 2, 2, 2, 2)	(1, 1, 1, 1, 1, 1, 1)	(3, 1, 1, 1, 1, 1, 1)	(2, 1, 1, 1, 1, 1, 1)	(2, 1, 1, 1, 1, 1, 1)	(1, 1, 1, 1, 1, 1, 1)

Notes: ln*USAGE* is the natural logarithm of individuals using the internet, and INS is the average of the six institutional indicators . *CC* is the control of corruption, *GE* is government effectiveness, *RL* is the rule of law, *RQ* is the regulatory quality, *PV* is political stability and absence of violence, *VA* is voice and accountability, ln*LF* is the natural logarithm of labour force, ln*GFCF* is the natural logarithm of gross fixed capital formation and ln*TRADE* is the natural logarithm of trade openness.The lag selection criterion in this model is Akaike's information criterion (AIC). The test values are significant at * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; *t*-statistics are reported in parentheses.

Source: Authors' own calculation

Table 2: ARDL estimation of internet access at home (*ACCESS*) and economic growth

	Dependent variable: *RGDPG*						
Explanatory variables	***GOV*** **(1)**	***CC*** **(2)**	***GE*** **(3)**	***RL*** **(4)**	***RQ*** **(5)**	***PV*** **(6)**	***VA*** **(7)**
$\ln ACCESS_{i,t}$	0.272** (2.461)	0.091* (1.873)	0.031** (1.077)	−0.151 (−1.606)	0.237*** (4.257)	0.454*** (4.437)	0.603 (5.219)
$GOV_{i,t}$	−0.100 (−0.238)	3.731*** (7.117)	2.039*** (2.993)	1.416** (2.398)	2.646 (3.791)	−0.318 (−0.642)	4.417*** (5.671)
$\ln USAGE_{i,t} \times GOV_{i,t}$	0.405*** (4.229)	0.564*** (4.114)	0.839*** (4.554)	0.358** (2.1208)	0.427*** (5.017)	−0.134 (−1.297)	1.489*** (6.300)
$\ln LF_{i,t}$	6.102*** (6.988)	0.379 (0.961)	0.291 (1.164)	−0.721 (−0.987)	3.383** (2.304)	−4.429 (−1.531)	−2.007 (−1.345)
$\ln GFCF_{i,t}$	0.943** (2.441)	−0.682 (−1.125)	1.527*** (3.482)	0.552 (0.736)	1.162** (2.042)	0.624 (0.680)	3.626*** (6.822)
$\ln TRADE_{i,t}$	−0.074 (−0.160)	1.073** (2.173)	1.813*** (4.313)	1.168** (2.034)	0.198 (0.320)	2.784*** (2.853)	1.317** (2.207)
$DSPRING_{i,t}$	−1.505*** (−11.476)	−1.346*** (−9.146)	−1.377*** (−20.434)	−0.630** (−2.057)	−1.335*** (−9.663)	−0.940*** (−4.022)	−0.989*** (−5.677)
Error correction term (ECT)	−1.1769*** (−5.3598)	−0.9207*** (−6.5901)	−0.7948*** (−7.2642)	−0.7663*** (−5.5157)	−1.0767*** (−6.6564)	−0.8332*** (−11.7916)	−0.9271*** (−5.7569)
Observations	320	347	320	360	347	360	347
Number of lags (ARDL)	(4, 1, 1, 1, 1, 1, 1)	(2, 1, 1, 1, 1, 1, 1)	(4, 1, 1, 1, 1, 1, 1)	(1, 1, 1, 1, 1, 1, 1)	(2, 1, 1, 1, 1, 1, 1)	(1, 1, 1, 1, 1, 1, 1)	(2, 1, 1, 1, 1, 1, 1)

Notes: ln*ACCESS* is the natural logarithm of the proportion of households with internet access at home. The lag selection criterion in this model is Akaike's information criterion (AIC). The test values are significant at * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; *t*-statistics are reported in parentheses.

Source: Authors' own calculation

Table 3: ARDL estimation of mobile cellular subscriptions (*MOB*) and economic growth

	Dependent variable: *RGDPG*						
Explanatory variables	***GOV*** **(1)**	***CC*** **(2)**	***GE*** **(3)**	***RL*** **(4)**	***RQ*** **(5)**	***PV*** **(6)**	***VA*** **(7)**
$lnMOB_{i,t}$	0.098* (0.998)	0.035* (0.341)	0.195** (1.905)	0.135 (1.771)	0.313*** (3.953)	0.059* (0.599)	−0.101 (−1.056)
$GOV_{i,t}$	−0.892 (−1.158)	5.263*** (5.103)	−0.268 (−0.267)	−1.079 (−0.952)	−0.442 (−0.681)	1.067 (1.922)	−0.621 (−1.110)
$\ln MOB_{i,t} \times GOV_{i,t}$	0.253*** (2.694)	1.265*** (4.579)	−0.031 (−0.214)	0.470* (1.909)	0.336*** (4.146)	0.231* (1.879)	0.001 (0.006)
$\ln LF_{i,t}$	−1.945 (−0.876)	−2.107 (−0.775)	−1.977 (−0.671)	1.371*** (4.464)	−2.334 (−1.526)	−0.870 (−1.610)	0.585 (1.129)
$\ln GFCF_{i,t}$	2.250*** (3.015)	−0.117 (−0.117)	−1.610 (−1.548)	2.442*** (5.993)	1.701*** (2.898)	1.754*** (3.666)	0.920* (1.660)
$\ln TRADE_{i,t}$	−0.973 (−1.316)	1.268 (1.119)	−0.171 (−0.166)	0.587*** (2.878)	1.790*** (2.883)	0.653* (1.703)	−0.065 (−0.163)
$DSPRING_{i,t}$	−1.569*** (−9.056)	−1.743*** (−6.752)	−1.977*** (−8.926)	−1.558*** (−7.638)	−1.618*** (−12.073)	−1.764*** (−10.123)	−1.824*** (−7.648)
Error correction term (ECT)	−0.9694*** (−6.7261)	−0.7710*** (−8.8293)	−0.8402*** (−9.8326)	−0.8589*** (−4.8393)	−1.0286*** (−6.3808)	−0.8328*** (−5.9168)	−0.7839*** (−10.0003)
Observations	351	366	366	350	351	351	366
Number of lags (ARDL)	(2, 1, 1, 1, 1, 1, 1)	(1, 1, 1, 1, 1, 1, 1)	(1, 1, 1, 1, 1, 1, 1)	(2, 2, 2, 2, 2, 2, 2)	(2, 1, 1, 1, 1, 1, 1)	(2, 1, 1, 1, 1, 1, 1)	(1, 1, 1, 1, 1, 1, 1)

Notes: ln*MOB* is the natural logarithm of mobile cellular subscriptions. The lag selection criterion in this model is Akaike's information criterion (AIC). The test values are significant at * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *t*-statistics are reported in parentheses.

Source: Authors' own calculation

Table 4: ARDL estimation of capital investment in telecommunications (*INV*) and economic growth

	Dependent variable: *RGDPG*						
Explanatory variables	***GOV*** **(1)**	***CC*** **(2)**	***GE*** **(3)**	***RL*** **(4)**	***RQ*** **(5)**	***PV*** **(6)**	***VA*** **(7)**
$\ln INV_{i,t}$	0.305 (1.161)	0.153* (0.519)	−0.178 (−0.827)	0.036 (0.165)	−0.069 (−0.341)	0.649** (2.401)	0.117* (0.3023)
$GOV_{i,t}$	−0.644 (−1.438)	−0.328 (−0.496)	2.617 (2.510)	0.116 (0.275)	−0.507 (−1.610)	−0.354 (−1.325)	0.549 (1.441)
$\ln USAGE_{i,t} \times GOV_{i,t}$	0.040 (0.137)	0.503* (1.720)	0.587 (3.471)	−0.201 (−0.668)	0.289 (1.740)	0.399* (1.847)	0.661** (2.338)
$\ln LF_{i,t}$	0.577 (1.213)	−4.034 (−1.282)	5.401 (2.023)	−0.758 (−1.290)	0.802 (2.084)	−0.109 (−0.240)	7.215** (2.128)
$\ln GFCF_{i,t}$	0.084 (0.158)	2.230** (2.325)	8.040 (10.594)	1.191** (2.014)	0.147 (0.400)	0.714 (1.539)	0.986 (0.984)
$\ln TRADE_{i,t}$	0.510 (1.275)	3.923*** (3.547)	1.607 (1.799)	0.883** (2.427)	0.245 (0.699)	0.675** (2.096)	6.054*** (5.338)
$DSPRING_{i,t}$	−1.513*** (−5.884)	0.104 (0.256)	1.351 (3.049)	−1.714*** (−7.001)	−1.017 (−4.343)	−1.632*** (−6.998)	−0.867** (−1.982)
Error correction term (ECT)	−0.7320*** (−9.6709)	−0.884*** (−11.7134)	−0.8210*** (−5.9613)	−0.7721*** (−9.0637)	−0.8430*** (−7.1917)	−0.7670*** (−9.9459)	−0.8636*** (−10.1323)
Observations	366	366	350	366	350	366	366
Number of lags (ARDL)	(1, 1, 1, 1, 1, 1, 1)	(1, 1, 1, 1, 1, 1, 1)	(1, 2, 2, 2, 2, 2, 2)	(1, 1, 1, 1, 1, 1, 1)	(1, 2, 2, 2, 2, 2, 2)	(1, 1, 1, 1, 1, 1, 1)	(1, 1, 1, 1, 1, 1, 1)

Notes: *lnINV* is the natural logarithm of capital investment in telecommunications. The lag selection criterion in this model is Akaike's information criterion (AIC). The test values are significant at * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *t*-statistics are reported in parentheses.

Source: Authors' own calculation

Looking at the interaction terms among the institutional indicators and ICT investment, it can be observed that some of the sub-components of institutional quality, such as *CC*, *PV* and *VA*, play an important role in turning ICT investment into productive outputs. This suggests that countries with better control of corruption, political stability and voice and accountability can benefit more from ICT investment to boost economic growth.

Our findings imply a strong link between the institutional quality indicators and the effect of ICT usage and investment on economic growth in the MENA countries. Better control of cor-

ruption, political stability and voice and accountability in a country can have a significant positive effect on the effectiveness of ICT investment for economic growth. This supports the idea that countries can maximize the benefits of ICT investment to drive economic growth by improving institutional indicators. Our findings suggest that investors tend to prefer countries with better control of corruption, making it an important factor in attracting foreign investment and boosting economic growth. Overall, our results support the hypothesis that the association among ICT usage, investment and economic growth in MENA countries relies on the institutional quality indicators.

Regarding the control variables, as shown in columns 1–7 of Tables 1, 2, 3 and 4, for *LF*, a statistically significant and positive association with *RGDPG* is found across most models. This means that a higher labour force participation rate increases economic growth. Our results also indicate that increases in capital accumulation lead to economic growth, as the coefficient for *GFCF* is found to be positive and significant in most of the estimations. Our findings also show that the coefficient for *TRADE* has a statistically significant and positive association with *RGDPG* in almost all the estimated models. This implies that trade openness permits exchanging technologies among the countries, which leads to improved domestic production, which will improve economic growth. Finally, the coefficient of the dummy variable for the *DSPRING* is statistically significant and negative in almost all estimations, implying that the Arab Spring adversely affected economic growth in these countries. These findings are consistent with those of Freund and Jaud (2014), who illustrated that MENA countries have experienced lower economic growth since the start of the Arab Spring.

To better quantify the effects of ICT usage and investment on economic growth at various levels of institutional quality, we calculate the marginal effect of these variables using the partial derivative shown in Equation (2).

$$\frac{\partial RGDPG}{\partial lnICT} = \theta_1 + \theta_3 \times INS \tag{2}$$

We choose two different levels of institutions (institutions at level 1 and institutions at level 2). Tables A.5 and A.6 in the Appendix present the results. The interaction terms among the ICT variables and institutional quality (*INS*) are positive and statistically significant in most of the estimations, indicating that the marginal impact of ICT on economic growth depends on the level of institutional quality. For instance, Model 1.1, at the institutional level of 1, shows that a one-percent increase in *USAGE* leads to an increase in the real GDP growth by 0.414 percentage points, *ceteris paribus*. At the institutional level of 2 for the same model, a one-percent increase in *USAGE* leads to a rise in the real GDP growth of 0.632 percentage points, *ceteris paribus*. Model 4.1 shows that the interaction term between *INV* and *INS* does not affect economic growth.

However, some of the remaining interaction terms between *INV* and institutional indicators have a positive impact on economic growth.

Finally, our study findings imply that institutional quality, specifically control of corruption, regulatory quality, political stability and absence of violence and voice and accountability, does have a significant impact on the effectiveness of ICT usage and investment for economic growth in the MENA region. In other words, favourable institutional indicators are essential to reap the economic benefits of ICT usage and investment in the region. In other words, our results underline the importance of institutions in various economic activities and emphasize their role as a critical component of a country's macroeconomic competitiveness. Hence, our findings lend support to the national competitive advantage theory, which states that a country's institutional quality influences the relationship between technology and economic growth. In conclusion, a favourable institutional environment is necessary to achieve maximum economic benefits from ICT usage and investment. Thus, improving institutional quality should be a top priority for policymakers in the MENA region.[6]

5. Conclusion

Policymakers in the Middle East and North Africa face the challenge of sluggish economic growth. This problem can be attributed to the region's inadequate institutional quality and slow implementation of cutting-edge technologies. This study delved into the impact of ICT usage and investment and their interaction with institutional quality indicators on the economic growth of MENA countries. We used panel data for 16 MENA countries for the period 1995–2018. By applying the panel ARDL model, the results emphasize the importance of providing a supportive environment for ICT usage and investment by improving institutional quality. A favourable investment climate can help increase the inflow of foreign direct investment and the uptake of innovative technologies, which in turn can contribute to economic growth. This study has important policy implications, as it provides a roadmap for policymakers in the region to address the issue of slow economic growth. Focusing on improving institutional quality can make ICT usage and investment more effective in boosting economic growth. The findings of this study also suggest that policymakers should work towards reducing corruption, improving regulatory quality, political stability and accountability and increasing citizens' voice in policymaking. In summary, good institutions can help harness the potential of ICT usage and investment to drive economic growth in the MENA region.

6 Robustness analyses and results confirm the validity of the main findings. The results can be presented upon request.

Acknowledgement

Funding: There was no funding, either externally or internally, towards this study.

Conflicts of interest: The authors hereby declare that this article was not submitted or published elsewhere.

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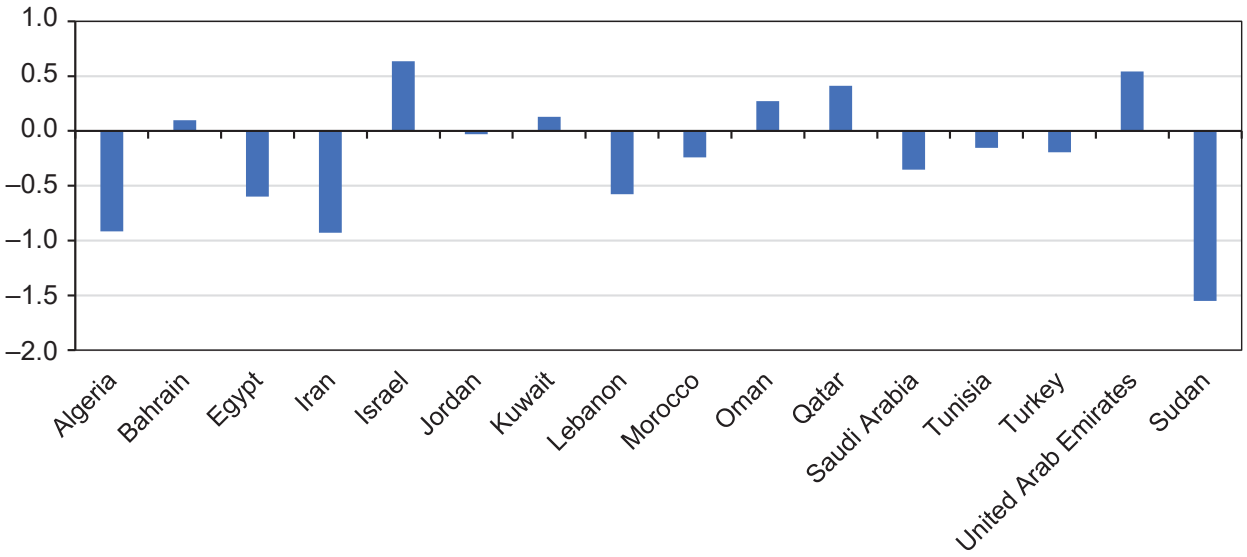
Appendix

Figure A.5: Institutional quality in MENA countries



Note: This figure represents the average score of six institutional indicators from 1995 to 2018. The scores range from –2.5, representing the worst, to 2.5, representing the best.

Source: WGI (2019).

Table A.1: List of variables and data sources

Variable	Description	Source
RGDPG	"Real GDP growth is the annual percentage growth rate of GDP at market prices based on constant local currency, aggregates are based on constant 2010 U.S. dollars."	World Bank (2020)
ACCESS	"*ACCESS* captures the proportion of households with the internet. Access is not assumed to be only via a computer – it may also encompass mobile phones, game machines, digital TV, *etc*., as a percentage of the population."	ITU (2020)
USAGE	"*USAGE* captures the individuals who have used the internet (from any location) in the last 3 months. The internet can be used via a computer, mobile phone, personal digital assistant, game machines, digital TV, *etc*., as a percentage of the population."	ITU (2020)
MOB	"*MOB* captures the subscriptions to a public mobile telephone service that provides access to the PSTN using cellular technology. The indicator includes the number of post-paid subscriptions and the number of active prepaid accounts. The indicator applies to all mobile cellular subscriptions that offer voice communications. It excludes subscriptions via data cards or USB modems, subscriptions to public mobile data services (per 100 people)."	World Bank (2020)
INV	"*INV* refers to private and government expenditure associated with the ownership of telecommunications equipment infrastructure (including supporting land and buildings and intellectual and non-tangible property such as computer software). These include expenditure on initial installations and additions to existing installations as a percentage of GDP."	ITU (2020)
LF	"Labour force participation rate refers to the total labour force as a percentage of the population ages 15–64."	ILO (2020)
GFCF	"Gross domestic fixed investment as a percentage of GDP."	World Bank (2020)
TRADE	"The ratio of the sum of exports and imports to GDP."	World Bank (2019)
INS	"Institutional captures the average of six indicators of institutional quality."	Authors' calculation
CC	"*CC* captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests."	World Bank (2019)
GE	"*GE* captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies."	World Bank (2019)
RL	"*RL* captures perceptions of the extent to which agents have confidence in and abide by the rules of society, the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence."	World Bank (2019)
RQ	"Regulatory quality captures perceptions of the government's ability to formulate and implement sound policies and regulations that permit and promote private sector development."	World Bank (2019)
PV	"*PV* measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism."	World Bank (2019)
VA	"*VA* captures perceptions of the extent to which a country's citizens can participate in selecting their government, as well as freedom of expression, association, and free media."	World Bank (2019)

Source: Authors' own calculation

Table A.2: Correlations matrix and descriptive statistics

Variables	*RGDPG*	*lnUSAGE*	*lnACCESS*	*lnMOB*	*lnINV*	*lnLF*	*lnGFCF*	*lnTRADE*	*GOV*	*CC*	*GE*	*RL*	*RQ*	*PV*	*VA*
RGDPG	1.00														
ln*USAGE*	−0.06	1.00													
ln*ACCESS*	−0.06	0.88	1.00												
ln*MOB*	−0.07	0.95	0.85	1.00											
ln*INV*	0.04	0.11	0.05	0.13	1.00										
ln*LF*	0.04	0.23	0.37	0.26	0.07	1.00									
ln*GFCF*	0.05	0.20	0.09	0.17	−0.02	−0.17	1.00								
ln*TRADE*	−0.01	0.38	0.40	0.38	0.05	0.37	0.04	1.00							
GOV	0.07	0.23	0.28	0.27	−0.12	0.72	−0.05	0.64	1.00						
CC	0.08	0.27	0.34	0.31	−0.07	0.75	−0.03	0.58	0.93	1.00					
GE	0.04	0.28	0.32	0.31	−0.12	0.69	0.00	0.61	0.93	0.88	1.00				
RL	0.04	0.28	0.35	0.33	−0.09	0.70	−0.06	0.59	0.96	0.89	0.87	1.00			
RQ	0.05	0.28	0.30	0.30	−0.09	0.64	−0.07	0.63	0.91	0.81	0.87	0.89	1.00		
PV	0.10	0.03	0.12	0.07	−0.10	0.57	−0.03	0.55	0.72	0.64	0.58	0.65	0.50	1.00	
VA	−0.02	0.07	−0.01	0.09	−0.17	0.20	−0.05	0.16	0.56	0.44	0.51	0.51	0.53	0.02	1.00
Mean	4.418	30.201	30.158	70.501	0.009	55.753	23.505	80.519	−0.197	−0.026	0.066	0.011	−0.024	−0.427	−0.781
Median	4.083	20.000	19.300	70.183	0.006	51.700	23.047	80.021	−0.117	−0.100	0.000	0.100	0.000	−0.500	−0.800
Maximum	30.012	100.000	100.000	212.639	0.141	89.000	46.020	191.872	0.800	1.600	1.500	1.500	1.300	1.200	0.800
Minimum	–7.076	0.001	0.000	0.012	0.000	37.200	1.111	17.859	–1.650	–1.500	–1.500	–1.700	–1.700	–2.500	–1.900
Std. Dev.	3.927	29.257	30.659	56.576	0.015	12.236	6.760	34.219	0.577	0.654	0.621	0.632	0.716	0.913	0.597
Observations	375	375	375	375	375	375	375	375	375	375	375	375	375	375	375

Source: Authors' own calculation

Table A.3: Panel unit root test results

	IPS *W*-statistic	
	Level	**1st difference**
RGDPG	–7.694***	–20.642***
ln*USAGE*	–11.365***	–9.790***
ln*ACCESS*	–7.394***	–2.867***
ln*MOB*	–15.523***	–5.515***
ln*INV*	–3.192***	–13.084***
ln*LF*	–1.105	–9.269***
ln*GFCF*	–4.825***	–12.634***
ln*TRADE*	–2.985***	–10.715***
GOV	–1.146	–12.300***
CC	–0.796	–11.991***
GE	–0.146	–14.207***
RL	–2.617***	–12.088***
RQ	–2.850***	–11.942***
PV	–0.906	–11.789***
VA	–2.352***	–13.468***

Notes: The Null Hypothesis is that the panels contain a unit root.
Automatic lag length selection based on AIC. The test values are significant at *** $p < 0.01$.

Source: Authors' own calculation

Table A.4: Marginal effects of ICT usage on economic growth at the governance levels of 1 and 2

USAGE			
	Governance of level 1	**Governance of level 2**	**Sig**
***GOV* (Model 1.1) of Table 1**	0.414	0.632	X
***CC* (Model 1.2) of Table 1**	0.846	1.123	✓
***GE* (Model 1.3) of Table 1**	0.474	0.763	✓
***RL* (Model 1.4) of Table 1**	0.148	0.274	✓
***RQ* (Model 1.5) of Table 1**	0.436	0.589	✓
***PV* (Model 1.6) of Table 1**	0.300	0.428	✓
***VA* (Model 1.7) of Table 1**	0.298	0.537	X
ACCESS			
	Governance of level 1	**Governance of level 2**	**Sig**
***GOV* (Model 2.1) of Table 2**	0.677	1.082	✓
***CC* (Model 2.2) of Table 2**	0.655	1.219	✓
***GE* (Model 2.3) of Table 2**	0.870	1.709	✓
***RL* (Model 2.4) of Table 2**	0.207	0.565	✓
***RQ* (Model 2.5) of Table 2**	0.664	1.091	✓
***PV* (Model 2.6) of Table 2**	0.32	0.186	✓
***VA* (Model 2.7) of Table 2**	2.092	3.581	✓
MOB			
	Governance of level 1	**Governance of level 2**	**Sig**
***GOV* (Model 3.1) of Table 3**	0.351	0.604	✓
***CC* (Model 3.2) of Table 3**	1.300	2.565	✓
***GE* (Model 3.3) of Table 3**	0.164	0.133	✓
***RL* (Model 3.4) of Table 3**	0.605	1.075	X
***RQ* (Model 3.5) of Table 3**	0.649	0.985	X
***PV* (Model 3.6) of Table 3**	0.172	0.403	✓
***VA* (Model 3.7) of Table 3**	−0.100	−0.099	X

Notes: *USAGE* is the internet usage. *ACCESS* is internet access at home, and *MOB* is the mobile cellular subscriptions. X means insignificant.

Source: Authors' own calculation

Table A.5: Marginal effects of ICT investment on economic growth at the governance levels of 1 and 2

	INV		
	Governance of level 1	**Governance of level 2**	**Sig**
***GOV* (Model 4.1) of Table 4**	0.345	0.505	X
***CC* (Model 4.2) of Table 4**	0.656	2.668	✓
***GE* (Model 4.3) of Table 4**	0.409	2.757	X
***RL* (Model 4.4) of Table 4**	−0.165	−0.969	X
***RQ* (Model 4.5) of Table 4**	0.22	1.376	X
***PV* (Model 4.6) of Table 4**	1.048	2.644	✓
***VA* (Model 4.7) of Table 4**	0.778	3.422	✓

Notes: *INV* is the capital investment in telecommunications. X means insignificant.

Source: Authors' own calculation