The Dynamic Impact of Financial Inclusion and ICT Diffusion on Sustainable Economic Development: Evidence from the MENA Region

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Abstract

This study investigates the dynamic relationship between financial inclusion, ICT development, renewable energy, and sustainable economic growth in the MENA region. Recognizing the growing importance of these factors in shaping the trajectory of sustainable economic development. This paper aims to contribute to the existing literature by providing new evidence from the MENA region, on how the interaction between financial inclusion and ICT development can lead to higher economic growth. This Study examines the impact of ICT diffusion and financial inclusion on economic growth by using an economic growth model that incorporates the joint effect of these two factors. The study employs dynamic panel system GMM estimation and focuses on a sample of 15 countries in the MENA region from 2004 to 2021. The findings reveal significant and positive associations between financial inclusion, ICT development, and sustainable growth in the MENA region. The findings reveal that financial inclusion has a positive effect on growth, ICT is expected to enhance growth by improving digital skills and increasing the efficiency of the financial market, particularly in the banking sector. Effective use of ICT, such as branchless banking and mobile banking, can be cost-effective and improve financial accessibility for previously marginalized individuals, thereby fostering financial inclusion. The interaction effects between ICT diffusion and finance are positive, indicating that the combined impact of ICT and financial inclusion can mitigate the negative effects of ICT investments.

Introduction

Sustainable economic development is defined by World Commission on Environment and Development as "development that meets the needs of the present, without compromising the ability of future generations to meet their own needs". It becomes a critical goal for many countries worldwide, particularly in the Middle East, where government's priorities are focused on diversifying their economies and reducing dependence on natural resources.

Sustainable economic development is acknowledged to be achieved by many contributors, from the most important sectors in literature that contribute significantly to sustainable economic development are the financial inclusion, information and communication technology advancements and recently the renewable energy consumption. The objective of financial system development is to increase access to financial services for the poorer segments of the economy, a financial inclusion strategy will need to be designed to include those who are financially disadvantaged and excluded. The development of a financial system is proportional to the extent to which it expands access to financial services for economically disadvantaged segments of the population. The financial institutions play a very important role in the fulfillment of the financial inclusion initiatives, in which they can offer individual and businesses appropriate and inexpensive financial services and products, allowing them to obtain credit and insurance, conduct financial transactions, make payments, save and any other services that enhance the quality of life. These services must be offered in a cost-effective and sustainable manner.

In recent years, the importance of financial systems' development, and by extension, financial inclusion enhancement, to economic growth has grown even more. Financial inclusion is becoming a more pervasive issue that requires attention from all stakeholders in society, indicating its importance for research. Financial inclusion is a challenge that governments are grappling with, and they are devising various strategies to address it.

It is noticed also that the rapid development of information and communication technology (ICT) become one of the significant drivers of economic growth. ICT improves the efficiency of many different economic activities by increasing the availability of information, forming new communication ways, reformatting production processes, and increasing the availability of information. Internet users continue to expand around the world as ICT and telecoms evolve at a rapid pace. This indicates that the ICT sector has become an important source of revenue for many nations.

The Nations are struggling to maintain the economic development especially in the situation of climate changing and global warming. Concerns regarding the consumption of fossil fuels have increased as a

result of the environmental effects of global warming and greenhouse gas emissions; consequently, renewable energy sources have become an important component of the world's energy consumption. The most important aspects of renewable energy sources are their ability to reduce carbon dioxide emissions and their contribution to environmental protection. Theoretically, fossil fuels are believed to be able to renew themselves for a very long time, but they are in imminent danger of becoming extinct. Previous studies have demonstrated that traditional fossil fuels (such as coal, natural gas, and oil) promote economic growth. However, the excessive use of nonrenewable resources causes a greenhouse effect by releasing a large amount of CO2 into the atmosphere. According to the World Resource Institute (WRI), more than one-third of the world's greenhouse gas emissions are produced by conventional energy sources. In a similar vein, Hamit-Haggar emphasized that greenhouse gas emissions assessment had become an integral component of the international climate policy agenda. Currently, a nation is required to have renewable energy sources (such as hydro, geothermal, wind, solar, wave, tidal, and biomass) with sustainable and non-polluting growth. The reduction of global greenhouse gas emissions has become the primary global objective for environmental sustainability and economic development.

While numerous studies have examined the individual contributions of financial inclusion, ICT development and renewable energy consumption to economic growth, few have analyzed the dynamic interactions between ICT development, financial inclusion initiatives and the renewable energy consumption and their impact on enhancing economic development.

In this context, the primary objective of our study, after re- examining these individual relationships in the MENA region countries, is to examine the dynamic association between ICT, financial inclusion, renewable energy consumption and economic development.

The structure of the research is divided into five sections. In Section 2, the researchers provide a brief review of the relevant literature and a discussion of the research hypotheses. The third section describes the empirical method used to observe the relationships between the variables. Section 4 presents the empirical findings. In light of the observed results and the conclusions presented in Section 5, the researchers recommend a number of policy implications.

Contextual Literature and Hypotheses Development

Financial inclusion, information and communication technology (ICT) and renewable energy as three major economic development tools are important for increasing a country's wealth, so it has piqued interest, as evidenced by the literature. Financial inclusion and economic development, ICT and economic development as well as renewable energy consumption and economic development, have been linked in the

literature. The interlinkage between financial inclusion, ICT development, renewable energy consumption and economic development is a topic that has received little attention in the literature. The researchers will look at all four relationships in this section, as well as the hypotheses that will be investigated in this study.

Nexus between financial inclusion and economic development

Financial inclusion refers to the supply of financial services (as saving opportunities, insurance and credit) to the public, with a particular emphasis on/targeting underprivileged segments of the public who may not otherwise have access to regular financial services. The financial inclusion plan encourages the use of financial services by previously excluded and unbanked people. The literature discussed the function of financial inclusion in inducing the economic development and drew both direct and indirect connections between a variety of issues, including poverty reduction, financial stability, firm growth, and gender equality, among others. In this regard, the current section examines financial inclusion and growth and economic performance issues in general. For example: S.R. Paramati et al. (2021) investigated the impact of financial inclusion and trade openness on the economic development of 27 European Union (EU) nations, the sample countries were classified into low-income, high-income, old-EU, and new-EU. To achieve the study's objectives, annual data from 1995 to 2015 and panel econometric techniques were utilized to control for a variety of variables, including capital, energy use, labor, and trade openness. The results showed that financial inclusion has played a significant and positive role in enhancing the economic performance of EU countries, is significantly greater in new-EU and low-income EU countries, where there is significant room for market expansion and development.

Focusing on Sub-Saharan Africa, Anarfo and Abor (2020) investigated stability in terms of financial inclusion. The findings suggest that the interaction between financial regulation and financial stability has a moderate impact on the inclusion drive in these nations. Some other studies investigated the effect of financial inclusion on financial stability in SMEs, some evidence found that increasing the proportion of lending to SMEs promotes financial stability. (Morgan and Pontines, 2018). Lobez & Winkler similarly investigated whether financial inclusion improves financial market stability by reducing the financial crisis. The study examined episodes of global financial crisis and found that countries with greater financial inclusion are better equipped to mitigate credit busts during times of financial turmoil.

Other studies have investigated whether financial inclusion improves gender equality by focusing on gender-based financial discrimination. (Botric and Broz, 2017; Ogunleye, 2017; Kairiza et al., 2017). Multiple studies have found that financial inclusion has positive effects on alleviating poverty. (Burgess and Pande, 2005; Park and Mercado, 2018; Inoue, 2019).

The purpose of some other studies was to examine the bidirectional association between the financial inclusion and the financial and economic development. (Pradhan et al., 2020a; Kim et al., 2018; Pradhan et al., 2018; Rasheed et al.,2016; Pradhan et al., 2013; Pradhan and Arvin, 2016; Nkwede, 2015; Sahay et al., 2015; Nirupam and Chhikara, 2013; Mohan, 2006). Rasheed et al.,2016 study was to determine whether financial inclusion can support financial development. Using a panel of 97 nations between 2004 and 2012, the researchers investigated the factors that influence financial development using the system generalized method of moments (System GMM). The findings discovered that financial inclusion had a positive and considerable impact on financial development. The improvement of financial inclusion presupposes financial development and subsequently economic development because the GDP per capita and financial development have a positive and significant relationship.

Based on the above discussion, we hypothesize the following:

H1: Financial Inclusion positively affect the economic development.

The rationale behind this hypothesis is that access to the necessary credit and the other aforementioned supporting financial services enables economic agents to use the financial resources optimally to develop their businesses and invest in endeavors that yield high returns on investment that are beneficial to the economy.

Nexus between ICT diffusion and economic development

ICT have a significant impact on the economy as a whole and is recognized as a contributing factor to economic growth. Not only is the use of ICT in business becoming more widespread, but its applications are also becoming more advanced and complex.

Particularly for innovation, competitiveness, and sustainability, the role of ICT in economic development is acknowledged. ICT utilization enhances market functioning, promotes trade, and leads to employment and demand growth.

Many research studies tried to explore the impact of ICT development on the economic growth, but the empirical studies conducted prior to the 1990s failed to provide substantial evidence that could validate the influence of ICT on economic growth. Then subsequent empirical research findings suggested a positive association, particularly in developing countries.

Dewan and Kraemer (2000) studied a sample of 36 countries and found a positive relationship between ICT and growth, specifically in developing countries. Roller and Waverman (2001) who focused on telecommunication networks, concluded that their impact on growth is significant after reaching a certain level of infrastructure development. Quah (2003) highlighted that ICT overcomes constraints of time and

space, facilitating the rapid delivery of information, increasing market transparency, and reducing information asymmetry.

Lee, Gholami, and Tong (2005) examined causality between ICT investment and growth in 20 countries, finding that ICT investment stimulates growth in developed countries, while the causality is from growth to ICT investment in developing countries. Other researches demonstrated a significant positive effect of ICT capital and investment on economic growth (Daveri, 2002; Colecchia & Schreyer,2002; Jorgenson & Vu, 2005).

Other cross-country studies, employing different methodologies such as Generalized Method of Moments (Nasab and Aghaei 2009; Vu 2011), have also supported the positive relationship between ICT and growth. A more recent study by Bahrini and Qaffas (2019) highlighted the internet and broadband usage as drivers of growth in the MENA region and established its superiority over SSA countries in this regard.

Recent studies highlighted the internet and broadband usage as drivers of economic growth (Brewer et al., 2005; Crandall, Lehr, & Litan, 2007; Bouras et al., 2009; Kathuria, Uppal & Mamta, 2009; Czernich et al., 2011; Bojnec & Ferto, 2012; Ghosh, 2016)

In their two research papers (2017a & 2017b) Pradhan, Arvin, Nair, Bennett, and Bahmani examined a broader range of ICT tools such as main lines, mobile phones, internet servers, users, and fixed broadband, to highlight the linkage between ICT and the FDI-Growth nexus in for Next-11 countries (2017a) and in Asian-21 countries(2017b), they found a long-run relationship and Granger causality between telecommunications infrastructure and usage, Foreign Direct Investment and economic growth. Similar results were obtained by Pradhan, Mallik, and Bagchi (2018b) who employed panel co-integration with selected G-20 countries to demonstrate that growth and ICT infrastructure are co-integrated and remain aligned in the long run. Another study by Pradhan, Mallik, Bagchi, and Sharma (2018c) expanded the analysis to include stock market development in EAGLEs (emerging and growth-leading economies) and found a long-run relationship and Granger causality among ICT penetration, growth, and stock market development.

On contrary, some studies have argued that ICT may have a negative impact on economic growth.

One argument suggested that the rapid expansion of ICT could lead to a decrease in the employment of unskilled workers, thus negatively affecting labor markets and subsequently hindering economic growth (Freeman et al., 1995; Aghion et al., 1998).

Results of some other empirical studies in literature have presented mixed evidence. Pohjola (2001) found a positive relationship between ICT and economic growth in 23 OECD countries but not in the other 16 countries based on data from 1980 to 1995. Hassan and Islam (2005) also

reported mixed findings, supporting the positive effect of ICT diffusion on economic growth in the overall sample of 95 countries but observing exceptional results in eight Middle Eastern and North African (MENA) countries. Yousefi (2011) investigated the contributions of ICT and other production factors to economic growth in 62 countries, finding that ICT can enhance economic growth in high- and upper-middle-income countries but not in lower-middle-income countries. Ishida (2015), focusing on Japan, found that ICT investment did not contribute to GDP growth using the autoregressive distributed lag boundary test.

Based on the above discussion, we hypothesize the following:

H2: There is a significant positive relationship between ICT diffusion and economic growth.

Renewable Energy and Sustainable Economic Development

Renewable energy refers to the utilization of energy derived from sources that are continuously available and considered infinite (Dawn Stover, 2011). These sources include solar, wind, rain, tide, wave, and geothermal energy. The term "infinite" can be understood in two ways: first, it pertains to energy sources that are abundant and cannot be depleted, such as solar energy, wind energy, and water energy. Second, it refers to energy sources that can be self-renewed in a short period and consistently replenished, such as biomass energy. Biomass energy involves the conversion of organic materials or plant-derived substances into clean energy sources that serve various economic and social activities. Unlike some energy sources that are limited to specific countries, renewable energy sources are available across many geographical regions.

The prudent utilization of renewable energy, plays a crucial role in fostering environmentally sustainable economic expansion (Chen et al., 2007; Apergis & Danuletiu, 2014; Bildirici, 2014). The influence of renewable energy consumption on economic growth varies across different regions. For instance, the findings of Tugcu, Ozturk, and Aslan (2012) work demonstrated that both renewable and non-renewable energy sources significantly contribute to enhancing economic growth. Marinaş et al. (2018) and Lee (2019) found substantial evidence of a positive association between renewable energy consumption and sustainable economic growth, likely due to its ability to mitigate negative environmental impacts. Also, research conducted by Fankhauser and Jotzo (2018), Ohene-Asare et al. (2020), and Kouton (2021) confirmed that improvements in energy efficiency can foster sustainable economic growth. Similar results were obtained by Le (2020) in 46 developing and emerging markets.

Conversely, Maji et al. (2019) arrived at an opposite conclusion, they examined the relationship between renewable energy consumption and economic growth in West Africa and found that it decreased the economic growth rate of those countries. This finding aligned with the

conclusions reached by Ahmed and Shimada (2019) and Sugiawan and Managi (2019).

Based on the above discussion, we will use the renewable energy as an important control variable in our models

The Joint Effect between ICT and financial inclusion on Economic development

Limited work in the existing literature focused on the joint effect of financial inclusion and ICT development on sustainable economic growth. (Schmied & Marr, 2016) concluded that enhancing financial inclusion facilitates the sharing of outcomes and narrowing of disparities. Financial inclusion has the potential to channel capital to rural areas using Internet technology and enable the equitable allocation of resources across different regions, fostering coordinated economic development. Moreover, financial inclusion can contribute to reducing income inequality through various means such as the distribution of income, lowering loan costs, and enhancing human capital. Furthermore, the study conducted by Ouyang and Li (2018) investigated the effects of financial inclusion and energy utilization on economic growth. The findings indicated that the use of non-renewable energy sources had a substantial positive impact on GDP growth. However, financial development was found to decrease energy consumption across all regions. These results were later validated by Al-Mamun, Sohag, Shahbaz, and Hammoudeh (2018) in their analysis of 25 OECD countries, as well as by Shahbaz, Van Hoang, Mahalik, and Roubaud (2017) in the case of applying in India.

Cui, L., Weng, S. & Song, M. (2022) employed the spatial Durbin model to examine the factors influencing the level of economic inclusive growth across various countries. Using panel data spanning from 2010 to 2020 and including 40 countries, they found evidence of a spatial autocorrelation in inclusive growth. Their analysis revealed that financial inclusion and renewable energy consumption positively contributed to inclusive growth. In other words, countries with greater access to financial services and a focus on sustainable energy sources tended to experience higher levels of inclusive economic growth. These findings underscore the significance of promoting financial inclusion and renewable energy adoption as means to foster economic development that benefits a wider range of people.

Some other research investigated the joint effect of ICT development, financial development and economic growth. Financial inclusion is a component of financial development whereas financial development pertains to the overall growth and sophistication of the financial system, financial inclusion specifically emphasizes expanding access to financial services and ensuring the participation of underserved populations. From these researches, Sassi and Goaied (2013) who extended the economic growth model proposed by Shamim (2007) by incorporating the

interaction effects of information and communication technology (ICT) and financial development. Their study, utilizing the generalized method of moments (GMM) approach, revealed a positive and significant relationship between the ICT-financial development interaction and economic growth in 17 countries in the Middle East and North Africa (MENA) region.

Similarly, Das et al. (2018) also examined the interaction effect between ICT and financial development in an economic growth model. By applying the GMM method to data from 43 developing countries spanning the period from 2000 to 2014, they demonstrated that the interaction effect of ICT and financial development can enhance economic growth in low-income countries. However, this effect was not observed in lower middle-income countries.

In summary, Sassi and Goaied (2013) and Das et al. (2018) both investigated the interaction effect between ICT and financial development on economic growth. Sassi and Goaied's study focused on MENA countries and found a positive relationship, while Das et al. analyzed a broader set of developing countries and highlighted the significance of this interaction for low-income countries but not lower middle-income countries.

Based on the empirical results presented above, the following hypothesis is proposed:

H3: The joint effect of financial inclusion and ICT development improves the sustainable economic development.

Figure 1: ICT diffusion and financial inclusion impact on economic growth
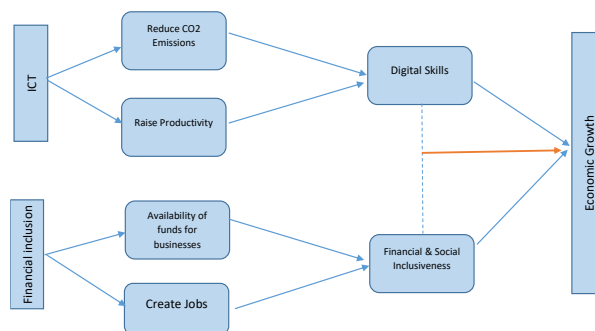
Source: Done by the Authors

Data & Methodology

The dataset used in this analysis was obtained from the World Development Indicators published by the World Bank. The dataset consists of annual data from a cross-section of 15 countries in the Middle East and North Africa (MENA) region covers the period 2000 – 2021. The specific countries included in the sample are listed in Appendix A.

The main variable dependent variable is the growth rate of per capita real GDP (GDPGR), which is used as a proxy for a country`s economic growth. In addition to the GDPGR, the model includes two key regressors which are ICT and an index that measures the degree of inclusiveness of a country`s financial system - FI. The financial inclusion index (FII) is constructed using two – stage principal component analysis (PCA). ICT – an index that is used to measure the degree of country`s readiness to move towards digitalization – is represented using three different indicators which are Mobile subscription (MU), the percentage of Internet users (IU), and fixed telephone users (FT).

Besides we used three control variables which are gross capital formation to GDP (GCF) as a proxy for investment, trade openness (TOP) and inflation (INF). A detailed explanation and description of the variables can be found in Table 1.

Constructing a more comprehensive variable to accurately represent financial inclusion proved to be a must for reliable and credible results. FI is a multidimensional concept that cannot be accurately captured by single indicators, such as bank account ratios, number of automated teller machines (ATMs), credits and bank deposits (Sarma, 2016; Nguyen, 2020 and Camara & Tuesta, 2014). Since when used alone, partial and incomplete information about the degree of comprehensiveness of the financial system is only provided. For this reason we construct an index for financial inclusion that measure the inclusiveness of the traditional financial system.

Thus, new variables were designed capturing *deposits, loans* and *payments* besides *saving and borrowing* of adults. These indicators are aggregated under two dimensions; access and usage of formal financial services (Beck *et al*, 2007; Honohan, 2008; Demirguc-Kunt and Klapper, 2012; Demirguc-Kunt *et al*, 2015, 2018.

Drawing inspiration from the methodologies introduced by Ang and McKibbin (2007), Gries et al. (2009), and Campos and Kinoshita (2010), we have opted to utilize four specific indicators for constructing our index. These indicators encompass the number of commercial bank branches per 100,000 individuals and per 1,000 kilometers, as well as the proportion of outstanding deposits and loans relative to GDP. To acquire the necessary data for these four financial development indicators, we obtained information from reputable sources such as the World Development Indicators (WDI) and the IMF Financial Access Survey data. Employing a multidimensional approach proposed by Ismael and Ali (2021), we have successfully created an index that captures various dimensions of financial development.

Econometric Model

This study extends the framework proposed by Sassi and Goaied (2013), to include the effect of financial inclusion, information and

communication technology (ICT) and the interaction between both on economic growth rate. Thus, the basic model is as follows:

$$Y_{it} = \alpha + \beta_1 GDPGR_{it\,-1} + \beta_2 ICT + \beta_3 FII_{it} + \beta_4 X_{it} + \varepsilon_{it}$$

The dependent variable is per capita GDP growth rate (GDPGR). The independent variables are ICT capture country`s readiness towards digitalization and FII which capture the inclusiveness of the traditional financial system. The control variables are renewable energy (REN), Gross Capital formation (GCF), trade openness as % of Real GDP, and Inflation rate. With the aim to examine whether ICT diffusion or financial inclusion are the key players in accelerating economic growth, both variables must be examined separately. Since ICT diffusion can significantly improve the operating efficiency of financial institutions and increase the inclusiveness of traditional financial system especially among unprivileged groups. Thus, an econometric model was used to test the interaction between both. The empirical results can help the policy makers and researchers to better understand why and how the interaction between both can boost economic development.

The estimated economic growth model for ICT diffusion and financial development as follows:

$$Y_{it} = \alpha + \beta_1 GDPGR_{it\,-1} + \beta_2 ICT + \beta_{34} X_{it} + \varepsilon_{it}$$

$$Y_{it} = \alpha + \beta_1 GDPGR_{it\,-1} + \beta_2 FI + \beta_{34} X_{it} + \varepsilon_{it}$$

Here, i = 1, 2, …., N (for the country), t = 1, 2, …., T (for the number of periods); where Y_{it} represents the output, GDPGR is the real GDP per capita, ICT development, FII is the financial inclusion index, Xit represents other control variables, β_0, β_1, β_2, β_3, β_4, and β_5 are the regression coefficients, and εit is the error term.

Finally, the economic growth model with interaction effects between ICT and financial inclusion is the following equation:

$$Y_{it} = \alpha + \beta_1 GDPGR_{it\,-1} + \beta_2 FI + \beta_3 ICT + \beta_4\, ICT^* FI + \beta_5 X_{it} + \varepsilon_{it}$$

This paper uses dynamic Generalized Method of Moments (GMM) proposed by Arellano and Bond (1991) and also was applied by C.Y. Cheng et al (2021) as method estimation. This estimation technique is particularly suitable for addressing challenges related to potential endogeneity, heteroscedasticity, and autocorrelation in panel data.

To address the possibility of reverse causality and endogeneity in our analysis, we employed a GMM dynamic framework and used lagged values of two or higher for the regressors as instrumental variables. This approach helps to mitigate biases and allows for a more robust estimation process and help address the potential endogeneity issue by capturing the effect of past values of the variables on the current values. The GMM method offers advantages over traditional Ordinary Least Squares (OLS) estimation when examining changes in financial variables. It accounts for

dynamics in the data by incorporating lagged values and addresses potential endogeneity concerns, resulting in more reliable estimates.

Moreover, to test for the validity of the dynamic panel data analysis, Arellano and Bond (1991) test was conducted. This test examines the correlation of the first-order series AR(1) and determines the relevance of the second-order series AR(2). By performing this test, we ensure that the model's assumptions hold and that the dynamic panel data analysis is appropriate for our study Furthermore, we employed the Sargan test to examine the potential over-identification of instrumental variables. This test helps determine whether the chosen instruments are not correlated with the error term in the model, ensuring that the instrumental variables used are valid and do not introduce bias.

According to the finding Bover (1995) and Blundel and Bond (1998), the system GMM estimator outperforms other estimators. Sotto (2009) suggests that this estimator is particularly advantageous when the number of units, such as countries, is small. It exhibits lower bias and higher efficiency compared to the first-difference GMM estimator. Thus, dynamic GMM is the best in our case. All econometric results are presented along with the Arellano-Bond test for serial correlation. As anticipated, the test results for second-order correlation show no evidence of model misspecification, thus accepting the null hypothesis of serial correlation in the first-difference errors at order (2).

System GMM estimators remain consistent only if the moment conditions used in the estimation process are valid. Although there is no direct method to test the validity of these moment conditions, we can assess the validity of the overidentifying moment conditions by conducting the Sargan test as discussed in Arellano and Bond (1991). Tables 1-3 provide compelling evidence that the overidentifying restrictions are valid, thus confirming the validity of the instrumental variables at a significance level of 5%.

Table 1: Dynamic GMM Estimates: Two Step Results Top of Form

Variable	Model (1)	Model 2
GDPGR (-1)	0.238 (0.000)	0.224 (0.003)
REN	0.163 (0.241)	0.418 (0.146)
FII	1.387 (0.026)	

FT		-0.203
		(0.338)
MU		0.483
		(0.108)
IU		0.0748
		(0.068)
TOP	1.759	-2.501
	(0.401)	(0.724)
GCF	-0.068	-0.483
	(0.478)	(0.005)
INF	0.802	0.841
	(0.000)	(0.001)
Constant	-7.455	-4.748
	(0.120)	(0.349)
AR2 Test	0.893	0.730
Sargan Test	0.018	0.008
Hansen Test	0.458	0.233
No. of Countries	15	15
No. of Observation	204	204

Source: STATA 14

Note: P-value is informed in brackets. The symbols of ***, ** and * represent.

Significant levels of 1%, 5% and 10%. For AR(2): Represents the Arellano-Bond test, whose null hypothesis is that there is no second-order autocorrelation in the first difference. For the Sargan test: when p-values are closer to 1, indicating that the instrumental variables are valid.

We use two-step system GMM estimators to examine the impact of financial inclusion on Economic growth rate **in MENA Region** (Model 1). All our econometric results report Arelleno-Bond test for serial correlation. As expected, there is no evidence of model misspecification as null hypotheses of serial correlation in the first differenced errors at order 2 are accepted. Moreover, the moment conditions used are valid as we use the Sargan test to check whether the over identifying moment conditions are valid. Model (1) examine the impact of FI index without ICT variables, the coefficient of FI index, at the 1% level, is significantly positive which shows that higher financial inclusion positively impacts economic growth. The result is consistent with previous literature where Cull and Xu (2020) found that expanding access to credit increased borrowing opportunities for households and firms which in turn boost

investment and productivity growth, and hence driving economic expansion. Several empirical studies supported our result (Chatterjee, 2020; Shen et al., 2021; Singh & Stakic, 2021). However, this analysis should be treated with cautious, according to the Global Findex Database **2017**, the percentage of adults with an account at a financial institution in Egypt, UAE, Jordan and Tunisia where 33%, 86%, 25% and 56% respectively. The variation came since some countries in MENA region are now fully digitalized their services especially the financial services.

Also, Lagged GDP per capita is significant and positive thereby implying that previous year's good (bad) performance will be continued the next year as well. This result aligned with the work of Barro (1991), where he examined the persistence of economic growth using data from a wide range of countries. The findings indicated a positive and significant relationship between lagged GDP per capita and current economic growth. Similarly, Levine and Renelt (1992) in their study using a large dataset from various countries, found robust evidence of positive serial correlation in economic growth rates. This suggests that lagged GDP per capita has a significant and positive impact on subsequent economic growth. Regarding our control variables; trade openness and gross capital formation (GCF) the results showed that both came insignificant. Wacziarg and Welch (2008) discovered a positive impact of trade openness on economic growth. Conversely, Rodríguez and Rodrik (2000) emphasized the context-specific nature of this relationship. Their research suggests that the influence of trade openness on economic growth can differ based on various factors, including country-specific circumstances. Similarly, the impact of GCF on economic growth has also been subject to debate. Some studies, such as Aschauer (1989), emphasize the positive relationship between investment and growth. However, other studies, including Mankiw et al. (1992), suggest that the relationship is more complex and depends on factors such as the efficiency of investment and the quality of institutions.

Finally, the positive impact of inflation on economic growth, which seems counterintuitive, has been observed in some studies. Khan and Senhadji (2001) found a non-linear relationship between inflation and growth, suggesting that moderate inflation levels can be conducive to economic expansion. However, it is important to note that other studies, such as Barro (1995), have shown a negative relationship between inflation and long-term economic growth

Model (2) examine the impact of ICT without including FI index to check for the relationship between ICT and economic growth. The dependent variable, endogenous variables and other control variables remain the same as model (1). The indicators of ICT used are mobile phone subscribers (Mobile Users) per 100 people, internet users per 100 people, fixed telephone line per 100 people.

The result of model (2) showed that that two out of the three ICT variables' coefficients are significant at the 5% significant level. In other

words, the advancement of information and communication technology (ICT) is crucial for economic progress. Table 1 summarizes the empirical result of causal link between growth and ICT variables. It shows that the ICT penetration variables such as mobile users & internet have positive and significant impact on economic growth rate. This is was supported by the significant increase in mobile phone penetration in MENA region. According to the Arab Monetary Fund, the mobile cellular subscription rate in the MENA region reached 109.1 subscriptions per 100 inhabitants in 2020. This results indicate that high percentage of mobile users is considered an opportunity for leveraging digital financial skills to enhance financial inclusion. This aligns with the findings of previous studies, such as Hassan (2005) and Sassi and Goaied (2013), which demonstrate that ICT plays a crucial role in the economic growth of a country. It enhances the country's productive capabilities and competitiveness by establishing connections with the global community.

It is important to note that the impact of mobile phones on economic growth may vary across countries and regions, depending on factors such as infrastructure development, regulatory frameworks, and socioeconomic conditions.

Moreover, mobile phones enable faster and Mobile phones are instrumental in enabling efficient information transmission and driving economic activities. They enhance connectivity, allowing businesses and individuals to effortlessly access and exchange information, thereby improving decision-making and boosting productivity. Additionally, the widespread availability of mobile phones facilitate information accessibility to those who are living remotely and in underserved areas. Therefore, ICT aids in promoting financial, social, and economic inclusion for all underprivileged groups, allowing them to actively participate in and contribute to the economy which in turn stimulates economic activities across regions.

In addition, ICT infrastructure, such as mobile networks, serves as the basis for a digitally interconnected society. It enables countries to join the global economic system, facilitating their involvement in international trade, investment, and the exchange of knowledge. This integration with the global economy promotes economic growth by attracting investments, encouraging innovation, and improving competitiveness

As expected, the impact of fixed telephone usage on economic growth is insignificant. This suggests that people are increasingly favoring mobile phones over fixed telephones due to its flexibility, portability, and accessibility. Thus, the importance of fixed telephones as a key component of ICT for driving economic growth has been lost.

These results is confirmed in different studies (Pradhan, Arvin, Nair, Bennett, and Bahmani, 2017a, 2017b)

Table 2: Dynamic GMM: Two Step Model with interaction terms

Variable	Model (3)	Model (4)	Model (5)	Model (6)
GDPGR (-1)	0.110 (0.038)	0.131 (0.056)	0.201 (0.079)	0.123 (0.047)
REN				
FI Index	47.998 (0.008)	60.05 (0.076)	48.752 (0.005)	29.281 (0.010)
ICT Index	-70.67 (0.009)			
ICT *FI	43.55 (0.009)			
FT		-1.59 (0.075)		
MU			-0.647 (0.017)	
IU				-0.830 (0.013)
FT* FI		26.083 (0.199)		
MU *FI			25.147 (0.005)	
IU * FI				24.817 (0.019)
TOP	-0.7455 (0.803)	4.501 (0.661)	-23.877 (0.021)	-18.115 (0.180)
GCF			-1.459 (0.000)	-0.904 (0.025)
INF	0.426 (0.322)	0.668 (0.067)	0.0237 (0.367)	1.434 (0.064)
REN	0.365 (0.038)	0.483 (0.218)	0.298 (0.567)	(2.568) (0.187)
Constant		15.922 (0.058)	40.478 (0.002)	91.501 (0.015)
AR2 Test	0.230	0.383	0.862	0.1667
Sargan Test	0.001	0.170	0.332	0.173
Hansen Test	0.422	0.319	0.474	0.880
No. of Countries	15	15	15	15

Variable	Model (3)	Model (4)	Model (5)	Model (6)
No. of Observation	204	204	204	204

Source: STATA 14

Note: P-value is informed in brackets. The symbols of ***, ** and * represent.

Significant levels of 1%, 5% and 10%. For AR(2): Represents the Arellano-Bond test, whose null hypothesis is that there is no second-order autocorrelation in the first difference. For the Sargan test: when p-values are closer to 1, indicating that the instrumental variables are valid

Models (3 - 6) analyze the interplay between ICT and financial inclusion and evaluate their joint impact on economic growth. More specifically, the study investigates whether advancements in ICT contribute to enhanced levels of financial inclusion, ultimately leading to higher economic growth.

Focusing on the coefficient of the interaction effect between ICT and FI indices we found that it is positive and significant at 1% level. This finding underscores the importance of incorporating ICT advancements into efforts to promote financial inclusion. The presence of this synergistic effect indicates that leveraging ICT to improve financial inclusion can yield favorable economic outcomes, including higher productivity, more investment opportunities, and enhanced innovation. Therefore, by embracing technological progress and ensuring broader access to financial services, we can fully unlock the potential of digital finance and its contributions to inclusive economic development.

The results of the models 3 – 6 provide more detailed analysis. The coefficients of all interaction effects of ICT and financial development, MU*FDP, IU*FDP, and fixed telephone number*FII, are positive, and the coefficients of MU*FII and IU*FII are significant at the 5% level. These results validate the previous observations made in model 3, indicating that ICT advancements play a crucial role in enhancing financial inclusion by equipping individuals with the necessary digital skills for greater economic inclusivity.

While investments in ICT initially demonstrate a negative impact on economic growth, the diffusion of financial inclusion can counterbalance this effect by bringing about positive impacts and stimulating economic growth.

This result is consistent with Hypothesis 3. In the past two decades, the use of telecommunications services has grown at an unprecedented rate. This growth is mainly driven by the liberalization of wireless technology and telecommunications markets and the huge government support and spending on ICT sector to foster the digitalization process. As King (2012) proposed, during the era of Bank 3.0, mobile financial services are

allowing companies to realize broad access rights, including telecommunications, retail, and e-commerce, in order to provide payment of bills and other financial services. This trend will continue and radically change the rules of the game of traditional banks and hence weaken the financial inclusion process unless it is supported with digital services.

Conclusion and policy Implications

This research paper examines the impact of ICT diffusion and financial inclusion on economic growth by utilizing an economic growth model that incorporates the joint effect of these two factors. The study employs dynamic panel system GMM estimation and focuses on a sample of 15 countries in the MENA region from 2004 to 2021. By adopting a dynamic perspective, the research investigates how the interplay between financial inclusion, ICT development, and economic growth evolves over time. Additionally, it assesses the combined influence of these factors on long-term economic sustainability in the MENA region.

The study contributes novel evidence to the existing literature on the interaction between financial inclusion and ICT development in the MENA region. This research holds significant importance as it focuses on a region undergoing economic transformation and striving for sustainable development. Gaining insights into the dynamic relationship between financial inclusion, ICT development, and economic growth in this context provides valuable understanding of the specific challenges and opportunities faced in the region.

The findings reveal that financial inclusion has a positive effect on growth, aligning with contemporary results. ICT is expected to enhance growth by improving digital skills and increasing the efficiency of the financial market, particularly in the banking sector. Effective use of ICT, such as branchless banking and mobile banking, can be cost-effective and improve financial accessibility for previously marginalized individuals, thereby fostering financial inclusion.

The interaction effects between ICT diffusion and finance are positive, indicating that the combined impact of ICT and financial inclusion can mitigate the negative effects of ICT investments. As ICT reshapes the timing and location of financial transactions, reinforcing and upgrading ICT applications in the financial sector can help counterbalance the adverse impact of increasing ICT development costs on economic growth. This is particularly relevant in the MENA region, which has been experiencing slower economic growth rates since 2020.

The study's results have important policy implications. The significant and positive influence of financial inclusion, ICT development, and their interaction on sustainable economic growth highlights the need for policymakers to prioritize these areas. Governments and stakeholders can leverage these findings to design and implement policies that promote

financial inclusion, enhance digital infrastructure, and encourage the adoption of renewable energy sources.

Investing in ICT infrastructure, expanding access to financial services, and promoting digital literacy are key policy actions to empower individuals and businesses, enabling them to participate more fully in the economy. Additionally, incorporating renewable energy sources contributes to sustainable development and reduces reliance on fossil fuels.

By aligning policies with the findings of this study, policymakers can tap into the untapped potential and foster sustainable economic growth in the MENA region. Continuous monitoring and adaptation of policies are crucial to effectively leverage the evolving dynamics between financial inclusion, ICT development, and long-term economic sustainability

Study Limitations and Future Research

While this study provides valuable insights into the dynamic relationship between financial inclusion, ICT development, and economic growth in the MENA region, it is important to acknowledge certain limitations. These limitations include: (1) Data Availability as the study relies on panel data for 17 years and a sample of 15 countries in the MENA region, which could impact the robustness and generalizability of the findings. (2) Causality and Endogeneity problem might exist despite employing dynamic panel system GMM estimation, where variables influence each other in a reciprocal manner, may be present and could affect the accuracy of the estimated coefficients. (3) The study relies on various indicators to measure financial inclusion, ICT development, and economic growth. The choice of indicators and their definitions may introduce measurement biases and limitations. Different indicators or alternative measures could yield different results. (4) The study examines the long-term relationship between financial inclusion, ICT development, and economic growth. However, it may not capture short-term dynamics and potential non-linear effects that could occur in the shorter term.

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