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Information and Communication Technology as a Resource for Revitalising the Arab World Economy in the Modern Digital Era

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Abstract

In the modern digital era, Information and Communication Technology (ICT) has become a core driver of economic prosperity. Therefore, this study examines the role and impact of ICT in enhancing the GDP per capita while controlling for inflation and Foreign Direct Investment (FDI) in the context of Arab countries from 2012 to 2021. We utilized a two-step system Generalized Method of Moments (GMM) to analyse dynamic panel data in both the short and long run. The findings of this research suggest that, apart from the number of mobile cellular subscriptions, other ICT indicators such as the number of individuals using the Internet and the quantity of fixed telephone lines have made significant contributions to GDP per capita. Notably, in both the short and long term, fixed telephone lines have shown a strong positive effect on GDP per capita in Arab countries. Therefore, a crucial policy priority should be the long-term development and maintenance of ICT infrastructure to enhance GDP per capita and mitigate the negative effects of macroeconomic crises, such as those caused by the closure of the economy due to COVID-19.

Keywords: ICT, Inflation, Foreign Direct Investment, GDP Per Capita, System GMM and Arab World Economy.

Introduction

With economies in the Arab world traditionally reliant on oil and gas exports, there is an urgent need to explore the effect of ICT on growth avenues, especially in the face of fluctuating oil and gas prices and economic uncertainties. In the modern economy, ICT serves as a fundamental driver of economic growth, employment, and productivity (Gómez-Barroso & Marbán-Flores, 2020; Vu et al., 2020). This influence is especially prominent with the rise of internet connectivity and artificial intelligence (AI). The COVID-19 pandemic notably amplified the use of ICT, further underlining its significance in contemporary economic structures (Song & Zhou, 2020). ICT's impact, viewed as a cornerstone of knowledge, aligns with Sen's (1985) human capabilities theory. This theory highlights the role of knowledge in

elevating living standards, enhancing education and health, and broadening societal choices (Yakunina & Bychkov, 2015). Substantial literature suggests that robust infrastructure in telecommunications encompassing the internet, broadband, landlines, and mobile phones correlates with an increase in GDP per capita (Bahrini & Qaffas, 2019; Tripathi & Inani, 2020). However, the extent to which ICT propels growth hinges on a nation's human capital development. Populations with higher educational attainment tend to gain more from technological adoption (Ortiz et al., 2015). Additional determinants affecting the influence of ICT warrant attention. For instance, Yi and Choi (2005) explored the internet's impact on inflation, a factor intrinsically tied to economic growth. They discovered that as a higher percentage of the population uses the internet, the inflation rate declines. Interestingly, there's an inverse relationship between inflation and economic growth (Olamide et al., 2022). Belloumi and Touati (2022) further illuminated that, in the long term, the quality of ICT infrastructure significantly influences Foreign Direct Investment (FDI) inflows. Countries entrenched in the digital economy seem better poised to magnetise foreign investment and mitigate inflation's adverse effects. The term digital economy refers to “a broad range of economic activities that include using digitized information and knowledge as the key factor of production, modern information networks as an important activity space, and the effective use of information and communication technology (ICT) as an important driver of productivity growth and economic structural optimization” (G20 Digital Economy Task Force, 2016 p1). Nonetheless, the interplay between macroeconomic factors (such as inflation and FDI) and the nexus of ICT and economic growth remains a subject of rigorous debate, especially in developing nations (Bahrini & Qaffas, 2019; Soomro et al., 2022).

The majority of empirical results align with theoretical studies, highlighting the positive effect of ICT on economic growth (Lucas, 1988, 1990; Romer, 1993; Romer, 1990; Romer, 1990; Schumpeter, 1934). However, conflicting findings have emerged, particularly from research in developing countries (Albiman & Sulong, 2016a; Dewan & Kraemer, 2000; Pohjola, 2002; Pradhan et al., 2015; Yousefi, 2011). This discourse gained prominence during the COVID-19 pandemic when most countries reported a surge in ICT usage (Song & Zhou, 2020). Consequently, understanding the impact of ICT on Gross Domestic Product (GDP) per capita amidst the macroeconomic upheavals of inflation and deflation caused by the pandemic is essential. This comprehension is particularly crucial for assessing the Arab world's economic performance in today's digital age. Addressing this knowledge gap, this study aims to examine the effect of individual internet usage, the number of fixed telephone lines, and mobile cellular subscriptions on GDP per capita, accounting for inflation and FDI in Arab countries. This research contributes significantly to the digital economy field in several ways. Firstly, it uniquely focuses on specific Arab countries, diverging from many prior studies which primarily centred on developing regions or the MENA or SSA countries. Secondly, the dataset utilised encompasses the most recent available panel data, inclusive of the COVID-19 pandemic period, marked by global macroeconomic challenges such as inflation and deflation. Thirdly, offering policy recommendations aimed at governments and stakeholders to support the integration of ICT in their economic development plans. Finally, both internal and external instrumental variables have been employed using the system generalised method of moments (GMM) technique. This approach ensures accurate monitoring for potential biases and inconsistencies in the impact results over short and long durations. The main findings suggest that, in both the short and long run, fixed telephones contribute more significantly to GDP per capita than the positive effects stemming from individual internet usage. Conversely, mobile cellular usage appears to negatively influence GDP per capita. The study's structure is

as follows: Section 2 offers a critical literature review, Section 3 outlines the econometric methodology, Section 4 details empirical results, Section 5 discusses these results, culminating in a concluding section.

Literature Review

Recently, a substantial body of literature has emerged on the theme of modern economic thought, underscoring the importance of understanding the relationship between technology, especially ICT, and economic growth. The theories propounded by endogenous growth economists like Romer and Schumpeter, and the human capabilities theory by Sen, offer deep insights into how technological advancements drive GDP growth and enhance individual capabilities. As the digital revolution continues to transform global economies, the connection between ICT and endogenous growth theories becomes increasingly pronounced. This literature review delves into these economic theories, particularly emphasising the significant impact of ICT on GDP per capita.

Romer (1990) posits that technological progress is an endogenous result of economic activities, distinguishing his views from exogenous growth theories, which suggest that technological advancements originate outside the economic system (Solow, 1956). Romer emphasises that countries investing heavily in knowledge and technology, including ICT infrastructure and digital education, tend to experience accelerated growth. Silicon Valley's technology clusters, for instance, focus intensively on ICT innovations, leading to the emergence of new markets and job opportunities that directly bolster GDP. Schumpeter (1934) propounds that economic growth is spurred by a continuous cycle of innovations introduced by entrepreneurs. These innovations often cause older technologies or products to become obsolete, a phenomenon he termed "creative destruction". An apt example is the phasing out of landline phones, replaced by contemporary smartphones. This relentless innovation cycle, particularly in the ICT sector, has ushered in technological shifts that drive growth. Echoing these sentiments, Lucas (1988) accentuates the pivotal role human capital and knowledge accumulation play in economic growth, arguing that technological progress is inherently endogenous. Concurrently, Sen (1985) underscores the enhancement of human capabilities, which can be synergised with technological advancements. He contends that genuine development should prioritise augmenting the freedoms and capabilities of individuals. The ubiquity of the internet, for example, has democratised access to information, opportunities, and services, transforming lives globally. In regions with scant traditional banking infrastructure, mobile banking technologies exemplify how ICT can amplify individual capabilities and stimulate economic growth. It is evident that ICT, and by extension artificial intelligence (AI), corroborate the validity of endogenous growth theories. Representing the epitome of technology and knowledge, ICT plays a pivotal role in propelling GDP growth and enriching individual capabilities.

A robust telecommunications infrastructure in a country can directly boost economic growth by reducing transaction costs and enhancing market information (Greenstein & Spiller, 1995; Pradhan et al., 2016). The marked rise in the use of portable computing and internet access has amplified the capabilities and reduced the costs of ICT (Sturgeon, 2021). As a result, ICT has indirectly fueled globalisation and economic growth (Maneejuk & Yamaka, 2020). Numerous studies have explored the potential effects of ICT on GDP. In advanced industrial economies, emerging telecommunication technologies, including mobile phones, personal computers, and the internet, have shown a statistically significant impact on economic growth (Inklaar et al., 2005; Koutroumpis, 2009; Kurniawati, 2020; Vu, 2011). For instance, in the USA,

Adedoyin et al (2020) highlighted the pivotal role of ICT in promoting economic advancement. In Japan, Shida (2015) observed a positive influence of ICT on both economic growth and energy consumption reduction. The contributions of ICT investments to GDP have been emphasised by Oulton (2002) for the UK, Salahuddin and Alam (2015) for Australia and Jorgenson (2006) for the G7 economies. A noteworthy correlation between mobile telecommunications diffusion and growth in GDP per capita and productivity has also been identified (Gruber & Koutroumpis, 2010). Thompson and Garbacz (2007), analysing extensive cross-sectional data, observed that rising adoption rates of telecommunications services have notably enhanced the productive efficiency of the global economy, especially in specific lower-income nations.

In developing countries, such as those in Africa, Andrianaivo and Kpodar (2011) investigated the contribution of ICT to economic growth. They used a variety of indicators, primarily mobile cellular phone and fixed telephone penetration rates, as well as the cost of local calls. Their findings underscored the significant contribution of ICT to economic growth. This result was similarly confirmed by Solomon and van Klyton (2020); Lee et al (2012) in studies conducted in Sub-Saharan Africa. In Middle East and North Africa (MENA) countries, Sassi and Goaied (2013) found a tangible impact of ICT on economic growth, as measured by internet usage, mobile phone adoption, and fixed-line telephones. Empirical evidence from Hodrab et al (2016) demonstrated the vital role ICT plays in bolstering economic growth in the Arab region. Belloumi & Touati (2022) further posited that ICT indicators positively influence both FDI inflows and GDP per capita over the long term in Arab countries. A comparative study by Roy et al (2014) revealed that ICT usage in MENA countries makes a more significant contribution to GDP per capita than in developed and emerging countries. Furthermore, Zhang and Danish (2019) affirmed a positive influence of ICT on GDP in Asian countries. In the same vine Pradhan et al (2015) concluded that the twin pillars revitalising the Asian economy are robust ICT infrastructure and financial development. Multiple studies conducted in developing economies, including those by Aghaei and Rezagholizadeh (2017); Mamaghani (2010); Roger et al (2021); Sharma et al (2021); Shodiev et al (2021); Tripathi and Inani (2020), have shown that a solid ICT foundation is essential for economic growth. Sturgeon (2021) found that in recent years, high-quality ICT infrastructure has become the cornerstone for the digital economy, propelling economic growth. Rong (2022) noted that countries with more advanced digital infrastructure have become increasingly competitive in the global market. Pleming (2022) projected that the complete digitalisation of MENA countries' economies could lead to a substantial 46% rise in GDP per capita over the next 30 years. This evidence underscores the importance of understanding the profound impact of ICT on GDP per capita, especially if the goal is to foster the development of the digital economy in the Arab region.

The majority of the literature supports the endogenous growth theory's hypothesis, which posits a positive influence of knowledge and information technology on economic growth. However, in the context of developing countries, some empirical studies have indicated negative outcomes. Dewan and Kraemer (2000); Pohjola (2002) found no statistically significant effect of ICT on economic growth in these nations. Likewise, investments in ICT did not seem to enhance economic growth in developing countries (Papaioannou & Dimelis, 2007; Yousefi, 2011). Albiman and Sulong (2016) through a nonlinear impact analysis, observed that fixed telephone lines, mobile phones, and the internet hindered economic growth in Sub-Saharan African (SSA) countries. Pradhan et al (2015) indicated that ICT doesn't seem to significantly influence the long-term economic growth of Arab oil and gas producers, as well as Western Asian nations. Morawczynski and Ngwenyama (2007) argue that merely

investing in ICT in certain African countries isn't sufficient to spur economic development. Furthermore, in less advanced economies, ICT could negatively impact the employment and labor market due to workers' low productivity in digital skills, leading to a rise in unemployment (Aghion & Howitt, 1998). A significant challenge for developing countries in adopting ICT has been the inadequate investment in ICT-related education, an issue that became prominent during the COVID-19 pandemic (Prasojo et al., 2019). Other hurdles include difficulties in policy formulation, legal frameworks, implementation, and evaluation (Makoza, 2019). Touray et a (2013) pinpointed several key barriers to ICT adoption in developing countries, such as a lack of internet exchange points and challenges related to micromanagement. Bahrini and Qaffas (2019) emphasised that MENA countries should bolster their investments in ICT infrastructure to enhance economic growth and mitigate the adverse impacts of inflation and government consumption. To date, studies examining the role of ICT in economic growth have yielded mixed results, necessitating a deeper dive into the influence of ICT components on the economic growth of the Arab region (Gheraia et al., 2022).

There are some macroeconomic factors can be controlled to pinpoint the influence of ICT on economic growth. Pradhan et al (2018) identified crucial variables, such as the consumer price index, labor force participation rate, and gross fixed capital formation, to control for the effect of ICT on GDP per capita. Bojnec and Fertő (2012) considered labor productivity growth, trade openness, and inward FDI as control variables to determine the impact of broadband availability on economic growth. To study the long-term effect of ICT on economic growth, Albiman and Sulong (2016) accounted for human capital, institutional quality, financial development, trade openness, and domestic investment. In recent study, Belloumi and Touati (2022) focus on FDI inflows as a control variable in Arab region to explore the long-term effect of ICT on GDP per capita, similarly, Soomro et al (2022) controlled for trade and DFI in a study focused on BRICS countries**.** From an empirical standpoint, there seems to be a gap in examining the impact of ICT on GDP per capita in the Arab world, especially during the global economic challenges of inflation, deflation, and in the aftermath of the COVID-19 pandemic. Hence, this study utilizes two primary control variables to discern the effect of ICT on GDP per capita both short-term and long-term. The first is inflation, measured by the annual consumer price, believed to substantially influence GDP per capita (Gotu & Tadesse, 2023; Zineb et al., 2022). The second is FDI, recognized as vital for technology dissemination (Keller, 2004). Other factors, including internal and external instrumental variables, should be taken into account, particularly when using system GMM estimators (Acheampong et al., 2019). A comprehensive discussion about control and instrumental variables will be provided in the methodology section.

Methodology

Data and Descriptive Analysis

This study employed various control and instrumental variables to explore the influence of ICT on GDP per capita. The selection of these variables drew inspiration from existing literature (Albiman & Sulong, 2016b; Ali et al., 2020; Bahrini & Qaffas, 2019). Furthermore, the data were sourced from the World Development Indicator, a publication by the World Bank. Particular emphasis was given to data encompassing 17 Arab countries[1] between 2012

[1] Algeria, Kuwait, Libya, Morocco, Qatar, Syrian Arab Republic, United Arab Emirates, Yemen, West Bank and Gaza, Tunisia, Saudi Arabia, Oman, Lebanon, Jordan, Iraq, Egypt and Bahrain.

and 2021. With a total of 153 observations, the panel data is well-balanced. The dependent variable in this study is GDP per capita. The independent variables representing ICT comprise three main components:

- ln_IUI, signifying the percentage of the population using the internet;
- ln_FTS, denoting the number of fixed telephone subscriptions per 100 inhabitants; and
- ln_MSC, which corresponds to the number of mobile cellular subscriptions per 100 people.

The reason for choosing and focusing on these particular independent variables is that these components are widely used by both individuals and public sectors in the Arab region. Furthermore, to account for any notable contributions from the variables mentioned above to the GDP per capita in Arab countries during the period in question, two control variables were integrated into the model. These are:

- ln_FDI, representing foreign direct investment as a proportion of GDP, and
- ln_I, which is the inflation rate measured by annual consumer prices.

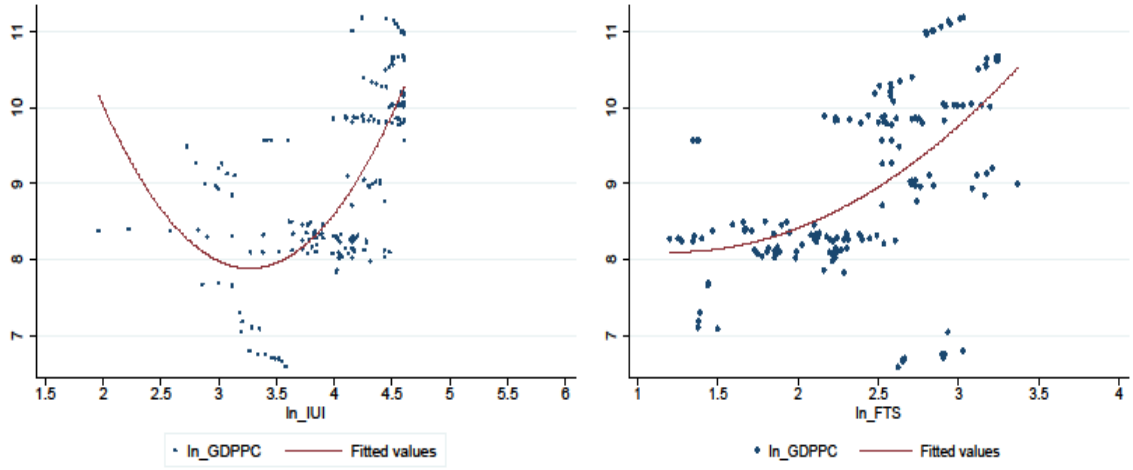
It's pertinent to note that all variables were transformed into their natural logarithms. Taking the logarithm of variables simplifies the model fitting process by stabilizing variance and normalizing the distribution of the variables.

Table 1 shows the descriptive statistical analysis of the data, differentiating the variability both between and within groups. The overall mean (in logarithm) for GDP per capita (ln_GDPPC) is 8.964, with a standard deviation of 1.137. This indicates a noticeable variability in the data, with values spanning from 6.588 to 11.196. The between-group standard deviation, standing at 1.116, signifies the dispersion of GDP per capita values across different groups. The values in this category fluctuate between 7.025 and 11.072, highlighting pronounced disparities in GDP per capita across countries. In contrast, the within-group standard deviation is 0.337, signalling the variation in GDP per capita within each group. These values extend from 8.077 to 11.516, denoting some variability within individual countries, albeit less pronounced than between different countries. Furthermore, the analysis of the ICT variables in the panel dataset reveals the following average values: 3.977 for individuals using the internet, 2.384 for fixed telephone subscriptions, and 4.649 for mobile cellular subscriptions. Their respective standard deviations are 0.556, 0.546, and 0.541, indicating a moderate spread. The between-group standard deviations underscore significant differences in ICT components amongst Arab countries. Such disparities suggest that some countries exhibit either higher or lower ICT levels relative to others. Conversely, the within-group standard deviation values for ICT components point to variations in ICT levels within countries over the period, albeit these are relatively minor compared to between-country variability. Of note is that the number of mobile cellular subscriptions boasts the highest median compared to both the percentage of individuals using the internet and fixed telephone subscriptions in Arab region countries (as detailed in Table 1).

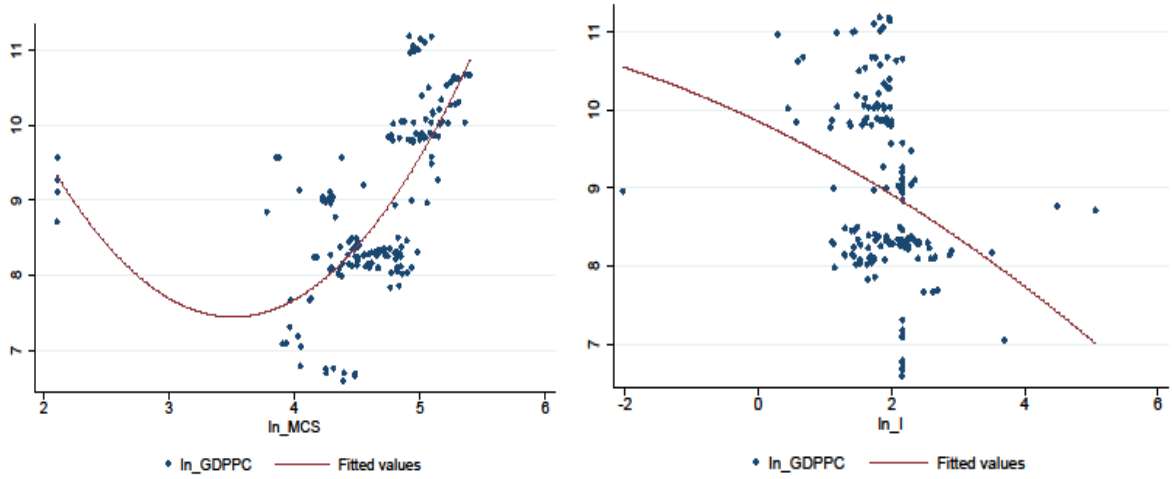
Table 1
Descriptive Statistics for The Period 2012-2021

Variable		Median	Mean	Std.Dev	min	max
ln_ GDPPC	overall	8.499	8.964	1.137	6.588	11.196
	between			1.116	7.025	11.072
	within			.337	8.007	11.516
ln_IUI	overall	4.152	3.977	.556	1.960	4.605
	between			.508	2.971	4.556
	within			.255	2.705	4.644
ln_FTS	overall	2.485	2.384	.546	1.200	3.367
	between			.541	1.394	3.208
	within			.146	2.005	2.971
ln_MCS	overall	4.766	4.649	.541	2.109	5.399
	between			.415	3.789	5.293
	within			.359	2.596	5.628
ln_I	overall	1.914	1.897	.642	-2.033	5.066
	between			.347	1.550	2.653
	within			.545	-2.260	4.840
ln_FDI	overall	1.819	1.685	.633	-2.133	2.779
	between			.495	.446	2.249
	within			.410	-0.895	3.066

Figure 1 depicts the behavior of individuals using the internet, represented as a percentage of the population, in relation to GDP per capita. There appears to be a positive association between the two variables, indicating that an increase in ln_IUI typically correlates with an enhancement in the value of ln_GDPPC. Similarly, a consistent relationship exists between ln_FTS and ln_ GDPPC. In Figure 2 the fitted curve appears to follow a U-shaped. Initially, the curve starts high, decreases to a minimum point, and then starts to increase again. This suggests that there are diminishing returns at first, followed by significant gains in GDPPC with higher levels of ln_MCS usage. This could be interpreted as an initial investment phase where infrastructure and usage are being developed and not yet fully economically productive, followed by a phase where the infrastructure and usage levels reach a critical mass that significantly contributes to economic growth in Arab region countries. Understanding this point can help policymakers and business leaders in strategising investments in ICT infrastructure and services. Conversely, a negative association is observed between ln_I and GDPPC, as anticipated. Notably, all ICT components display a positive relationship, suggesting their potential to bolster the value of GDPPC. However, it is worth noting that this descriptive data analysis might reflect not only the causal relationship but also potential endogeneity bias. Hence, obtaining more robust empirical evidence via system GMM analysis is essential to definitively ascertain the relationship between ICT and GDPPC.



Figures 1: Bivariate relationship between internet, fixed telephone and GDP per capita



Figures 2: Bivariate relationship between Mobile cellular, inflation and GDP per capita

Method

The theoretical foundation of this study is rooted in the endogenous growth theory, complemented by an extensive array of related academic research. Championed by Romer (1990); Lucas (1988), the endogenous growth theory posits that economic growth is predominantly driven by internal factors rather than external ones. The theory accentuates that investments in human capital, innovation, and knowledge (particularly Information Technology) play pivotal roles in fueling economic growth. Given this, the model for our study can be represented by the equation:

$$lnGDPPC_{it} = B_0 + B_1 lnGDPPC_{it-1} + B_2 lnIUI_{it} + B_3 lnFTS_{it} + B_4 lnMCS_{it} + B_5 lnFDI_{it} + B_6 lnI_{it} + \varepsilon_{it}$$

This equation is a logarithmic linear regression, where $lnGDPPC_{it}$ represents the GDP per capita (constant 2015 US$) for a given location *i* in each country in the panel dataset, and t indicates the time period. B_0 is the intercept, representing the expected value of $lnGDPPC_{it}$ when all independent variables are zero. The term $B_1 lnGDPPC_{it-1}$ incorporates the lagged GDP per capita to capture its influence from the prior time period "t-1" on the current GDP per capita. The coefficient B_1 measures this association and its statistical significance is crucial to affirm the model's dynamic specification. $B_2 lnIUI_{it}$, $B_3 lnFTS_{it}$ *and* $B_4 lnMCS_{it}$

represent estimated parameters for independent variables: percentage of the population using the internet, the number of fixed telephone subscriptions per 100 inhabitants and the number of mobile cellular subscriptions per 100 people respectively). While the $B_5 lnFDI_{it}$ and $B_6 lnI_{it}$ stand for control variables, representing foreign direct investment as a percentage of GDP and inflation rate gauged by annual consumer prices, respectively and ε_{it} is the error term.

The coefficient of variables in this study was estimated using the two-step system GMM (Generalised Moment of Method). The GMM approach, extensively applied in econometrics—particularly in panel data analysis—defines specific moment conditions for the regression model (Wooldridge, 2010). The two-step system bolsters the estimator's robustness and efficiency. The adoption of this method is justified for several reasons: **Heteroskedasticity and Autocorrelation**: The GMM is robust to the presence of heteroskedasticity and autocorrelation within panels. This makes it a valuable approach when such issues are detected (Arellano & Bond, 1991; Arellano & Bover, 1995). **Endogeneity:** The model incorporates the orthogonality condition, ensuring consistent estimates of the coefficient even in the presence of endogeneity and unobserved effects specific to each country (Blundell & Bond, 1998). Furthermore, when explanatory variables are potentially endogenous, the GMM method employs instrumental variables to account for this endogeneity. As a result, there's a careful need for a judicious selection of instruments to avert overfitting.

In this study, the external instrumental variables encompass the labour force participation rate, trade, inflation, tertiary school enrolment, and the government efficiency index. The latter comprises the following indicators: Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence, Regulatory Quality, Rule of Law, and Voice and Accountability. These instrumental variables indirectly influence the dependent variable, channeling their effects through the endogenous explanatory variables. This permits the instrumental variables to segregate the variation in the endogenous explanatory variables that is unrelated to the error term, ensuring the derived coefficients are consistent and unbiased. Conversely, the internal instrumental variables include lagged GDP per capita and general government final consumption expenditure. Leveraging internal instruments is a strategic approach to address endogeneity, yielding more precise and dependable parameter estimates (Blundell & Bond, 1998). Additionally, the model integrates the diagnostic tests of Hansen and Arellano Bond (AR2) to scrutinise serial correlation and the validity of the (rellano and Bond, 1991; Hansen, 1982).

Result

Results derived from the two-step system GMM model are presented in two tables. Table 2 illustrates short-term results from the system GMM, while Table 3 details long-term outcomes, focusing only on factors that significantly influenced GDPPC in the short term. Diagnostic tests, including the Arellano Bond (AR2) and Hansen, are also documented in Table 2. The AR(2) test, as reported, is insignificant, suggesting an absence of second-order serial correlation in the regression. This confirms no evidence of model misspecification. Concurrently, the Hansen test endorses the null hypothesis, elucidating that the instruments are aptly specified and remain uncorrelated with the error term. It is pivotal for the instrument count to be fewer than the group count, safeguarding against overfitting and potential bias. This emphasises that the instruments are valid and the model is correctly specified. (as shown in Table 2). Furthermore, the data output underscores the significance

of lagged GDP per capita, underpinning that the model operates as a dynamic system and validates the correct construction of the GMM approach.

Table 2
Estimates of Dynamic Panel Data with System GMM for Short Run

Dependent variable: ln_GDPPC				
Variables	Coefficient	Std.Error	t-statistic	Prop
lnGDPPC				
L1.	.91314	.01408	64.84	0.000
ln_IUI	.08650	.09975	2.56	0.021
ln_FTS	.14122	.01699	8.31	0.000
ln_MCS	-.07264	.00767	-9.47	0.000
ln_FDI	-.03032	.02180	-1.39	0.183
ln_I	-.02100	.01012	-2.07	0.055
Constant	.52887	.11120	4.76	0.000
No. of Observations	153			
No. of Groups	17			
No. of Instruments	7			
Arellano Bond AR (2)	0.197			
Hansen Test	0.215			

Table 3
Estimates of Dynamic Panel Data with System GMM for Long Run

Variables	Coefficient	Std.Error	z-statistic	Prop
ln_IUI	.99600	.32904	3.03	0.002
ln_FTS	1.62599	.36174	4.49	0.000
ln_MCS	-.83636	.11204	-7.46	0.000
ln_I	-.24187	.09480	-2.55	0.011

Table 2 details the significant findings of the study. In the countries observed, GDP per capita is positively influenced by the percentage of individuals using the internet (ln_IUI) and the number of fixed telephone subscriptions (ln_FTS). Specifically, a 10% increase in both internet usage and fixed telephone subscriptions leads to a respective rise in GDP per capita by 0.8650% and 1.4122%. Looking forward, Table 3 suggests that in the long run, these figures are expected to escalate further, with internet usage and fixed telephone subscriptions projected to boost GDP per capita by 9.9600% and 16.2599%, respectively. It's evident that fixed telephone subscriptions exert a considerably greater positive effect on GDP per capita than internet usage, both in the short and long term. Conversely, mobile cellular subscriptions (MCS) have a marked negative influence on GDP per capita in both timelines. The data highlights that a 10% rise in mobile cellular subscriptions could depress GDP per capita by -0.7264% in the short term and by a more pronounced -8.3636% in the long term. Notably, while descriptive analysis previously suggested a positive link between mobile cellular subscriptions and GDPPC, this association was likely skewed by endogeneity issues. Such discrepancies underline the limitations of relying solely on descriptive analyses, like scatter plots, which might present a distorted picture. The system GMM method, on the other hand, strives for consistency by leveraging specific moment conditions, thereby unveiling potentially contrasting relationships. Furthermore, the inflation rate also emerged as a

detrimental factor for GDP per capita. A 10% upswing in the inflation rate could trim GDP per capita by -0.2100% in the immediate term, with this negative effect intensifying to -2.4187% over a prolonged period. However, the study observed no significant correlation between foreign direct investment and GDP per capita.

Discussion and Policy Recommendations

The central question of this study is to determine the impact of ICT, specifically the most commonly used technologies in the Arab region internet usage, the number of fixed telephones, and the number of mobile cellular devices on GDP per capita. The analysis considers the controlling factors of inflation and foreign direct investment over the period from 2012 to 2021. Limited research has addressed the effect of ICT on GDP per capita within Arab nations Bahrini & Qaffas (2019); Soomro et al (2022), especially in the wake of macroeconomic upheavals such as inflation and deflation prompted by the COVID-19 pandemic. Our research utilises a dynamic panel data analysis through the system GMM approach, which offers advantages over other estimation methods (Arellano & Bover, 1995; Blundell & Bond, 1998). Notably, the two-step system GMM enables the specification of both internal and external instrumental variables. The external set includes labour force participation rate, trade, inflation, tertiary school enrolment, and a government efficiency index comprising Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence, Regulatory Quality, Rule of Law, and Voice and Accountability. The internal instruments, on the other hand, encompass lagged GDP per capita and general government final consumption expenditure. These instruments are employed to account for potential endogeneity, bias, and inconsistency of country effects in both short and long-term analyses. The appropriateness of these instrumental variables is affirmed by the Hansen test (Hansen, 1982). It's worth noting that our methodology differs from that of Hodrab et al (2016) who used fixed and random effects to explore the impact of ICT on economic growth in the Arab world.

The findings outlined in Table 2 demonstrate that the percentage of individuals using the Internet (IUI) and the number of fixed telephone subscriptions per 100 inhabitants (FTS) positively influence GDP per capita in Arab countries. Specifically, a 1% rise in IUI and FTS enhances GDP per capita by 0.09% and 0.14% respectively in the short term. These outcomes align with Sassi and Goaied (2013) who highlighted the positive impact of fixed lines and the internet. It confirms the suggestion of endogenous growth theory Romer (1990) that knowledge and technological advancements, notably ICT, bolster economic growth. However, the influence of mobile phones on GDP per capita presents a contrasting picture. The study points to a negative impact of mobile phone on GDP per capita.

In the long term, both IUI and FTS maintain their positive significance in influencing GDP per capita. This supports Albiman and Sulong (2016a) findings regarding the internet and fixed lines' long-term positive impact on economic growth, though discrepancies arise concerning the mobile phone component. Bahrini and Qaffas (2019) observed that, aside from fixed telephone lines, ICT elements such as mobile phones, the internet, and broadband positively influence GDP per capita in the Middle East, North Africa, and Sub-Saharan Africa. Yet, this study indicates that, barring mobile phones, other ICT elements positively contribute to GDP per capita in Arab nations. Many of the study's outcomes resonate with findings from prior research (Appiah-Otoo & Song, 2021; Belloumi & Touati, 2022; Roger et al., 2021; Tripathi & Inani, 2020). However, discrepancies arise concerning the relationship between mobile phone adoption and GDP per capita, particularly within the specific context of the Arab region.

Although preliminary analyses revealed a positive correlation between mobile cellular subscriptions and GDP per capita, further examination using the system GMM highlighted a negative influence both in the short and long term. This situation might be explained by market saturation and dynamics in places where there is already a high penetration of mobile phones. In such economies, further increases in mobile phone numbers may not have a significant impact on economic growth. As the market approaches full saturation, the additional benefit of each new mobile phone tends to diminish, especially if the new subscriptions offer minimal improvements in connectivity and productivity. Furthermore, if Arab nations predominantly import mobile technologies without witnessing proportional surges in productivity and innovation, it could result in these observed discrepancies.

The coefficient for FTS, when compared to IUI and MCS in the Arab region, is notably higher both in the short and long term. A plausible reason for this might be that FTS benefits from an established infrastructure that predates both IUI and MCS. This is particularly true given the vital role telecommunication played in its early days for companies. Businesses likely regard FTS as more consistent and dependable compared to mobile connections, which can be inconsistent in some areas. Furthermore, the minimal impact of internet usage in the Arab region might be due to several factors. These include the high costs associated with ICT, inadequate institutional frameworks, limited investment in ICT, or monopolies prevalent in the region's telecommunication industry. Such challenges could hinder the region's economic evolution towards a more digitised economy. Another considerable impediment to economic growth is inflation. The study's empirical findings corroborate the significant negative correlation between inflation and GDP per capita, a conclusion that aligns with findings from (Barro, 2013; Olamide et al., 2022). Interestingly, Yi and Choi (2005) observed a negative correlation between internet usage and inflation. This might suggest that harnessing ICT could potentially mitigate the adverse effects of inflation on the Arab world's GDP per capita. Conversely, the data from Tables 2 and 3 highlight a negligible and non-significant impact of foreign direct investment flows (FDI) on GDP per capita. Presently, the reliability of ICT infrastructure, particularly internet connectivity and mobile services, isn't sufficient to attract FDI to the Arab region.

The results of this study indicate a few key policy recommendations. First, it is crucial to establish robust legal and regulatory frameworks to oversee foreign direct investment and the mobile phone sector, which will ensure fair competition and prevent monopoly. Second, investments should be made in infrastructure that supports both physical and digital connections, which will amplify the advantages of mobile technology and create a more appealing environment for sustainable foreign investment. For example, the promotion of mobile banking and financial services could enhance financial inclusion, decrease transaction costs, and contribute to economic stability, possibly reducing inflation.

Conclusion

ICT has the potential to augment human capabilities and enhance the quality of life through technological advances. Endogenous growth theory posits that knowledge and technology are catalysts for economic prosperity, while human capital theory emphasises the role of education and innovation in increasing individual wealth. This study sought to validate these theories, examining the hypothesis that ICT elements, particularly internet usage and fixed telephone numbers subscriptions, positively impact GDP per capita in Arab countries. Many Arab countries face challenges with inadequate ICT infrastructure and high inflation, issues that were exacerbated during the COVID-19 pandemic, slowing economic growth. Integrating

ICT presents a potential remedy to these problems. Extensive research underscores the positive effects of ICT on economic growth, productivity, and innovation. However, there is a significant gap in research on how ICT can specifically benefit the economies of Arab countries specially, during Covid-19 pandemic. Therefore, this was examined between 2012-2021, taking inflation and direct foreign investment into account. A two-step system GMM model was employed to dissect dynamic panel data. This approach facilitated the incorporation of various internal instrument variables, like lagged GDP per capita and general government final consumption expenditure, and external ones such as the labour force participation rate, trade dynamics, inflation, tertiary school enrolment, and government efficiency metrics. These instruments were pivotal in mitigating endogeneity and bias, ensuring the reliability of the results.

This research makes a substantial contribution to the digital economy field in various ways. Firstly, it distinctly emphasises certain Arab countries, differing from numerous previous studies that mainly concentrated on developing regions or the MENA or SSA countries. Secondly, it employs the latest available panel data, including the period of the COVID-19 pandemic, which was characterised by significant global macroeconomic challenges like inflation and deflation. Thirdly, it provides policy recommendations targeted at governments and stakeholders to promote the incorporation of ICT in their economic development strategies.

Our research reveals that internet usage and fixed telephone numbers have a notably positive effect on GDP per capita, both short-term and long-term. However, the proliferation of mobile cellular devices hasn't translated into economic advantages for Arab nations. One plausible explanation could be the diversion of mobile devices towards non-economically productive activities. Further exacerbating this scenario is the deflation triggered by the COVID-19 pandemic, coupled with the underutilisation of mobile technology, which might have amplified the adverse inflationary effects on GDP per capita. Interestingly, fixed telephone subscriptions emerged as the most potent contributor to GDP per capita, possibly proving crucial during pandemic-induced lockdowns. These findings intimate that Arab policymakers should pivot towards heavier ICT infrastructure investments, especially in fixed telephony, which showed more GDP per capita benefits than mobile phones. Additionally, there's an evident need to revamp the financial sector, optimising internet connectivity to harness the full potential of smartphones in online banking scenarios. In sum, to counteract the detrimental GDP effects, Arab nations need to bolster government efficiency, offer digital skill training in professional arenas, and devise strategies to manage FDI influxes, mobile adoption, and inflation rates. Adopting such strategies could spearhead the Arab region's transition to a more digitally-oriented economy.

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