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Article

The Effect of ICT Usage on Economic Growth in the MENA Region: Does the Level of Education Matter?

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Abstract: This paper examines the effect of information and communication technology (ICT) usage on economic growth in the Middle East and North Africa (MENA) region, with a focus on how education levels modulate this relationship. Covering data from 2000 to 2020 and employing a panel ARDL model for analysis, this research finds that, while ICT is prevalent across MENA, its impact on economic growth is negative. Furthermore, it reveals that education plays a crucial role in determining ICT's effectiveness on economic growth. However, the positive impact of education is overshadowed by the adverse effects of brain drain, which negates the potential benefits ICT could have on the economy. This study highlights the importance for MENA policymakers to address the brain drain issue to enhance the positive impact of ICT on economic growth, suggesting the need for strategies that leverage both ICT and education to effectively foster economic development.

Keywords: ICT; economic growth; education level; MENA region

JEL Classification: I25; O15; O33



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1. Introduction

Over the past few decades, the proliferation of information and communication technology (ICT) has played a transformative role in enabling nations and their governments to leverage information as a springboard for economic progress. As reported by the International Telecommunication Union in 2021, 59.5% of the world's population now engages with the internet. This surge in ICT accessibility has sparked a considerable volume of research into its contributions towards economic enhancement, especially highlighting its benefits for growth in the developing world. While many studies have confirmed that ICT adoption fosters growth, increases productivity, and creates job opportunities, there remains a gap in the literature specifically exploring how education levels impact the relationship between ICT use and economic growth (EG) (Sarangi and Pradhan 2020; Nabi et al. 2023).

Although previous investigations have investigated the impacts of either ICT or education on EG separately (Abu Alfoul et al. 2024; Gómez-Barroso and Marbán-Flores 2020), the combined effects of their interaction remain less explored. Some research has focused on ICT's role in enhancing educational efficiency and its subsequent effect on EG (Fu 2013; Cox and Marshall 2007). Nevertheless, the effect of educational attainment on the effectiveness of ICT in driving EG has not been thoroughly examined. This study explores how educational attainment influences the relationship between ICT use and EG, particularly in the Middle East and North Africa (MENA) region. Highlighting the importance of ICT in stimulating economic activities, the World Bank noted that numerous countries have achieved

significant economic milestones through effective ICT deployment. This recognition has led many governments across both developed and developing countries to invest heavily in ICT infrastructure and adopt various advanced technologies, acknowledging their critical role in economic development. Thus, the nexus between education levels and ICT usage presents a complex dynamic with potentially varied effects on economic outcomes.

Moreover, international bodies such as the World Bank have committed significant resources to support educational initiatives, viewing them as crucial drivers of a country's economic triumph. In April 2012, the World Bank dedicated an average annual budget of \$2.4 billion to education in low- and middle-income nations, expecting significant returns in productivity, innovation, and development levels. Globally, each additional year of schooling results in a 9% increase in hourly earnings (Klees et al. 2019). However, challenges emerge when the economic framework fails to optimally utilize ICT optimally, reflecting stunted EG. Factors like inadequate education quality can skew the labor market and impede growth, potentially driving individuals towards brain drain as a viable option for livelihood (Ernst and Feist 2024; Khatatbeh 2019; Dodani and LaPorte 2005). The brain drain trend has notably increased in MENA countries over recent years, raising concerns about its future implications if unaddressed.

This paper's contributions to the literature are twofold. First, it investigates how educational attainment influences the impact of ICT on economic growth, addressing a gap in existing research, particularly in the MENA region. By including education as a moderating variable, this study provides another perspective of understanding the relationship between ICT and education. Second, it highlights the issue of brain drain and demonstrates its detrimental effects on the potential benefits of ICT and education. These contributions provide practical recommendations for policymakers, emphasizing the need for strategic investments in education and ICT infrastructure and addressing brain drain to enhance economic growth.

The remainder of this paper is organized as follows. Section 2 reviews the literature on education and institutional quality. Section 3 presents this study's variables and discusses the data and the model specification. Section 4 discusses the empirical results. Section 5 provides policy implications, recommendations and conclusion.

2. Literature Review

The theoretical framework in this study builds on endogenous growth theory (Romer 1990; Lucas 1988), which emphasizes the role of human capital, innovation, and knowledge diffusion in long-term economic growth. In this context, ICT acts as a catalyst for productivity improvements, while education is crucial in enabling the workforce to utilize ICT technologies fully. Furthermore, human capital theory (Becker 1964) reinforces the importance of educational quality and access in determining how effectively ICT drives economic growth. Given the high rates of skilled labor migration (brain drain) in MENA, migration theories, such as Todaro's (1976) model, offer additional insight into how the loss of educated individuals can reduce the potential economic gains from ICT investment.

The literature on the relationship between ICT and EG has evolved significantly. Initial skepticism, as observed in early works by Jorgenson and Stiroh (1995), which reported a modest contribution of ICT to productivity growth, has gradually given way to a broader consensus on its substantial impact. Subsequent studies by Schreyer (2000) and Oulton (2002), and more comprehensive analyses by Fukao and Miyagawa (2007) have documented the transformative role of ICT in enhancing EG across various countries. These studies stress the critical role of ICT in driving productivity and economic expansion, particularly from the mid-1990s onwards. This body of research marks a significant shift in understanding, from viewing ICT's economic contribution as minimal to recognizing its pivotal role in global economic development. Particularly, the widespread adoption of ICT has significantly enhanced the efficient allocation of resources, reduced production costs, and stimulated greater demand and investment across various economic sectors (Khatatbeh and Moosa 2022; Abu Alfoul et al. 2022; Bahrini and Qaffas 2019). Moreover, internet usage

and broadband availability have accelerated innovation by fostering competition, leading to the creation of new products, services, and business models. Additionally, mobile phones have become a key driver of economic growth by improving access to financial services and enhancing information flow, which mitigates the challenges of distance and time, thereby increasing productivity and inclusivity. The following subsections present the literature on ICT, EG, and education and EG, respectively.

2.1. ICT on Economic Growth

The investigation of the relationship between ICT and economic productivity has significantly evolved over the years. Early research conducted by Jorgenson and Stiroh in the mid-1990s suggested that the role of informatics in enhancing productivity growth was relatively modest. Their analysis, which spanned 1959 to 1973 across various nations, indicated that informatics contributed a mere 6% to an annual productivity increase of 2.94%. However, this perspective shifted dramatically in later years, with further investigations revealing a more substantial effect of ICT on economic development. By the end of the 20th century, studies by [Jorgenson and Stiroh \(2000\)](#), along with [Oliner et al. \(2008\)](#), highlighted that the influence of ICT on the U.S. economy expanded significantly post 1995. This period, marked by a technological boom, saw ICT contributing to approximately 13% of the total economic growth and 27% of labor productivity enhancement between 1973 and 1995.

Early studies such as [Schreyer \(2000\)](#) identified a positive correlation between ICT and productivity growth across all G7 countries during the latter half of the 1990s. Similarly, [Oulton's \(2002\)](#) findings corroborated this pattern within the United Kingdom, suggesting a widespread effect of ICT advancements on economic indicators in developed nations. [Piatkowski's \(2003\)](#) study on Poland further emphasized the significance of ICT investments, attributing 8.9% of GDP growth and 12.7% of labor productivity improvements between 1995 and 2000 to technological advancements. The impact of ICT was not limited to Western economies; [Van Ark and Piatkowski \(2004\)](#) observed that ICT adoption facilitated the restructuring of manufacturing sectors in Central and Eastern Europe, aligning these economies closer to the standards of the former EU-15. Notably, the adoption and integration of ICT in these regions were found to exert a more substantial impact on productivity growth than observed within the EU-15. A comprehensive analysis by the OECD in 2007 and 2008 further validated the escalating influence of ICT-producing sectors on labor productivity across the globe since the mid-1990s.

In Asia, [Fukao and Miyagawa's \(2007\)](#) study highlighted Japan's labor productivity and total factor productivity (TFP), revealing that, post 1995, Japan matched the TFP growth rates of the four major economies in the European Union—Germany, France, the United Kingdom, and Italy. Concurrently, [Hausmann et al. \(2008\)](#) argued that countries specializing in ICT exports tend to witness higher productivity and economic growth rates. Similarly, [Koutroumpis \(2009\)](#) identified a significant link between ICT and economic growth in 22 OECD countries from 2002 to 2007, emphasizing the necessity of adequate technological infrastructure for this relationship to hold. [Hawash and Lang \(2010\)](#), in their analysis of 33 developing countries between 2002 and 2006, concluded that ICT adoption, coupled with higher education levels, significantly boosts productivity growth.

[Bohlin et al. \(2010\)](#) expanded this analysis to 192 countries from 1990 to 2007, providing substantial evidence of ICT's positive impact on productivity growth. Khuong [Vu \(2011\)](#) further validated these findings in a decade-long study from 1996 to 2005 across 102 countries, highlighting ICT's pivotal role in fostering economic growth. Nevertheless, [Niebel \(2018\)](#) examined the economic growth of 59 countries from 1995 to 2010 and found no clear evidence that developing and emerging economies benefit more from ICT investments than developed ones, pointing out the importance of considering political and societal contexts in evaluating ICT's economic impact. This body of literature highlights a broad consensus on the positive correlation between ICT investments and economic growth, with variations across different regions and economic statuses ([Vu et al. 2020](#)). While

ICT investments can drive growth, the extent of their impact is influenced by factors such as export specialization, technological infrastructure, education levels, and socio-political environments.

Furthermore, ICT has emerged as a pivotal force propelling the growth of various economic sectors, especially in the context of global liberalization efforts. [Kais \(2014\)](#) examined the specific effects of ICT on Tunisia's economic expansion, revealing a pronounced and direct relationship with the nation's GDP. [Samimi et al. \(2015\)](#) conducted a comprehensive analysis to understand the impact of ICT on economic growth across a broad set of countries, including both developed and developing economies, over the period from 2001 to 2012. Their research highlights a significant positive correlation between ICT deployment and economic growth, suggesting that investments in technology are beneficial for enhancing growth globally. However, their findings also point to variations in the impact of ICT, with developing countries experiencing different levels of economic benefit compared to their developed counterparts, indicating a complex relationship between ICT and economic growth. In a related study focusing on Bangladesh, [Naym and Hossain \(2016\)](#) explored the nexus between ICT investments and economic growth for the period between 1997 and 2013. While they identified a positive link between the use of ICT and economic growth, the correlation was not statistically significant. The researchers attributed this to the relatively modest share of ICT in the nation's GDP and the constrained duration of the study, which limited the scope for a more detailed analysis. [Bakry et al. \(2023\)](#) suggest that the adoption and usage of ICT could have varying impacts on economic growth depending on different factors. Specifically, while ICT can boost growth in the long term, its impacts might not be significant in the short term.

The study by [Appiah-Otoo and Song \(2021\)](#) provides an insightful comparative analysis of the impact of ICT on economic growth in rich and poor countries. The findings reveal a significant positive correlation between ICT and economic growth across both groups, but with varying degrees of impact. In rich countries, ICT contributes more substantially to economic growth, facilitated by advanced infrastructure, higher investment in technology, and a more skilled workforce. Conversely, in poorer countries, while ICT still positively influences growth, the effects are less pronounced due to challenges such as inadequate infrastructure, lower levels of investment, and a gap in digital skills. The study underscores the importance of enhancing ICT accessibility and infrastructure in poorer countries to harness its growth potential fully ([Moosa and Khatatbeh 2023](#)). [Awad and Albaity \(2022\)](#) reveal that ICT significantly contributes to economic growth in Sub-Saharan Africa, primarily through improved access to information, enhanced efficiency in business operations, and the facilitation of innovation. However, the impact is mediated by several factors, including the level of ICT infrastructure, the regulatory environment, and the availability of complementary resources such as education and energy. The authors find that, while ICT can drive substantial economic growth, realizing this potential requires addressing existing infrastructural and institutional barriers. The study by [Kowal et al. \(2022\)](#) examines the critical role of digital innovations, particularly ICT, in fostering sustainable development during crises, such as the COVID-19 pandemic. The authors highlight how digital technologies, including remote work platforms and digital payments, enable economic resilience by allowing businesses to continue operating despite disruptions. Additionally, digital education platforms ensure continuity in human capital development, mitigating the impact of educational disruptions. The study also emphasizes the contribution of ICT to environmental sustainability through improved resource management, reduced emissions, and the promotion of smart city initiatives. Furthermore, digital tools like telemedicine and real-time data systems enhance crisis management by supporting better decision making and resource allocation. Overall, the research underscores the dual role of digital innovations in addressing immediate crisis challenges and contributing to long-term sustainable development.

The level of institutional quality also moderates the relationship between ICT and EG. For instance, [Abu Alfoul et al. \(2024\)](#) investigate the ICT's effect on EG across the MENA

region, considering the role of institutional factors. The study finds that ICT significantly promotes economic growth in MENA countries by enhancing productivity, facilitating innovation, and improving connectivity. However, the magnitude of ICT's impact varies depending on the quality of each country's institutions. Strong institutional frameworks, characterized by efficient governance, regulatory quality, and the protection of property rights, tend to amplify the positive effects of ICT on economic growth. In contrast, countries with weaker institutional environments may experience diminished benefits from ICT due to barriers such as regulatory inefficiencies and lack of investor confidence. The research underscores the importance of institutional reform alongside investments in ICT infrastructure and human capital development to maximize the socioeconomic benefits of digitalization in the MENA region. By fostering a supportive institutional environment, policymakers can create conditions that encourage ICT adoption, stimulate entrepreneurship, and attract investment, thereby driving sustainable economic growth. This study contributes valuable insights into the interplay between ICT, institutional quality, and economic development in the MENA context. It emphasizes the need for integrated policy approaches that address both technological advancements and institutional challenges to unlock the full potential of ICT as a catalyst for economic transformation. In the same context, [Khatatbeh and Abu-Alfoul \(2024\)](#) and [Adeleye et al. \(2023\)](#) argue that policymakers should prioritize improving institutional quality alongside investments in ICT to ensure that economic growth benefits are translated into enhanced well-being, especially for lower income group countries.

To sum up, the existing literature emphasizes the key role of ICT in driving EG. Building on these insights, this study aims to fill existing gaps by setting clear objectives and research questions to better understand the interaction between ICT, education, and economic growth in the MENA context. The primary objective of this study is to assess the impact of ICT usage on economic growth in the MENA region. Accordingly, the study poses the following research question.

RQ1: How does ICT usage influence economic growth in the MENA region?

2.2. Education on Economic Growth

The nexus between education and EG has been central to the economic development literature. To begin with, the seminal works by [Romer \(1986\)](#) and [Lucas \(1988\)](#) highlight the essential role of educational development in economic progress. Subsequent empirical research has reinforced that education significantly contributes to EG. [Barro \(1991\)](#) demonstrated that enhancements in secondary school enrolments directly correlate with increases in the annual income growth rate, underlining education's pivotal role in national economic development. [Benhabib and Spiegel \(1994\)](#) investigated the impact of the labor force's educational attainment on EG, finding that human capital is a key driver of EG. Their analysis also revealed that the influence of education on innovation capabilities exhibits a stronger significance in wealthier nations compared to their less affluent counterparts, suggesting that the level of a country's development influences the education-growth nexus. [Krueger and Lindahl \(2001\)](#) show that education significantly fosters growth in nations where educational levels are initially low, highlighting the transformative potential of educational investments in developing contexts. Similarly, [Barro \(2001\)](#) employed an endogenous growth model to analyze data from 100 countries between 1960 and 1995, concluding that cognitive skills, rather than merely the amount of education, play a more decisive role in propelling EG.

Contrasting these findings, [Pritchett \(1996, 2001\)](#) utilized cross-sectional data to argue that the nexus between human capital and EG does not hold for MENA countries. He attributed this finding to governance issues prevalent in the region, which hinder human capital accumulation and investments in education. Moreover, Pritchett pointed out that the education system in these countries often lacks in developing cognitive skills, further complicating the relationship between education and economic development. [Altinok \(2007\)](#) examined the dynamics between education and EG across 105 countries from 1960 to 2000, using international student achievement surveys to craft new performance indica-

tors, highlighting education's beneficial impact on EG. Similarly, [Creel and Pilon \(2008\)](#) utilized the augmented Solow model and found that human capital and public investment significantly contribute to EG, enhancing labor productivity and spurring technological advancements. Similarly, [Pradhan \(2009\)](#) explored this relationship in the Indian context from 1951 to 2001, identifying a uni-directional causal link from education to EG based on correlation error modelling techniques. In contrast, [Barro and Lee \(2013\)](#) positioned education at the core of economic development, using random and fixed effects models to highlight the critical role of human capital levels in driving EG. [Quenum \(2011\)](#) emphasized the importance of education levels in various economic sectors. A nuanced analysis was employed to differentiate the impact of different education levels on growth. His findings indicated a counterintuitive negative effect of post-primary education on EG in the South Asian Association for Regional Cooperation (SAARC) countries, emphasizing the paramount importance of education quality over the mere quantity of human capital between 1960 and 2013.

[Barro's \(2013\)](#) study highlights the critical role of education in driving economic growth. Using an empirical framework, the research shows that higher levels of education, especially secondary and tertiary, significantly boost economic growth by enhancing human capital, labor productivity, and innovation. The quality of education, measured by indicators like test scores, is also crucial for growth, with better educational outcomes leading to stronger economic performance. While primary education is important for basic skills, advanced education drives substantial development. Barro emphasizes the need for policies that improve education access and quality, such as investments in teacher training and infrastructure. The study also notes that countries with supportive economic and institutional environments see the greatest benefits from educational investments, highlighting the importance of a holistic approach to development.

A closely related issue is the phenomenon of brain drain, characterized by the emigration of highly skilled and educated individuals from their home countries to more developed nations, which presents a complex interplay of causes and effects that significantly impacts the relationship between ICT and EG ([Iqbal et al. 2020](#)). Brain drain in developing countries arises from several interrelated factors. First, economic disparities, as individuals often migrate in search of better job opportunities, higher wages, and an improved quality of life ([Beine et al. 2011](#)). The contrast between limited prospects in their home countries and the wealth of opportunities in developed nations acts as a strong incentive for migration. In addition, [Panagiotakopoulos \(2020\)](#) argues that political instability plays a significant role in this phenomenon. Repressive political regimes, corruption, and lack of personal freedoms push skilled professionals to seek safer and more stable environments abroad, where their chances of career advancement are greater. Poor educational infrastructure is another key contributor, as individuals from developing nations often pursue higher education abroad due to a lack of quality educational opportunities at home ([Usman et al. 2022](#)). The consequences of brain drain on economic growth, particularly in relation to ICT, are complex. One major issue is the loss of human capital, where the emigration of skilled workers leads to a shortage of qualified personnel in critical sectors like ICT. This can hinder innovation, reduce productivity, and limit the ability of developing countries to fully leverage technological advancements. As noted by [Liu et al. \(2016\)](#), brain drain can reduce total factor productivity (TFP) growth in the home country, thereby hindering economic development. However, there are some positive effects, notably through remittances. Skilled emigrants often send money back home, providing financial support to families and contributing to local economies ([Khatatbeh and Moosa 2023](#)). These funds can also help boost investments in ICT infrastructure ([Hunter 2015](#)). However, the impact of brain drain is not uniform across regions; while some areas may benefit from remittances, others face severe skill shortages that stifle economic growth and technological progress.

In a cross-country context, [Wang and Liu \(2016\)](#) assessed the education–growth nexus through a panel data model spanning 55 countries from 1960 to 2009. Their analysis revealed a robust positive link between human capital and EG, irrespective of a country's

development status. However, they noted that, while primary and secondary education levels did not significantly affect EG, tertiary education exhibited a profound positive influence. Hanif and Arshed (2016) also concluded that higher education exerts a more substantial impact on EG than lower education levels, aligning with the broader consensus that the quality and level of education are critical determinants of a nation's economic trajectory. Finally, Habibi and Zabardast's (2020) study thoroughly examines how digitalization and education collectively influence economic growth in both Middle Eastern and OECD countries. The study finds that digitalization significantly contributes to economic growth by enhancing productivity, fostering innovation, and creating new economic opportunities. This impact is more pronounced in OECD countries due to their advanced digital infrastructure and higher levels of digital literacy. In contrast, while benefiting from digitalization, Middle Eastern countries face challenges such as digital divides and less mature digital ecosystems, which can limit the full realization of digitalization's economic benefits. Education emerges as a crucial factor that amplifies the positive effects of digitalization on economic growth. Higher educational attainment and better-quality education systems equip individuals with the necessary skills to leverage digital technologies effectively.

The literature above aims to develop this study's second main objective, which is to examine the moderating effect of education on the relationship between ICT and economic growth in the MENA region. Studies show that education enhances the favourable impact of ICT on economic growth. Higher educational attainment, especially in STEM fields, equips individuals to better utilize digital technologies, boosting economic benefits. Additionally, secondary and tertiary education levels play a key role in fostering innovation and increasing human capital, strengthening the overall effect of ICT on growth. Countries with stronger education systems are better positioned to capitalize on digitalization's potential. Hence, this current study considers the following question.

RQ2: Does the level of education moderate the relationship between ICT usage and economic growth?

3. Data and Methodology

3.1. Data

This study utilizes a comprehensive panel dataset from 2000 to 2020, encompassing annual data from 15 countries in the MENA region, where complete data on the relevant variables were available. The countries included in this analysis are "Algeria, Bahrain, Egypt, Iran, Israel, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, Turkey, and the United Arab Emirates". The primary variable of interest in this investigation is real GDP growth (RGDPG), serving as the indicator for EG, the dependent variable of this study.

The variable of ICT usage within these countries is captured through five distinct proxies: personal computers per 100 inhabitants (computers), mobile cellular subscriptions per 100 individuals (mobile), percentage of individuals using the internet (Internet users), percentage of households with internet access (Internet access), and telephone lines per 100 people (telephone). These variables offer a multifaceted view of ICT engagement, where computers and telephones reflect the infrastructural conditions of ICT; mobile highlights the proliferation of contemporary telecommunications technologies; and Internet users, along with Internet access, illustrate the populace's connectivity to the internet. It is anticipated that these measures of ICT usage will exhibit a positive correlation with EG.

To examine the moderating effects of education on the relationship between ICT and EG, two educational proxies are utilized: the secondary school enrollment rate (secondary) as an indicator of broad educational coverage and a basic measure of a country's human capital quality, and the tertiary school enrollment percentage (tertiary), reflecting the higher likelihood of internet use and access among individuals with tertiary education compared to those with lower levels of education. This study resonates with the sentiment expressed by Jean-Louis Sarbib, Senior Vice President of the World Bank's Human Development Network: "Secondary education is the highway between primary schooling, tertiary education, and

the labour market. Its ability to connect the different destinations and to take young people where they want to go in life is crucial”.

Additionally, this analysis incorporates control variables such as gross fixed capital formation as a percentage of GDP (investment), which is expected to enhance labor efficiency through technological employment and increased access to ICT tools. This investment is also projected to stimulate local employment and labor productivity. Furthermore, this study controls for trade openness (openness), representing the sum of exports and imports as a percentage of GDP, facilitating technological exchange among nations. The impact of the Arab Spring on the region’s EG is also considered, with a dummy variable (DSPRING) assigned a value of 1 from 2011 onwards and 0 for prior years, to account for its potential effects. Detailed definitions and sources for all variables are provided in Table A2 in Appendix A.

3.2. Estimation Method

We estimate a standard growth model expressed by the following equation:

$$RGDPG_{i,t} = \beta_1 \ln ICT_{i,t} + \beta_2 \ln EDU_{i,t} + \beta_3 (\ln ICT_{i,t} \times \ln EDU_{i,t}) + \beta_4 \ln INVESTMENT_{i,t} + \beta_5 \ln OPENNESS_{i,t} + ARABS_{i,t} + u_{i,t} \quad (1)$$

where $i = 1 \dots, 16$ and $t = 2000, \dots, 2020$. The variable $RGDPG_{i,t}$ represents the annual growth of GDP, $ICT_{i,t}$ represents the set of ICT variables, and $EDU_{i,t}$ is the set of education variables, while $INVESTMENT_{i,t}$ and $OPENNESS_{i,t}$ are the control variables. The impact of the Arab Spring is taken into account in the model by the dummy variable $ARABS$; \ln is the natural logarithm and $u_{i,t}$ represents the error term.

Descriptive statistics and a correlation matrix for these variables are detailed in Table A2 in Appendix A. To address potential issues of multicollinearity and to conserve the model’s degrees of freedom—particularly critical given the finite nature of the observations available—ICT variables are introduced into the regression sequentially. This approach is twofold: firstly, it acknowledges the significant correlations among the ICT variables themselves; secondly, it aims to optimize the model’s degrees of freedom by judiciously selecting variables for inclusion, thereby mitigating the risk of multicollinearity and enhancing the robustness of our findings.

4. Empirical Results and Discussion

In this study, we employ the Im, Pesaran, and Shin (IPS) unit root test, and its modified version introduced by Im et al. (2003), suited for the analysis of unbalanced panel data, which characterizes the dataset used in this research due to certain gaps in ICT variable observations. Prior to employing the Autoregressive Distributed Lag (ARDL) approach for estimation, we initially conducted a panel unit root test to ascertain the stationarity status of the variables involved. This preliminary step is crucial for establishing the foundation for subsequent panel cointegration testing, which probes into the potential long-term equilibrium relationships among the study variables.

The results of the panel unit root test, exhibited in Table A3 in Appendix A, reveal that the data series exhibit mixed orders of stationarity, alternating between $I(0)$ and $I(1)$. This mixed stationarity state fulfils a critical precondition for proceeding with the cointegration test aimed at detecting any long-term equilibrium dynamics among the variables. The outcomes of the panel cointegration tests lead to the rejection of the null hypothesis of non-cointegration, thereby supporting the argument for substantial long-term equilibrium relationships between the dependent variable, EG, and the various explanatory variables under consideration. Estimating these long-run relationships employs the panel ARDL methodology, as proposed by Pesaran et al. (1999), and involves the analysis of five distinct long-run equation variants. These variants reveal the effects on real GDP growth rates based on different dimensions of ICT usage—namely, Internet usage, Internet access, mobile, telephone, and computers, in addition to various control variables. The ARDL method was chosen due to its ability to capture both short-term dynamics and long-term relationships

between variables, which is critical for assessing the interaction between ICT, economic growth, and education over time in the MENA region. The panel ARDL model allows us to address the mixed stationarity of the dataset, as it can handle variables that are stationary at different levels (i.e., $I(0)$ and $I(1)$) without losing information from the data. This flexibility makes the ARDL model more suitable than other methods such as traditional fixed or random effects models, which may not fully capture the complex and dynamic nature of the variables in question.

Additionally, the panel ARDL model includes an error correction term, which helps in analyzing how quickly variables return to equilibrium after a short-term shock, offering deeper insights into the long-run effects of ICT on economic growth, moderated by education. This choice of method is optimal in this context because it provides a robust framework for understanding both the immediate and delayed impacts of ICT usage on economic performance, particularly given the unique structural and economic characteristics of the MENA region.

The results in Table 1 showcase the estimated coefficients for both the long-run relationships and the error correction terms (ECT) across all five ICT usage variants. Notably, the error correction coefficients in each of the specifications are negative, implying a mechanism for adjustment back to the long-run equilibrium. This observation aligns with the theoretical expectations and empirical findings noted by Long and Samreth (2008), highlighting the dynamic process through which variables adjust to restore equilibrium over time. The estimated coefficients reveal a significant negative association between ICT usage and EG within the MENA region, which is consistent with the findings of Noh and Yoo (2008). In their examination of 60 countries between 1995 and 2002, they find a detrimental effect of ICT on economic prosperity, ascribing this trend to the digital divide among nations. Similarly, Vu (2011) observed adverse outcomes from increased ICT usage in certain locales.

Table 1. Results of ARDL regression with different levels of education.

	Dependent Variable: GDPG							
	Secondary School Enrolment (Secondary)				Tertiary School Enrolment (Tertiary)			
	lnUSAGE	lnACCESS	lnMOB	lnFIX	lnUSAGE	lnACCESS	lnMOB	lnFIX
Long-run coefficients:								
$\ln ICT_{i,t}$	−3.883 *** (−2.998)	−4.081 ** (−2.344)	−4.091 *** (−3.400)	−5.227 ** (−2.784)	−0.739 *** (−3.621)	−0.578 *** (−4.348)	−2.162 ** (−2.593)	−3.203 *** (−3.302)
$\ln EDU_{i,t}$	−0.102 (−0.047)	0.831 (0.374)	−8.480 *** (−3.322)	−1.254 (−1.504)	−2.155 *** (2.829)	0.393 (0.481)	−7.048 *** (−3.377)	−1.931 *** (−2.732)
$\ln ICT_{i,t} \times \ln EDU_{i,t}$	1.105 (3.383)	1.199 (2.918)	1.039 (3.401)	1.134 (2.712)	1.720 *** (3.660)	1.496 *** (3.319)	1.139 *** (3.061)	0.924 *** (3.307)
$\ln GFCF_{i,t}$	4.648 *** (5.698)	4.244 *** (4.888)	0.834 (0.890)	1.866 ** (2.375)	−1.139 (−1.322)	0.056 (0.075)	−6.656 *** (−4.180)	1.982 *** (3.852)
$\ln TRADE_{i,t}$	−0.443 (−0.502)	3.697 *** (3.569)	3.904 *** (4.192)	1.108 *** (2.705)	3.996 *** (5.041)	1.701 *** (3.176)	9.196 *** (7.457)	1.009 *** (2.743)
$ARABS_{i,t}$	−0.723 * (−1.966)	−0.330 (−0.729)	−1.010 *** (−4.467)	−1.957 *** (−6.410)	−1.271 *** (−3.083)	−0.136 (−1.273)	−0.286 (−0.860)	−1.268 *** (−4.496)
Short-run coefficients:								
Error correction term	−0.956 *** (−10.274)	−0.865 *** (−12.150)	−1.013 *** (−7.458)	−0.751 *** (−8.954)	−0.925 *** (−5.370)	−1.263 *** (−5.075)	−0.956 *** (−5.635)	−0.781 *** (−8.340)
Observations	347	360	351	366	331	317	332	360
Number of lags (ARDL)	(1, 2, 2, 2, 2, 2)	(1, 1, 1, 1, 1, 1)	(2, 1, 1, 1, 1, 1)	(1, 1, 1, 1, 1, 1)	(3, 1, 1, 1, 1, 1)	(4, 1, 1, 1, 1, 1)	(3, 1, 1, 1, 1, 1)	(1, 1, 1, 1, 1, 1)

Note 1: GDPG is an annual percentage growth rate of GDP; lnICT represents all proxy variables of ICT; lnUSAGE is the natural logarithm of individuals using the internet as a percentage of the population; lnACCESS is the proportion of households with internet access at home as a percentage of the population; lnMOB is the natural logarithm of mobile cellular subscriptions per 100 people; lnFIX is the natural logarithm of fixed telephone subscriptions per 100 people; lnGFCF is the natural logarithm of gross fixed capital formation as a percentage of GDP; lnEDU1 is the natural logarithm of the school enrolment, secondary as a percentage of gross; lnEDU2 is the natural logarithm of the tertiary school enrolment as a percentage of gross; lnTRADE is the natural logarithm of trade openness as a percentage of GDP; ARABS is a dummy for the Arab Spring in 2011, which equals one in 2011 and onwards, and zero in the years before 2011. Note 2: The lag selection criterion in this model is Akaike's information criterion (AIC). Note 3: The test values are significant at * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. t statistics are reported in parentheses.

Exploring the underlying reasons for ICT's negative impact on EG in the MENA countries, insights from the Arab Social Media Report series shed light on regional social

media engagement. The report highlights that the Arab world boasted 164 million monthly Facebook users, with Egypt leading in daily engagements at 24 million users. Moreover, Saudi Arabia showcased the world's highest year-on-year social media user growth rate at 32% in 2018, significantly surpassing the global average of 13%. The prevalence of social media as a primary news source among Arab Youth is notable, with 63% turning to platforms like Facebook and Twitter first for news, and nearly half (49%) accessing news daily on Facebook. Additionally, the presence of social media and instant messaging apps among smartphone users in the Arab region is remarkable, with 98% using at least one social media app and 91% utilizing instant messaging apps. This pervasive use of social media and messaging apps highlights the digital engagement patterns that may influence the observed negative correlation between ICT usage and EG in the region. These results are also consistent with the study by [Salem \(2017\)](#), who found that 69% of internet users in the Arab world have increased the time they spend online today compared to two years ago and habitually access the news via the internet.

This study also uncovered that the mean monthly expenditure via online platforms stands at approximately \$74, markedly lower than figures observed in other global regions. Furthermore, a significant 92% of Arab participants indicated their use of the internet predominantly for social interaction, whereas about 79% of users engaged with news content through their social networks. Additionally, approximately 77% of individuals in the region reported utilizing the Internet for job application purposes. The motivations behind using various messaging apps and social media platforms, such as Facebook, WhatsApp, Snapchat, and Instagram, were also scrutinized. The findings illustrate that nearly half of the Arab users engage with instant messaging applications for socializing and entertainment.

On the other hand, 25% use these platforms primarily for professional reasons, and 9% for educational objectives, where only 8% leverage these apps for income generation and profit-making activities. This pattern suggests a tendency among MENA populations to engage with the internet and social media in ways that may not directly contribute to productive endeavors, potentially explaining the observed decline in productivity and its consequent impact on EG. [Al-Dabbagh et al. \(2016\)](#) demonstrated the inefficacy of time spent on social media in enhancing labor productivity. Furthermore, using social media during work hours has been identified as a significant detractor from productivity, prompting some business owners to prohibit social media access at the workplace. These observations provide a basis for understanding the negative influence of ICT on EG within the region.

“According to a short online survey that 50 young people between 18–24 in Egypt took, Egyptian Streets found that 90% said that they found social media to negatively affect their productivity and 85% saw that it also impacted their psychological health.”

The Team Lease World of Work Report highlights a significant trend in the workplace, remarking that employees spend an average of 2.35 h per day on social media, which accounts for a 13 percent loss in overall productivity attributable to social media engagement. Furthermore, the report reveals that individuals in MENA countries dedicate an average of 27 h weekly to internet usage. Specifically, the average daily internet usage in Egypt reaches 8 h, with a substantial 3 h spent on social media platforms. Similarly, in the UAE, individuals access the internet for about 7.5 h daily, allocating approximately 2.56 h to social media activities.

These findings stress the detrimental impact of ICT and social media usage on economic productivity. Several studies corroborate this viewpoint, indicating that a considerable portion of the time spent on social media does not contribute positively to labor productivity. Moreover, engagement with social media during work hours has been consistently identified as a factor that diminishes labor productivity, significantly distracting workers. As a response to these challenges, numerous business owners have introduced policies that restrict or completely prohibit the use of social media in the workplace, aim-

ing to mitigate its negative effects on productivity and, by extension, on EG. This body of evidence provides a solid foundation for understanding the adverse consequences of excessive ICT and social media usage on EG, particularly within the MENA region.

The effects of education, both at secondary and tertiary levels, predominantly showcase a negligible or even negative effect on EG, as exhibited in Table 1. This observation seemingly contradicts the hypothesized positive effect of educational attainment on EG, as supported by a wealth of theoretical and empirical literature, including works by Benos and Zotou (2014), Hanushek and Woessmann (2010), Mankiw et al. (1992), Romer (1990), Solow (1956), and Temple (1999). A closer examination reveals that the adverse impact of education on economic performance within MENA countries can be attributed to the prevalent issue of low-quality education, characterized by inadequate educational curricula and insufficient development of cognitive skills, as identified by Chapman and Miric (2009). This stance is corroborated by UNICEF's report, highlighting the substandard education quality across the region.

Moreover, our analysis aligns with Pritchett's (1996) contention that, while schooling may elevate private wages by signaling desirable traits such as ambition or innate talent to employers, its direct contribution to enhancing cognitive skills or productivity remains ambiguous, particularly in developing regions like MENA. This perspective suggests that, while education is acknowledged as a determinant of income, its efficacy in bolstering productivity is still a subject of debate. In addition, the phenomenon of 'brain drain' post-graduation exaggerate the issue, where a significant number of Middle Eastern students opt to emigrate, thus depriving their home economies of the investments made in their education. This emigration is often motivated by the scarcity of job opportunities or the high unemployment rates prevalent in the region. The Silatech report highlights that 26% of young individuals in MENA countries perceive a lack of growth potential in their region, prompting them to seek better prospects abroad. This migration trend not only emphasizes the challenges within the MENA educational system but also amplifies the economic consequences of brain drain.

Moreover, the results show that secondary education enrolment does not significantly alter the nexus between ICT usage and EG. However, tertiary education enrolment appears to enhance this relationship positively. These results align with the findings of Hanif and Arshed (2016), who show a superior effect of higher education on EG relative to secondary and primary education levels. Additionally, Saidi and Mongi (2018) employed a vector error correction model (VECM) to demonstrate a uni-directional causality flowing from education and mobile cellular telephone usage towards EG. Their study also reveals a uni-directional causality between internet usage and mobile cellular telephones towards research and development while identifying a bi-directional causality between education, internet usage, and mobile telephony in the short term. Dedrick et al. (2013) further substantiate that regions with growing tertiary enrolment rates benefit more substantially from ICT investments than others.

This pattern suggests that the quality of education, particularly at higher levels, is crucial in maximizing the benefits of ICT for EG in the MENA region. The previously discussed issue of substandard educational quality in these countries can undermine the potential productivity gains from internet usage, thereby impacting overall EG negatively. Enhancing the quality of education, especially through investments in cognitive skills training and improved curricula, can significantly bolster ICT's effectiveness, leading to more productive outcomes and enhanced EG. This premise is supported by an extensive literature emphasizing education as a key factor in economic development (e.g., Altinok and Aydemir 2016; Barro and Lee 2013; Krueger and Lindahl 2001; Wang and Liu 2016).

Turning to the control variables' effect, gross fixed capital formation (GFCF) and trade openness (TRADE) significantly and positively influence EG, as detailed in Table 1. The GFCF is shown to enhance employment rates and labor productivity, while an increase in investment rates is correlated with increased output levels. These outcomes are consistent with theoretical and empirical evidence suggesting that investment rates are fundamental

to economic expansion (e.g., [Iwaisako and Futagami 2013](#); [Li and Liu 2005](#); [Romer 1986](#)). Similarly, trade openness fosters EG by facilitating technology exchange among nations, thereby improving domestic production capabilities. The study findings also corroborate those of [Freund and Weinhold \(2002\)](#) and [Frankel and Romer \(1999\)](#), who identified trade openness as a catalyst for EG.

Furthermore, this study highlights that the Arab Spring has significantly and negatively influenced EG across the MENA region, as evidenced in our analysis. This finding aligns with [Kasmaoui et al. \(2018\)](#) and [Murdoch and Sandler \(2002\)](#), who demonstrated that civil unrest and wars have a detrimental effect on the economic performance of neighboring nations. The Arab Spring has undermined market confidence within these countries, primarily through the erosion of public trust in governmental and institutional efficacy, thereby hampering economic development. Additionally, our results resonate with the arguments put forward by [Freund and Jaud \(2014\)](#), who noted that the economic benefits previously experienced by the MENA region saw a significant decline following the onset of the Arab Spring and the ensuing political upheavals.

Lastly, the findings suggest that the impact of ICT on EG is intricately linked to the prevailing levels of education within the region. The findings indicate that the substandard quality of education in MENA countries has been a critical factor in slowing down GDP growth ([Saidi and Mongi 2018](#)). The inadequacy in educational quality has, in turn, impeded the effective utilization of ICT for economic advancement. This leads to the conclusion that educational attainment plays a crucial role in facilitating various economic activities and represents a significant determinant of a country's economic development ([Moosa et al. 2024](#); [Dedrick et al. 2013](#)). Thus, enhancing the quality of education emerges as a pivotal strategy for leveraging ICT as a catalyst for EG in the MENA region.

5. Conclusions and Policy Recommendations

This study examined the moderating role of education level on the relationship between ICT usage and EG in the MENA region. Employing a panel ARDL model to sample data from 2000 to 2020, the research reveals that, despite the widespread prevalence of ICT across the MENA countries, its impact on EG is predominantly negative. This counterintuitive finding underscores a complex nexus between ICT usage and economic development, further heightened by the region's brain drain phenomenon, which hinders the potential positive effects of ICT on the economy.

The findings assert the critical role of education level in determining the effectiveness of ICT on EG. It was found that secondary education enrolment does not significantly influence the ICT-EG dynamic. In contrast, tertiary education enrolment was shown to positively affect this relationship, highlighting the importance of higher education in maximizing the benefits of ICT for economic development. These findings align with previous research, emphasizing the transformative potential of higher education on EG. The negative influence of ICT on EG in the MENA region is attributed to several factors, including the prevalent issue of low-quality education, characterized by inadequate curricula and underdeveloped cognitive skills. This educational shortfall hampers the productive utilization of ICT, thus impeding EG. The research suggests that improving the quality of education, particularly through enhanced cognitive skills training and curriculum development, could significantly amplify the economic benefits of ICT. Moreover, this study addressed the significant and negative impact of the Arab Spring on EG across the MENA region. This political upheaval has eroded market confidence, primarily through the diminishing trust in governmental and institutional efficacy, further challenging economic development. Once more, the phenomenon of brain drain, exacerbated by the lack of job opportunities and high unemployment rates, has been identified as a critical barrier to realizing the economic potential of both ICT and education.

The implications of this study's findings are manifold. The findings point out a complex dynamic in which the expected positive impacts of ICT on economic development are hindered by factors such as brain drain and the prevailing quality of education. Conse-

quently, for policymakers in the MENA region, these insights offer a valuable framework for crafting strategies aimed at harnessing the full potential of ICT to foster EG. First, addressing the quality of education emerges as a critical policy imperative. Investments in the education sector should not only focus on increasing access but also on improving curricula, incorporating digital literacy, and fostering critical thinking and problem-solving skills. Second, the brain drain phenomenon causes a substantial challenge to realizing the economic benefits of ICT and education. Policymakers must implement comprehensive strategies aimed at retaining talent within the region. Third, it is also crucial to foster a conducive environment for digital transformation to enhance the impact of ICT on EG. This includes investing in ICT infrastructure to ensure widespread and equitable access to digital technologies, promoting digital literacy among the population, and supporting the development of local digital content and services. Finally, the negative impact of the Arab Spring on EG underscores the need for political stability and quality of institutions. Strengthening governance and ensuring the rule of law, government effectiveness, and transparency are essential to restoring market confidence and attracting both domestic and foreign investment (Alfoul 2022).

While this study provides valuable insights into the relationship between ICT, education, and economic growth in the MENA region, it has limitations. First, the dataset covers the period from 2000 to 2020, and more recent data from 2021 onwards were not included due to data availability constraints. As such, this study does not account for the significant impacts of the COVID-19 pandemic on digital transformation and economic growth, which may have altered some of the dynamics analyzed. Lastly, this study focuses on broad indicators of ICT and education, and more granular variables, such as specific digital skills or regional differences within countries, were not included, limiting the depth of the analysis. Future research could address these limitations by incorporating more recent data, exploring more specific ICT-related variables, and conducting country-level case studies to gain deeper insights into the local dynamics.

Future research studies may investigate the sector-specific impacts of ICT and education on EG, explore the role of vocational training in enhancing ICT's economic benefits, and examine the potential of digital literacy programs in mitigating the negative effects of brain drain. In addition, investigating the differential impacts of public versus private education on ICT effectiveness could offer valuable insights into policy formulation aimed at fostering economic development in the MENA region.

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Appendix A

Table A1. List of variables and data sources.

Variables	Description	Sources
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
Internet_access	“Internet access captures the proportion of households with the Internet. Access is not assumed to be only via a computer—it may also be by mobile phone, game machines, digital TV, etc. (as a percentage of the population).”	ITU
Internet_users	“Internet users are 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, games machine, digital TV, etc. (as a percentage of the population).”	ITU
Mobile	“Mobile cellular telephone subscriptions are 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
Telephone	“Fixed telephone subscriptions refer to the sum of an active number of analogue fixed telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents and fixed public payphones.”	ITU
Investment	“Gross fixed capital formation includes land improvements (fences, ditches, drains, and so on), plant, machinery, and equipment purchases, and the construction of roads and railways (as a percentage of GDP).”	Euromonitor International
Secondary	“School enrolment, secondary is the gross enrolment ratio, the ratio of total enrolment, regardless of age, to the population of the age group that officially corresponds to the level of education shown.”	World Bank
Tertiary	“Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level.”	World Bank
Openness	“Trade openness is the sum of exports and imports of goods and services measured as a share of gross domestic product (as a percentage of GDP).”	World Bank

Table A2. Correlations matrix and descriptive statistics.

Variables	GDPG	lnUSAGE	lnACCESS	lnMOB	lnFIX	lnEDU1	lnEDU2	lnINVESTMENT	lnOPENNESS
GDPG	1.000								
lnUSAGE	−0.026	1.000							
lnACCESS	−0.046	0.876	1.000						
lnMOB	−0.028	0.941	0.843	1.000					
lnFIX	0.008	0.212	0.235	0.244	1.000				
lnEDU1	−0.019	0.391	0.455	0.411	0.673	1.000			
lnEDU2	−0.148	0.520	0.523	0.491	0.449	0.627	1.000		
lnINVESTMENT	0.134	0.145	0.043	0.107	−0.057	0.056	−0.019	1.000	
lnOPENNESS	0.052	0.313	0.352	0.319	0.327	0.382	0.183	−0.009	1.000
Mean	4.247	2.389	2.475	3.452	2.582	4.419	3.367	3.111	4.310
Median	3.930	3.059	2.996	4.274	2.671	4.492	3.431	3.140	4.390
Maximum	26.170	4.605	4.605	5.360	3.913	4.897	4.756	3.829	5.257
Minimum	−7.445	−5.478	−2.303	−4.458	−1.185	3.543	1.686	0.105	2.950
Std. Dev.	3.685	2.129	1.793	1.931	0.831	0.255	0.548	0.368	0.432
Observations	369	369	369	369	369	369	369	369	369

Notes: GDPG is the annual percentage growth rate of GDP; lnUSAGE is the natural logarithm of individuals using the internet as a percentage of the population; lnACCESS is the proportion of households with internet access at home as a percentage of the population; lnMOB is the natural logarithm of mobile cellular subscriptions per 100 people; lnFIX the natural logarithm of fixed telephone subscriptions per 100 people; lnINVESTMENT is the natural logarithm of gross fixed capital formation as a percentage of GDP; lnEDU1 is the natural logarithm of the school enrolment, secondary as a percentage of gross; lnEDU2 is the natural logarithm of the tertiary school enrolment as a percentage of gross; lnOPENNESS is the natural logarithm of trade openness as a percentage of GDP.

Table A3. Panel unit root test.

	IPS W-Statistic	
	Level	1st Difference
GDPG	−7.278 ***	−18.666 ***
lnUSAGE	−11.365 ***	−9.790 ***
lnACCESS	−7.394 ***	−2.867 ***
lnMOB	−15.523 ***	−5.515 ***
lnFIX	−1.067	−6.318 ***
lnEDU1	0.350	−9.531 ***
lnEDU2	0.268	−8.135 ***
lnGFCF	−4.825 ***	−12.634 ***
lnTRADE	−2.985 ***	−10.715 ***

Null hypothesis: unit root. Note 1: GDPG is an annual percentage growth rate of GDP; lnUSAGE is the natural logarithm of individuals using the internet as a percentage of the population; lnACCESS is the proportion of households with internet access at home as a percentage of the population; lnMOB is the natural logarithm of mobile cellular subscriptions per 100 people; lnFIX the natural logarithm of fixed telephone subscriptions per 100 people; lnGFCF is the natural logarithm of gross fixed capital formation as a percentage of GDP; lnEDU1 is the natural logarithm of the school enrolment, secondary as a percentage of gross; lnEDU2 is the natural logarithm of the tertiary school enrolment as a percentage of gross; lnTRADE is the natural logarithm of trade openness as a percentage of GDP. Note 2: Automatic lag length selection based on AIC. The test values are significant at * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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