Digitalization and poverty alleviation in MENA countries: A dynamic panel analysis

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Abstract:

Over the last three decades, MENA countries have witnessed massive digital improvements. On the other hand, poverty rates in the region have risen since 2011 as a result of various factors such as wars, political instability, and climate change. Correspondingly, our study investigates the relationship between digitalization and poverty in MENA countries over the period from 1990 to 2019. Using the available data from ten MENA countries, the study applied the system GMM to assess the influence of two ICT tools: mobile phones and the Internet. The results indicate that the usage of mobile phones contributes to an increase in the poverty headcount ratio and an increase in the poverty gap in MENA countries. However, the use of the Internet seems to decrease the poverty headcount ratio and the poverty gap. The study urges governments to target the determinants of poverty in the region as a priority to apply suitable ICT tools.

Keywords: digitalization, ICT, MENA region, poverty alleviation, system GMM

JEL classification: I30, I39, L86

1. Introduction

Digitalization, or digital transformation, is a terminology that is recognized as an improvement in economic activity due to the implementation of ICT in various sectors (Mićić, 2017). It is also perceived as the automation of many aspects of life by the increasing use of information and communication technologies (ICT). In a simple sense, digitalization may be interpreted as the use of digital technology in all aspects of life (Srai & Lorentz, 2019). The role of technology in promoting economic growth has been widely explained in neoclassical models and the theory of endogenous economic growth (Zharov, 2019). However, economic growth is assumed to lead to poverty reduction but not by default (Škare & Družeta, 2016).

Digitalization has grown significantly in many MENA countries. However, the digital infrastructure between countries is not equally established. In some economies, such as Iraq, users may suffer from slow and weak mobile broadband, whereas Gulf countries enjoy fast and high connections (Langendorf & Farley, 2021). The significant growth in the use of digitalization in MENA countries might have an impact on poverty. The poor in MENA countries live in rural areas where digital infrastructure is usually unavailable (World Bank, 2021). The unconnected and the least connected people are falling further behind as the government, commercial sector, and civil society organizations transfer more services and activities online (Hernandez & Roberts, 2018).

Poverty remains a complex problem by nature and is determined using different approaches. The most widely used approach is the monetary dimension. It measures poverty by tracking the lack of income or expenditure (Wisor, 2012). The goal of this measure is to estimate the level of a household's income or consumption (goods and services) that will allow a person to meet the bare minimum of basic needs (Haughton and Khandker, 2009). The monetary approach uses different indicators such as the poverty gap and the headcount ratio. The poverty gap is the average deficiency from the poverty lines expressed as a percentage of the poverty lines that indicates the intensity as well as the prevalence of poverty. The headcount ratio is the percentage of the population living below a certain poverty threshold (World Bank, 2021).

However, the population's well-being is determined by both monetary and other non-monetary attributes (Bourguignon & Chakravarty, 2019). Accordingly, other approaches have been developed such as the

multidimensional approach that measures the type and severity of continuous poverty in healthcare, education, and living standards (Alkire et al., 2018). A current digital dimension, known as the digital approach, has been added to poverty dimensions due to the spread use of technology (Seah, 2020). The concept of digital poverty seeks to establish the minimal ICT usage and consumption levels, as well as population income levels, required to demand ICT products (Cáceres, 2007). However, "digital poverty" is infrequently used; instead, the term "digital divide" is widely used to investigate discrepancies in ICT access and use at the household and national levels (Galperin & Mariscal, 2007).

Poverty rates in the region have been increasing since 2011 due to different factors such as wars, political instability, and climate change (World Bank, 2020). The increasing dependence on ICT along with the increase in poverty rates in the MENA region has prompted the need to re-investigate the relationship between poverty and digitalization, and whether this digital transformation has a favorable effect on the poor. Therefore, our study examines the direct effect of ICT on poverty in MENA countries. The study focuses on measuring the impact of two ICT tools: mobile phones and the Internet. Our work used the poverty headcount ratio of $1.90 a day and the poverty gap as the main monetary dimensions of poverty to determine the effect of ICTs on the number of the poor and the depth of poverty. We employed the datasets of middle and low-income countries after excluding high-income countries. The system generalized methods of moments (GMM) was applied using the World Bank and the International Telecommunications Union (ITU) available data from ten MENA countries (Egypt, Algeria, Djibouti, Iran, Iraq, Jordan, Morocco, Tunisia, West Bank and Gaza, and Yemen). As a sample comparator, we had to include the data of 22 emerging countries to fulfill the conditions of the system GMM (N>T) (See table 6 in the Appendix).

Although the study of the relationship between poverty and digitization is not new, studies that examined the effect of digitalization on poverty in MENA countries are insufficient. Some of these studies focused on the descriptive approach. Others did not measure the direct effect of ICT on poverty and relied on the ICT effects on other development dimensions such as employment, economic growth, and investment. The study of Bahrini and Qaffas (2019) in addition to the study of Habibi and Zabardast (2020) found a positive relationship between digitalization and economic growth in the MENA region. However, the effective impact of digitalization on these macroeconomic

variables does not necessarily lead to poverty reduction. The positive impact of digitalization on economic growth, for instance, may not reach the poor where high inequality exists, as in the Middle East, since poverty becomes less sensitive to growth (Alvaredo et al., 2019; Son & Kakwani, 2004). Similarly, the effect of ICT on investment and employment does not provide a clear vision of the impact of poverty in the region. Therefore, this study seeks to answer the question of whether the use of ICT has a direct impact on reducing the number of poor and narrowing the poverty gap in the region.

Our study contributes to the literature in three main ways: First, we examine the direct effect of digitalization on the poor in the region using the poverty headcount ratio and the poverty gap to determine the effect on the intensity of poverty. Secondly, we employed a longer dataset on poverty in MENA countries from 1990 to 2019. Finally, this study uses the system GMM as some ICT variables are endogenous and the idiosyncratic disturbances are exogenous as proved in the works of Datta & Agarwel (2004); and; Ward & Zheng (2016); and Myovella et al. (2020). Furthermore, the data are unbalanced due to the lack of poverty data in the MENA region. Therefore, the system GMM is considered a suitable model for the study.

2. Digitalization and poverty in the literature

The lack of digital services is a consequence of broader structural and social factors such as poverty (Bach et al., 2018; Bhavnani et al., 2008). As a result, the relationship between digitalization and poverty is interrelated and complex. Digitalization might have an indirect beneficial impact on poverty by applying ICT in education and agriculture (Ali & Selmi, 2020). In education, the Internet is utilized to increase literacy and reduce poverty as it broadens the breadth of education, which also facilitates research and intellectual interaction (Aftab & Ismail, 2015; Tikam, 2013). For agriculture, ICT can further play a vital role in monitoring factors that affect the state of food security, such as weather, drought, and crop failures (Singh & Singh, 2012). The use of ICT might also lower prices by reducing the costs of trade and transactions in addition to decreasing information asymmetry.

On the other hand, the use of digital technology can increase poverty since it may exclude those without digital access or people with lack of required digital skills. ICT expenditure might also divert household resources away from essentials (May, 2021).

Given the increasing use of ICT, a growing number of studies have explored the relationship between digitalization and some economic variables, for instance, development, education, inequality, employment, and economic growth. Investigating the relationship between ICTs and economic growth is crucial due to the expected impact of GDP on poverty. A significantly high proportion of studies are concerned with the impact of ICT on economic growth. Although this relationship has been analyzed from various perspectives, several studies point out that ICT positively affected economic growth. Using OLS estimation, Niebel (2018) affirmed the positive relationship between GDP and ICTs. The study also concluded that developing and developed countries have similar benefits from ICT. GDP, capital services (ICT and non-ICT), and labor services were employed as the variables of the study. Bilan, et al. (2019) confirmed the same relation in Ukraine using a correlation and regression analysis. The study used IDI (Information and Communication Technology Development Index) and the ICT Component of the Global Competitiveness Index (GCI) as explanatory variables and GDP per capita as the dependent variable.

Within this context, a study by Stanley, et al. (2018) investigated the differential impact of ICT on GDP growth in developing and developed countries using meta-regression analysis. Landlines, cell phones, computer technology, and Internet access are the four ICTs used in the study. The findings of the study indicated that both types of countries benefit from Mobile and telephone subscriptions. However, developed countries benefit far more from computing than developing countries do, while there is little evidence that the Internet has boosted growth. A partial least square (PLS) study by Fernández-Portillo et al. (2020), which was applied to OECD countries, proved that the adoption and utilization of ICT support the growth of the economy. The study used the DESI (The Digital Economy and Society Index) as a proxy for ICT. This interest is not limited to the use of ICT but also to the investment in ICT that affects economic growth (Aghaei & Rezagholizadeh,2017; Erumban & Das,2016). Other studies have attempted to demonstrate the impact of digitalization on economic growth in the Middle East. The studies applied OLS fixed-effect and GMM methods using Mobile subscriptions, Internet users, and Broadband subscriptions and ensured a positive relationship between ICTs and economic growth (Habibi, & Zabardast,2020; Bahrini, & Qaffas, 2019).

Furthermore, a growing number of studies have explored the relationship between digitalization and poverty. Some of these studies are supporters of the

use of ICT as a poverty reduction tool. Others claim it may detract governments' attention from addressing the problems of the poor, especially when countries have limited access to ICT innovations and many poor are left behind (OECD, 2003; Quibria & Tchang, 2001). A review study by Galperin and Viecens (2017) indicated that the effect of the Internet on poverty alleviation in developing countries remains uncertain due to the complexity and the interrelated relationship between the social and economic factors of poverty.

On the optimistic side of using ICT, Klonner and Nolen (2008) concluded that when mobile-phone infrastructure was introduced in South Africa, the pro-poor effects of mobile phones increased household income. The study used the income data of South Africa and applied the OLS technique. A descriptive survey designed by Sofowora (2009), which used income data from Nigeria, showed that mobile and ICT usage has helped in reducing poverty and high unemployment rates. Sife et al. (2010) used a partially mixed concurrent dominant status design, which included both quantitative and qualitative approaches, and concluded that the use of mobile phones has contributed to reducing poverty, improving rural livelihoods, and decreasing the cost of doing business in Tanzania. Another study by Galperin et al. (2014) used a quasi-experimental approach, which employed the data from household surveys and personal interviews in Latin America pointed out that the Internet can affect poverty through economic growth, employment, and inclusion effect. The use of the Internet may additionally allow the poor who live in isolated communities to overcome geographical isolation. However, the study mentioned digital skills as an important factor in determining the effect of the Internet on poverty.

Another study used a quasi-experimental approach to determine the effect of ICT on small and micro enterprises in Tanzania. The findings revealed that the increased use of mobiles and the Internet has exerted a significant impact on poverty reduction (Mascarenhas, 2014). A survey that was conducted among women in one of Tanzania's villages used different variables, such as ICT availability, accessibility, and ICT possession, outlined ICT benefits such as job growth, increased accessibility to banking facilities, and improved agriculture through access to economic opportunities (Khaliq et al., 2016). Yilmaz and Koyuncu (2018) established a significant correlation between poverty reduction and the use of ICT using a panel dataset of 182 countries. The study used different independent variables such as the headcount ratio,

poverty gap, Watts, Gini coefficient, Mild, and Human Development Index. The dependent variables used were mobile subscriptions, fixed broadband subscriptions, the Internet, and computer usage. In a comparative study by Kwilinski et al. (2020), which was applied to the EU countries, two variables were used; the digital economy and society index (DESI) and people at risk of poverty (AROPE). The study applied a comparative and correlation analysis in addition to the Monte Carlo method. The findings of the study revealed that countries with higher digitalization rates have witnessed a more substantial decline in poverty rates. These results are consistent with many other studies that found evidence of the beneficial effect of the Internet on poverty in developed countries (Galperin & Viecens, 2017). Moreover, a cross-sectional study, which used a dataset of 43 African countries, employed the variables of the ICT development index, mobile subscription, internet, adult literacy, GNP per capita, inequality level, Human Development Index (HDI), and poverty level. The study used descriptive statistics, Cobb Douglas production function, and a three-stage simultaneous equation. The results of the study pointed out that mobile subscriptions and the Internet have decreased poverty. The research also proved a link between ICT development, human development, and poverty levels in Africa (Nosiru & Sodique, 2020).

In contrast, Kurantin and Osei-Hwedie (2019) conducted an OLS technique, using GDP per capita income (a proxy for poverty), foreign direct investment, inflation, mobile cellular subscriptions, and found that FDI investment in ICT in Ghana and South Africa has not had a significant impact on the income of the poor.

As previously stated, the findings of several studies looking at the relationship between poverty and digitalization are mixed. This is primarily due to differences in government policy, poor demographics, and digital infrastructure among countries. Moreover, the impact of ICT on poverty varies between developed and developing countries. As a result, comparing multiple applied studies conducted in different countries or regions is dubious.

3. The state of poverty in the MENA region:

The MENA region is characterized by high inequality, and poverty is concentrated in rural areas and among illiterates, large families, ethnic and religious minorities (Sida, 2019). The poor in the region suffer from limited class mobility since they usually work in the informal sector with insufficient income due to deficient job growth (OECD, 2021). As a result, they are vulnerable to any economic shock. They also experience a lack of income, healthcare, and education. The region is also home to the highest youth

unemployment rate in the world due to the lack of proper education (World Bank, 2018). Except for the Gulf Cooperation Council Countries (GCC), food security and adequate nutrition are major challenges for the majority of MENA countries (Giovanis & Ozdamar, 2019). However, it is worth mentioning that differences exist among countries in the region regarding the level of income and other resources. In addition, the scarcity of poverty data and the way of collecting data makes it difficult to compare countries (Egset, 2000). Table 1 depicts some poverty characteristics based on the latest available data in selected MENA countries.

Table 1: Characteristics of poverty in selected MENA countries

	Poverty line%				Multidimensional Poverty Index	Contribution of deprivation in dimension to overall multidimensional poverty		
	Urban %	**Rural %**	**Male %**	**Female %**	**Headcount**	**Health %**	**Education %**	**Standard of living %**
Djibouti (2017) US$1.90	10.0	58.0	17.0	17.0	-	-	-	-
Algeria	-	-	-	-	1.4 (2018/2019)	31.2	49.3	19.5
Egypt (2017) US$3.20	20.0	31.0	25.0	27.0	5.2 (2014)	40.0	53.1	6.9
Iran (2017) US$5.50	5.0	27.0	11.0	11.0	-	-	-	-
Iraq (2012) US$5.50	50.0	72.0	57.0	58.0	8.6 (2018)	33.1	60.9	6.0
Jordan (2010) US$5.50	17.0	23.0	18.0	19.0	0.4 (2017/ 2018)	37.5	53.5	9.0
Morocco (2013) US$3.20	15.0	8.0	8.0	8.0	6.4 (2017/ 2018)	24.4	46.8	28.8
Tunisia (2015) US$3.20	1.0	8.0	3.0	3.0	0.8 (2018)	24.4	61.6	14.0
West Bank and	24.0	14.0	23.0	24.0	-	-	-	-

Gaza (2016) US$5.50								
Yemen (2014) US$1.90	7.0	24.0	19.0	19.0	48.5 (2013)	29.0	30.4	40.6

Source: World Bank, Middle East and North Africa, Poverty and Equity (2020); Alkire et al., (2021)

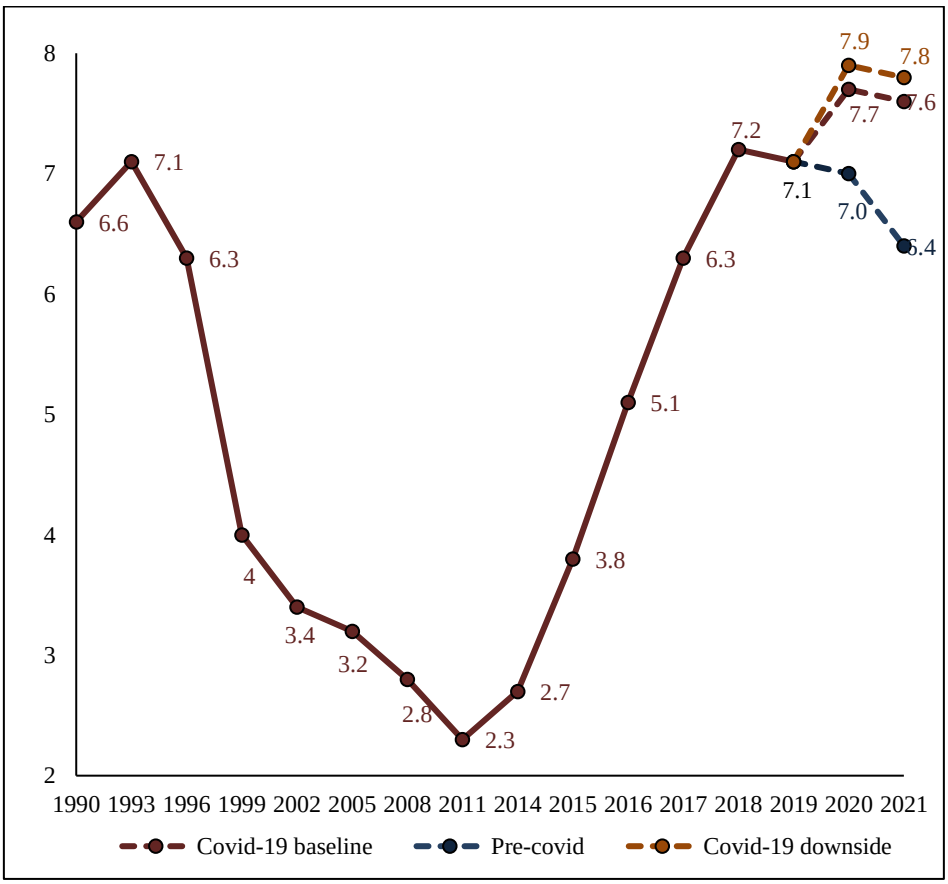
Notes: a) The monetary poverty is calculated based on a poverty line of $1.90 per day
b) Health includes nutrition and child mortality
c) Education includes years of schooling and school attendance
d) Standard of living includes (Cooking fuel, Sanitation, Drinking water, Electricity, Housing, Assets)

According to table 1, we can notice that rural regions have more impoverished people than urban areas in all nations except Morocco and the West Bank and Gaza. There are no substantial differences in the percentage of impoverished males and females in the region. Furthermore, education has the largest contribution of deprivation to overall multidimensional poverty in all countries except Yemen. Health comes in second place in the contribution of deprivation to overall multidimensional poverty in all countries except Morocco and Yemen. Despite the similarities among the selected MENA countries, Yemen has a different order in terms of the causes of poverty, as the standard of living represents the highest share followed by education and health, respectively. Yemen has also the largest number of impoverished people compared to other MENA countries, followed by Iraq, Morocco, and Egypt, respectively.

Poverty in the MENA area plummeted from 7.1 percent in 1993 to 2.3 percent in 2011 as depicted in Figure 1. The reduction in poverty rates was mainly due to the continuous increase in the region's economic growth, which benefited the lowest quintile. Furthermore, the increase in remittance due to migration has also helped the poor. The region has also witnessed an investment boom and significant growth in the public sector, which was reflected in the growth of real wages (Adams & Page, 2001). Since the Arab uprising in 2011, the poverty rate started to increase until it reached 7.2 percent in 2018, mainly due to political instability in some Arab countries and civil wars in Iraq and Libya (Sida, 2019). Poverty rates nearly doubled between 2015 and 2018, triggered by conflicts in Syria and Yemen (World Bank, 2020). The Nowcasts of the MENA region's poverty rates reflect the influence of COVID-19 on the rising poverty rates. The pre-COVID scenario incorporates

the Global Economic Prospects (GEP) growth estimates for 2020 and 2021 as well as the June 2020 forecast for 2019. The COVID-19 downside and baseline scenarios are based on June 2020 GEP growth predictions that project an eight and five percent reduction in global growth in 2020, respectively. It is worth noting that the availability of poverty data has worsened owing to political instability in the region (Atamanov et al., 2020).

Figure 1: The Nowcasts of poverty rate in the MENA region at the US$1.90- a day- poverty line (1990-2021)



Source: Lakner et al. (2020) (updated); World Bank, Global Economic prospects (as cited on PovcalNet (online analysis tool), 2020)

Notes: a) The number of people living on less than $1.90 per day is counted as extreme poverty.

b) The official global poverty estimates for 2017 are the last ones available.

4. Overview of ICT indicators in the MENA region:

Several indices have been used to assess countries' digital performance in the last decade such as the Digital Readiness Index (DRI), the Networked Readiness Index, and the Inclusive Internet Index (Philipp, 2020). The index compositions vary and are determined by various indicators that can signify a country's level of digitalization. The index components can reflect the ICT demand or supply side. The demand side represents the use and the adoption of ICT services. Alternatively, the supply side represents the availability of the ICT infrastructure in the country. In our analysis, we concentrated on selected MENA countries, where data is available, and excluded high-income countries where there is no extreme poverty.

The Digital Readiness Index (DRI) is an index that depends on many components such as technological infrastructure, technology acceptance, ease of doing business, human capital growth, business and government spending, basic human needs, and the start-up climate. Technology adoption is one of the DRI indicators that refer to the demand side and consists of Mobile Device Penetration, Internet Usage, and Cloud Services. Alternatively, technology infrastructure presents the supply side and consists of Mobile Broadband Subscriptions (MBB), Fixed Broadband Subscriptions (FBB), Secure Internet Servers, and Household Internet Access (Cisco, 2020).

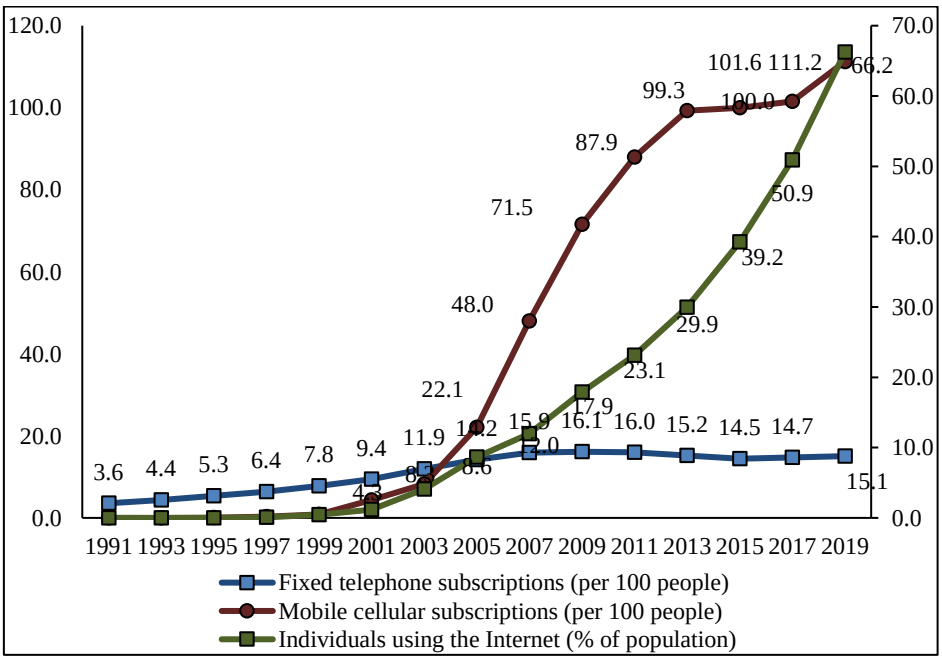
Despite the importance of access to technology and infrastructure, countries can not fully benefit from digital prospects if primary necessities are unsatisfied, such as access to clean drinking water, lack of education, or job chances (Cisco, 2020). Activation, acceleration, and amplification comprise the three steps that countries go through to become digitally ready. Five MENA countries from middle and low-income countries are included in this index (Yemen, Iraq, Algeria, Egypt, and Iran). Yemen is the only country in the activated stage, while other countries are classified in the low acceleration stage in the index and all its sub-indices (Cisco, 2019). This classification indicates that these countries had achieved some progress but have significant room to enhance or accelerate their digital preparedness.

Another index is the Networked Readiness Index (NRI), which consists of four core components (technology, people, governance, and impact). The index employs 60 indicators to measure the use and access of technology in addition to its impact. The most successful NRIs are often advanced economies, while low and medium-income economies score smaller NRIs. The NRI’s performance relies principally on the country's income level. Consequently, eight middle and low-income MENA countries (Yemen,

Algeria, Morocco, Tunisia, Lebanon, Egypt, Iran, and Jordan) are included in the index and they all have a modest rating (NRI, 2020).

The Inclusive Internet Index determines the extent to which the Internet is not just accessible and affordable but also relevant to everybody when it comes to language and content. The index additionally includes the dimension of Internet readiness, which concentrates on skills, cultural acceptance, and policy support. The overall index score is calculated using the scores in the areas of availability, affordability, relevance, and readiness. Iran ranks first among other MENA countries, as it ranks 57 out of 120 countries covered in the index. The rest of MENA countries rank from 67 to 86 (EIU, 2021). Furthermore, the use of the Internet in the MENA region combines the use of Fixed Broadband (FBB) and Mobile Broadband (MBB). Notably, the growth in the number of fixed telephone subscriptions in the region (per 100 people) has been relatively constant since 2005, while the number of mobile subscriptions and the percentage of individuals using the internet during the same period has been significantly growing (ITU, 2020) (Figure 2).

Figure 2: Number of fixed telephone subscriptions, mobile cellular subscriptions, and the internet use in MENA countries (1990-2019)



Source: International Telecommunication Unit (ITU), ICT indicators database, 2020

The growth of demand for mobile subscriptions indicates more reliance on MBB rather than FBB through fixed telephones. According to the ITU statistics, the growth in active MBB subscriptions is significantly increasing compared to FBB. Active MBB penetration rates reached 68 percent in the MENA region in 2019, which is still lower than the global average of 83 percent. The 3G mobile networks covered 95 percent of the people in the MENA region. However, only about half of MBB users have or use an Internet-enabled phone (GSMA, 2019).

In a nutshell, according to the region's ICT indicators, the scores of the selected MENA countries may refer to a lack of digital infrastructure in these areas. Furthermore, the MENA region experiences some structural and long-term challenges regarding digital transformation, including business environment, human capital development, and digital urban bias. Meanwhile, most of the poor are concentrated in rural areas (World Bank, 2021). This digital urban bias may create a rural-urban digital divide that affects job opportunities and access to high education (Langendorf & Farley, 2021). In addition, most of the indicators include other sub-non-digital indices such as a country's income and measurements of basic needs and human development. Correspondingly, countries with high poverty rates score low in ICT indicators, which indicates that the degree of poverty in a country may affect its digital transformation.

In the light of poverty and ICT indicators, we can conclude that ICT effects on poverty reduction should consider three determinants. The first is connectivity, which means the availability of digital services. The second is affordability, can poor people afford the cost of ICT. The third is capability, which includes the proper training, skills, and expertise in embracing technology and understanding the best way to employ it (Dhaoui, 2020; Gerster & Zimmermann, 2003). In this regard, the effect of ICT on poverty in each MENA country might differ due to some differences in the characteristics of poverty and the degree of digital transformation.

5. Estimation procedure and methodology

We applied the Generalized Methods of Moments (GMM) estimator to investigate the effect of ICT on poverty in the MENA region. The system GMM was developed by Arellano and Bover (1995) and Blundell and Bond (1998). To fulfill the conditions of the system GMM model, the number of countries should be more than the time span (N>T) (Roodman, 2006). However, the available poverty data for the MENA region includes only ten countries. Therefore, we had to include the data of 22 emerging countries as a

sample comparator. The 22 emerging nations were chosen due to the probable strong growth similarities between emerging and MENA countries (Emara & Mohieldin, 2020). As a result, our choice of the system GMM was based on two main points: First, the number of countries (N=32) is larger than the time span (T=29). Second, the model deals with the problem of endogeneity, using instrumental variables, since some ICT variables are not exogenous as mentioned in the introduction. The model also accounts for unobserved heterogeneity while removing potential small sample biases from the difference (Asongu et al, 2017).

The dynamic panel model can be written as follows:

$$Pov_{it} = \alpha + \rho Pov_{it-1} + \beta X_{it} + \varphi MICT_{it} + +\delta EICT_{it} + \eta_i + \varepsilon_{it} \qquad (1)$$

i = 1,2,…..,N,t = 1990,…….,T

Where

Pov it is the poverty headcount ratio in model (1) and the poverty gap in model (2)

X_(i,t) is a vector of poverty explanatory variables (GDPppp, Tra, Cf, Pop)

MICTit is a vector of two interaction terms of ICT in MENA countries (menacel, menaint)

$EICT_{it}$ is a vector of two interaction terms of ICT in emerging countries (eccel, ecint)

The previous model included two dependent variables: the poverty headcount ratio in model (1) and the poverty gap in model (2). The lag of the dependent variable is represented by Pov_{it-1}as the change in poverty headcount ratio or poverty gap is expected to be related to its level in the previous year. The independent variables include GDP per capita PPP since the increase in GDP is commonly believed to reduce poverty rates but not by default (Škare & Družeta, 2016). Furthermore, using the purchasing power parity is important in determining global estimates of the number of people living in poverty (Ackland et al., 2013).

Tra is the trade openness variable, calculated as the sum of exports and imports as a percentage of GDP. We expect a positive relationship between

trade openness and poverty in MENA countries since trade openness increases countries' welfare according to the traditional theories of trade (Le Goff & Singh, 2014).

The change in Gross capital formation (Cf) is expected to drive rapid economic growth which may reduce poverty rates (Akobeng, 2016). In addition, poverty is strongly influenced by population (Pop), especially if parents cannot afford to provide education and health care for their children (Desai, 1992).

MICTi,t is a vector of two interaction terms, where M is a dummy variable multiplied by the ICT variables. These interaction terms are used to determine the impact of ICT variables on poverty in MENA countries only. Following the work of Emara and Mohieldin (2020), the dummy variable was coded as (M =1) for MENA countries and (M=0) for emerging countries. To conduct a comparison between the impact of ICT on MENA countries and emerging countries, we created another two interaction terms (eccel for mobile cellular subscriptions and ecint for individuals using the Internet). Therefore, EICTi,t is a vector of two interaction terms, where E is a dummy variable coded as (E=1) for emerging countries and (E=0) for MENA countries.

Country and time period are denoted by the subscript i and t, respectively. ηi is the unobserved country-specific effect, and ε_(i,t)is the error term. All variables are log-transformed, except MICTi,t in model (2).

To remove the country-specific effect, we took the first difference of equation (1):

$$(Pov_{it} - Pov_{i,t-1}) = \alpha + \rho(Pov_{i,t-1} - Pov_{i,t-2}) + \beta(X_{i,t} - X_{i,t-1}) + \varphi(MICT_{it} - MICT_{i,t-1}) + \delta(EICT_{it} - EICT_{i,t-1}) + (\varepsilon_{it} - \varepsilon_{i,t-1}) \quad (2)$$

By conjoining equation (1) with equation (2), the system GMM combines the difference estimator with the estimator in levels. The estimator uses the lagged levels as instruments for equation (2) and the lagged differences as instruments for the equation in level (Arellano and Bover, 1995). We also used the lagged explanatory variables as instruments Therefore, the difference equation employs the following moment conditions:

$$E\,[Pov_{i,t-s}(\varepsilon_{it} - \varepsilon_{it-1})] = 0 \quad for\ t = 3, \ldots\ldots, T, \quad S \geq 2 \quad (3)$$

$$E\,[M_{i,t-s}(\varepsilon_{it} - \varepsilon_{it-1})] = 0 \quad for\ t = 3, \ldots\ldots, T, \quad S \geq 2 \quad (4)$$

In addition to the following restrictions for equation (1):

$$E\,(u_{it}\,\Delta Pov_{i,t-1}) = 0 \qquad where\ u_{it} = \eta_i + \varepsilon_{i,t} \tag{5}$$

$$E\,(u_{it}\,\Delta M_{i,t-1}) = 0 \tag{6}$$

Where Mi,t is a set of all independent variables, including Xi,t , EICTi,t , and MICTi,t.. To assess the validity of the estimator, we conducted the Sargan test of over-identifying restrictions in addition to the Arellano and Bond test for autocorrelation. The null hypothesis of Sargan test states that the instruments are valid and are not correlated with the error term. Therefore, rejecting the null hypothesis implies that the instruments are weak. We preferred the Sargan test as it is not weakened by the instruments. Furthermore, accepting the null hypothesis of Arellano and Bond test for autocorrelation refers to the absence of the autocorrelation problem. However, we focused on the second order of Arellano and Bond test of Autocorrelation since the existence of autocorrelation in the first order is expected due to lagged variables. In addition, studies in the literature relied mainly on the second order (Narayan et al., 2011).

5.1 Data

The study employed the available panel dataset of ten MENA countries (Egypt, Algeria, Djibouti, Iran, Iraq, Jordan, Morocco, Tunisia, West Bank and Gaza, and Yemen) in addition to the 22 emerging countries over the period 1990 to 2019. The data of poverty headcount ratio, poverty gap, GDP PPP, trade openness, gross capital formation, and population growth were obtained from the World Bank Development Indicators (WDI) database. Two ICT indicators were chosen to measure both access and usage of ICT. Access to ICT variables includes mobile cellular subscriptions, excluding the use of the Internet as a service. We neglected the access to fixed telephone subscriptions since the growth of fixed telephones is stagnant during our period of study (see figure 2). The extent of ICT usage is measured by individuals using the Internet. This indicator covers the use of Fixed Broadband (FBB) and Mobile Broadband (MBB). The datasets of mobile cellular subscriptions and individuals using the internet were obtained from the International Telecommunication Union (ITU) (Table 2).

Table 2: Definitions of variables

Variable name	Definition	Abbreviation
Poverty Headcount ratio	The percentage of the population living on less than $1.90 per day at 2011 international prices	Hcount
Poverty Gap	The poverty gap at $1.90 per day (2011 PPP) is the average shortfall in income or consumption from the poverty line of $1.90 per day (considering non-poor as having no shortfall), expressed as a percentage of the poverty level. This measure indicates both the severity and the prevalence of poverty.	Gap
GDP (PPP)	GDP (PPP) stands for gross domestic product based on purchasing power parity (constant 2017 international $)	GDP_ppp
Trade Openness	The sum of exports and imports (as a percentage of GDP)	Tra
Gross capital formation	Gross capital formation (as a percentage of GDP) includes outlays on additions to the economy's fixed assets (land improvements, machinery, equipment purchases, etc.) as well as net changes in the level of inventories.	Cf
population growth	Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage	Pop
Mobile cellular subscriptions	Mobile cellular telephone subscriptions per 100 inhabitants	Cel
Individuals using the Internet	Internet users (as a percentage of the population)	lnt

5.2 Descriptive statistics of variables:

To examine the effect of digitalization on the population living below the national poverty line and their depth of poverty, two models were estimated in the study using two dependent variables. Model (1) uses the poverty headcount ratio at $1.90 a day (2011 PPP) as a percentage of the population, while model (2) uses the poverty gap at $1.90 a day (2011 PPP) to determine the intensity of poverty in MENA countries. The study applied these two monetary poverty measures due to their relevant availability compared to other poverty dimensions in the region. ` A set of explanatory variables were selected to explain variations in the response variables in both models. The independent variables include GDP per capita PPP (constant 2017 international $), trade (as a percentage of GDP), gross capital formation (as a percentage of GDP), and population growth (annual). Table 3 presents the descriptive statistics of the chosen variables.

Table 3: Descriptive statistics of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Gap	428	2.31285	3.542376	0	24.1
Hcount	428	7.311215	10.6461	0	66.3
Cel	990	50.52152	51.71944	0	186.159
Int	980	20.31726	24.03014	0	84.5165
Tra	923	67.65782	41.63305	0.0209992	347.9965
Cf	909	24.89268	7.437674	-0.0984	56.87369
Pop	989	1.353339	1.154618	-2.170699	5.614586
GDP_ppp	902	11658.28	6592.887	1423.896	33221.08

Table 4: Correlation Coefficients Matrix of variables

Variables	gap	Hcount	cel	Int	Tra	cf	Pop	GDP_PPP
gap	1.0000							
Hcount	0.9546	1.0000						
cel	-0.4984	-0.5086	1.0000					
Int	-0.4470	-0.4798	0.8460	1.0000				
Tra	-0.2742	-0.2633	0.2315	0.2659	1.0000			
cf	-0.0221	0.0384	0.0022	-0.0414	0.1707	1.0000		
Pop	0.2673	0.3027	-0.4321	-0.3826	-0.2444	-0.0224	1.0000	
GDP_PPP	-0.4633	-0.5505	0.5972	0.6937	0.2390	-0.1212	-0.4983	1.0000

The correlation coefficients for the whole sample are shown in Table 4. With a moderate value of 0.49, there is a modestly negative relationship between mobile subscriptions and the poverty gap as well as the headcount ratio. Internet access has also an inverse relationship with the poverty gap and the headcount ratio. Notably, there is a strong positive relationship between Internet use and mobile phone subscriptions with a value of 0.85. This correlation coefficient implies that people in MENA countries use the internet extensively through mobile phones.

6. Results and discussions

In this section, we interpret and discuss the results of applying the system GMM to measure the effect of ICT on poverty. Table 5 presents the estimation results of model (1) and model (2). As for model (1), we used the poverty headcount ratio, as the dependent variable, in addition to poverty control variables and ICT variables as independent variables. We tested for serial correlation using the Arellano and Bond test of autocorrelation. AR (2) in the

first difference shows that the residuals are not serially correlated. We also applied the Sargan test for endogeneity and the P-value suggests that the instruments are exogenous.

Table 5: The impact of ICT variables on poverty headcount ratio and poverty gap in MENA countries

Regressors	Model 1	Model 2
lnHcount (-1)	0.896***	
	(0.0445)	
lngap (-1)		0.787***
		(0.0387)
lnmenaint	-1.051*	-1.673**
	(0.5231)	(0.6936)
lnmenacel	0.988*	1.453**
	(0.4987)	(0.6105)
lnecint	-0.108*	-0.136**
	(0.0544)	(0.0543)
lneccel	0.119	0.137**
	(0.0731)	(0.0683)
lngdp_ppp	-0.258	-0.442**
	(0.1542)	(0.1249)
lncf	-0.553***	-0.791***
	(0.1257)	(0.1369)
lnpop	0.027	0.005
	(0.0329)	(0.0513)
lntra	-0.136	-0.127
	(0.0954)	(0.0891)
Number of observations	161	144
Number of instruments	157	138
Arellano-Bond Test (AR2)	0.376	0.854
Sargan prob > Chi-Square	0.424	0.366

Standard errors are in parentheses, ***p < 0.01, **p < 0.05, *p < 0.1

The findings of model (1) show that the increase in the lag of the headcount ratio by one percent leads to a rise in the poverty headcount ratio by 0.90 percent of the population. The rise in capital formation by one percent decreases the poverty headcount ratio by 0.55 percent of the population. However, population growth, GDP, and trade openness do not seem to have an impact on the poverty headcount ratio. As for the ICT variables, the conditional effect of mobile cellular subscriptions in MENA countries on the poverty headcount ratio (menacel) is 0.99 while the effect of mobile subscriptions in emerging countries (eccel) is not statistically significant. Furthermore, the

conditional effect of individuals using the Internet in MENA countries (menaint) and in emerging countries (ecint) on poverty headcount ratio is -1.05 and -0.11, respectively.

In model (2), we used the poverty gap as the dependent variable, while poverty control variables and ICT variables were included as independent variables. The variables in this model are log-transformed. As expected, the poverty gap is raised by 0.79 percent for every increase in its lag by one percent. The rise in GDP_ppp by one percent decreases the poverty gap by 0.44 percent. The coefficient of capital formation is significant, indicating that a rise of one percent in capital formation decreases the poverty gap by 0.79 percent. The population growth and trade openness in this model are also insignificant. In terms of the ICT variables, the results show that the conditional effects of mobile subscriptions in MENA countries (menacel) and in emerging countries (eccel)on poverty gap are 1.45 and 0.14, respectively. As for the usage side, the conditional effect of individuals using the Internet in MENA countries (menaint) and in emerging countries (ecint) are -1.67 and –0.14, respectively. Considering the validity of the estimator, the second-order of the Arellano and Bond test (AR2) shows no sign of serial autocorrelation. Moreover, the Sargan test of over-identifying restrictions implies that the instruments are exogenous.

By comparing the results of both models, it is clear that GDP has a significant impact on reducing the poverty gap but not the poverty headcount ratio. Furthermore, capital formation has an impact on reducing the poverty gap and the poverty headcount ratio. However, population growth and trade openness do not seem to have a significant effect on poverty in both models. As for mobile phones, the increase in the number of mobile subscribers contributes to an increase in the poverty headcount ratio and the poverty gap in MENA countries. The conditional effect of mobile subscriptions on the poverty gap is larger in MENA countries compared to emerging countries. However, the use of the Internet appears to reduce the poverty headcount ratio and the poverty gap in the MENA region more than in the emerging countries. This result is consistent with the results of many studies applied to other developing countries including the study of Mora-Rivera and García-Mora (2021) and Barrantes, et al. (2014).

Contrary to the findings of Klonner and Nolen (2008), Sofowora (2009), and Sife et al. (2010), the increase in the use of mobile phones in our study

increases the poverty gap and the headcount ratio in MENA countries. This result could be justified by the fact that the costs of mobile phones' handsets and services are relatively high for the poor in the region. In 2019, the cost of mobile phones was 15.3 percent of the monthly per capita GDP compared to four percent on average in high-income countries. The poor in the region are concentrated in rural areas where infrastructure deployment requires high rollout costs and results in low returns. Accordingly, people living in rural areas are 37 percent less likely to use MBB than urban residents (GSMA, 2020). In addition, a smartphone unit costs approximately 20 percent of monthly income, but it represents 96 percent of the poorest 20 percent average income (El-Hamidi, 2020).

Concurrently, mobile phones are becoming a necessity, as people use them to access the Internet and handle many jobs. However, it enlarges the digital divide and increases the number of the poor if they are unaffordable for them. Telecom providers are faced with the challenge of providing complete services at a more reasonable cost because of technological advancements. It is still critical to make mobile phones as affordable and widely available as possible since mobile phones could be a burden on low-income families due to the cost of the devices and the monthly fees required to use the services (Bhavnani et al., 2008). Even though mobile lines have evolved into a strong economic substitute for fixed-line service, there is still a disconnect between mobile broadband availability and user adoption. In many locations, the cost of mobile voice and data bundles has not met the UN's Broadband Commission's affordability target, thus excluding millions of families from the digital economy (Langendorf & Farley, 2021). Furthermore, a mobile phone call is significantly more expensive than a fixed phone call in terms of costs (GSMA, 2012). The lack of network infrastructure, limited spectrum, financial constraints, and elevated levels of taxes are all major impediments to mobile Internet access (Cambini et al., 2018).

The study of Nsor-Anabiah (2017) on rural areas in Ghana found that the absence of mobile network coverage, excessive costs of devices or services, and digital illiteracy may hinder the beneficial effect of mobile phones on poverty reduction. Similarly, high costs and the absence of mobile digital infrastructure in some rural areas in the MENA region seem to delay the favorable effect of mobile phones on poverty alleviation. The impact of Internet usage on reducing poverty may indicate that impoverished people in the region might acquire the fundamental digital skills that enable them to access the Internet. However, mobile phones and the Internet are sometimes

used for social purposes by the poor but not as an effective tool to enhance their life conditions (Elder et al., 2013).

In light of the previous results, poverty indicators, and ICT indicators, we can conclude that ICT can play a vital role in poverty alleviation in the region. However, differences in the level of technological transformations between countries should equally be considered. For instance, Yemen may need to focus on meeting fundamental needs, since the standard of living acts as the main cause of poverty in Yemen. The rest of MENA countries are in the low acceleration stage, and education seems to be the key factor that causes poverty in these countries. As a result, these countries should direct more attention to using ICT in education and establishing digital infrastructure in places where the poor live. The affordability dimension should also be considered to make sure that ICT is affordable for the poor; otherwise, countries may risk a digital divide and ICTs may increase poverty. Countries can also use ICT to aid poverty data collection. For instance, mobile phones could be used to draw poverty maps, anticipate poverty, and collect data on the poor's socioeconomic status (Blumenstock et al., 2015; Steele et al., 2017).

Our study proved the favorable effect of economic growth on poverty and the effective role of the internet on poverty alleviation in MENA countries. However, the study also showed that the use of mobile phones leads to an increase in poverty, which contradicts the results of many previous studies. Therefore, despite the important role of technology in promoting economic growth in the neoclassical and endogenous growth theory, digitalization does not necessarily lead to poverty reduction.

7. Conclusion

Despite the noticeable decrease in poverty rates in the MENA region since the 1990s, poverty rates have risen again after the events of the Arab Spring in 2011. On the other hand, the region has witnessed a rapid digital transformation throughout the last three decades. The significant dependence on the use of ICTs along with the continuous rise in poverty rates has raised the question about the possible effects of ICT on poverty in the region. The results of the study indicate that the internet has a decreasing effect on the poverty headcount ratio and the poverty gap in MENA countries. On the contrary, mobile phones increase the poverty headcount ratio and the poverty gap in the region. The poorest in rural areas may be unable to use mobile phones due to the region's unequal development of digital infrastructure

between rural and urban areas. Despite improvements in affordability, the costs of mobile devices and services will continue to represent a barrier for many of the unconnected, especially those with insufficient incomes. In addition to the lack in poverty data of some MENA countries, the study does not consider the rural-urban digital divide, the gender digital divide, the inequality in the digital age, or the digital skills. The study also focuses exclusively on the monetary dimension of poverty and neglects other poverty dimensions. Future research can include these neglected factors and reach a more specific justification for the findings of this study. Forthcoming studies may also measure the opposite effect of poverty on ICT in the region.

In conclusion, governments should direct the use of ICT to alleviate the determinants of poverty in each country. The degree of digital transformation of each country should be considered as in the case of Yemen, where the standard of living represents the most important contributing factor to poverty. If governments did not target poverty determinants, especially with the growing use of digital technologies, they might risk exacerbating a digital divide between the poor and those who can afford to use it.

Appendix

Table 6: List of countries included in the sample

List of MENA countries	List of emerging countries
Algeria	Argentina
Egypt, Arab Rep.	Bangladesh
Djibouti	Brazil
Iran, Islamic Rep.	Bulgaria
Iraq	China
Jordan	Chile
Morocco	Colombia
Tunisia	Hungary
West Bank and Gaza	India
Yemen, Rep.	Indonesia
	Malaysia
	Mexico
	Pakistan
	Peru
	Philippines
	Poland
	Romania
	Russian Federation
	South Africa
	Thailand
	Turkey
	Ukraine
	Venezuela

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