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Research article

Impact analysis of the mobile telephone and the internet on economic development in the east African community

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Abstract: This study evaluated the East African Community (EAC), where information communication technology (ICT) adoption is still low, aiming to analyze the impact of mobile phones and the internet as components of ICT on economic development. In the first section, we used a random effect model for analysis and found out that mobile phones do not have a positive impact, while internet penetration contributes significantly to economic development. In the second section, we used the autoregressive distributed lag (ARDL) model and the error correction term (ECM) with data from six countries (Burundi, Rwanda, DR Congo, Tanzania, Uganda, and Kenya) from 2007 to 2021. Different studies evaluating ICT through mobile phone use have shown that these contribute to boosting economic development. However, economic development from ICT seems to be slower in developing countries than in developed countries; this occurs since in the former, ICT tools are mostly used to maintain social relations and not yet for economic activity purposes.

Keywords: ICT; mobile use; digital economy; economic development

JEL Codes: O33, O55, L96

1. Introduction

The economic literature of the 21st century emphasizes information and communication technology (ICT) as a critical factor to accelerate economic growth, significantly reduce poverty, and promote the development of nations. As technology progresses at an exceptional pace, the digital

economy continues to gain momentum and transforms trade and consumer behavior, resulting in changes in economic landscapes (Simione & Li, 2021; Vu, 2011). However, not all opportunities from new technologies have been attained, particularly in East African Community (EAC) countries, where infrastructure investment is low. At the same time, many people in EAC countries access the internet mainly for social relations, rather than economic activities, resulting in the possibilities of the internet being largely underutilized (Archibugi & Pietrobelli, 2019; ITU, 2022; Shodiev et al., 2021). In the case of Sub-Saharan Africa, a lack of sufficient infrastructure limits the continent's ability to leverage connectivity, thus raising costs. This disparity underscores the need for more research, particularly given the comparison between African experiences and those from more developed regions. Although the benefits of ICT are clear, countries in East Africa still face limitations in the integration and application of these technologies (The World Bank, 2009).

The focus of this study is to explore ICT through mobile phone penetration and internet connectivity as a propellant for economic development and to provide avenues to economic growth through communication and innovation, while providing a necessary perspective on these two factors, which could be core factors in EAC. In the end, the findings should inform policymakers and planners hoping to shape future development.

2. Problem statement

It is argued that the advancement of technology in the contemporary world, especially in the era of the digital economy, has transformed the manner in which individuals, businesses, and governments interact and operate across global borders. This paper shows that high-speed mobile phone adoption has, in fact, impacted the behavior of economic stakeholders. Hence, long-term development is crucial due to the implementation of new telecommunication technologies that support both employment and economic growth in rapidly developing regions. The greatest economic value of broadband can be attributed to a combination of enhancing people's readiness to engage with broadband technology and the readiness of telecommunication networks. Broadband integration in online services is likely to be the most effective approach for achieving significant value-added outcomes in these services (Fornefeld et al., 2008). ICT adoption has led to significant changes to the business models and the productivity, creativity, and competitiveness of nations. However, the great majority of cross-national studies have shown that ITC investment is associated with significant productivity for industrialized but not developing nations (Dedrick et al., 2013). In developed countries, the adoption and use of ICTs are a key ingredient for economic development. Prior research in the accounting field has also shown that ICT capital formation played an important role in promoting economic development in developed economies since the mid-1990s (Niebel, 2018).

Nevertheless, the integration of ICTs and the expansion of the digital economy via mobile phones and internet connectivity in the East African Community (EAC) pose a major challenge. Despite improvements in the adoption of ICT through mobile communication in EAC countries, there is still a dearth of knowledge on its effects on the development of their economy. Previous research has suggested that access and use of ICTs enhance the productivity and economic growth in developed nations; nevertheless, there is no previous research on mobile phone and internet use in East African nations.

For instance, businesses involved in ICT equipment and network access are following a trend toward standardization. The penetration rate of households with network connectivity continues to rise, and nearly every individual, regardless of their income level or sociodemographic characteristics,

possesses a mobile phone. It may be helpful to develop a broad index of these effects to reveal potential relationships between internationalization and the profitability of infrastructures within the emerging techno-economic paradigm (Katz, 2012).

The Great Lakes region is unique in its combination of political conflicts and economic interdependence between states. The general problems faced by the region stem from post-colonial legacies and also from longstanding historical and sometimes personal tensions among national leaders. Deteriorated relations between different groups within particular countries often influence the political landscape of other countries. Several of these conflicts are currently evident in the eastern Democratic Republic of Congo, involving Ugandan, Rwandan, and Burundian militant groups (World Bank Group, 2023).

However, this community is tasked with enhancing intergovernmental cooperation between all its members, guaranteeing security among nations, and fostering balanced economic integration across the region through free movement and trade among EAC member states. However, despite efforts across Africa to improve internet access, network availability and quality remain unequal on the continent, both between and within countries. As fixed broadband investments are expensive, countries focus on the more flexible and cheaper mobile broadband.

The ITU report (2022) highlighted the importance and contribution of ICT adoption, stating that increasing broadband penetration by one unit would boost a country's GDP by 0.08, and one unit of mobile phone penetration would raise the GDP by 0.15. In 2021, a 40% increase in mobile broadband was observed (International Telecommunication Union (ITU), 2021). On the other hand, Carmody (2012) stated that mobile phones aggravate poverty in families, based on another angle of the socio-economic structures in EAC countries, and suggesting deeper issues in mobile phone adoption.

Poverty projections by Moyer et al. (2021) showed that across the African Continent, 35.4% of people lived in extreme poverty between 2016 and 2025; this rate will decrease to 31% between 2026 and 2035. The same study demonstrated that 90% of the population living in extreme poverty will be in Africa, among whom 80% will live in rural areas. With such a disparity, there are many cases in which the use of mobile phone technology complicates the current social inequity, thereby deepening instead of eradicating the poverty crisis.

Possibly, ICT technologies may aggravate this division in the East African Community, as more of the population lives in rural areas with no access to electricity or the internet. As such, an increase in ICT adoption could potentially aggravate the differential disparities that already exist; when there is some sort of inequality as to who gets to use mobile phone technology, those without access become even more excluded in an increasingly technological society. Close access to information increases the chances of alleviating poverty for different classes and races; thus, the digital divide may widen these gaps.

A cross-sectional research conducted among university students in Tanzania revealed that students spent more money on accessing mobile phone connectivity than on food. As stated in the UNCTAD Information Economy Report (2008), the advancement of the global knowledge economy requires a solid foundation for learning and technology development. For developing countries to grasp the opportunities of globalization while facing new international challenges, it is essential to invest in building these capacities. Kleine & Unwin (2009) suggested, however, that ICTs alone cannot solve all issues of underdevelopment; much more needs to be accomplished to achieve the objectives of ICTs in enhancing the standard of living of poor and disadvantaged groups. ICTs are already being adopted for several uses, legal and otherwise.

However, cross-national research in Africa has shown that mobile phones serve mostly for social connection or as social symbols. They are also commonly used to maintain the so-called *weak ties* with business partners (Miller & Skuse, 2005). In the EAC, mobile phones are not typically used with the purpose of connecting to the global economy, similar to Ghana, where mobile phones are mostly used for relational purposes (Skuse & Cousins, 2005). In some cases, users "flash" each other to express emotions. This behavior could be considered as socially connecting, but does not directly contribute to the economy or add value to the global production network (Carmody, 2012). Similar findings have been found by Souter et al. (2005), who conducted research in Tanzania, Mozambique, and India and found that social support is the most frequently mentioned use of mobile phones. A study conducted in Tanzania revealed that even in extreme poverty, social relations are critical for survival, and mobile phones are critical tools for maintaining extended family and friend networks. The same study confirmed that mobile phones have not significantly enhanced the incomes of rural households (Sife et al., 2010).

On average, the lowest growth in mobile phone penetration has been observed in Ethiopia, Somalia, and the landlocked nations of Central and West Africa (Beuermann et al., 2012). Within the EAC, the internal digital divide remains a concern. In rural areas, mobile connectivity is uncertain, often limited to 3G. According to a report by Union (2017), 2G usage stood at 56.4% in both urban and rural areas, while 3G usage accounted for 43.6%. However, in rural areas only, 2G is mainly used (85.3%), with only 14.7% of the population having access to 3G. These statistics show that in countries where most of the population lives in rural areas, ICT adoption rate is slow, making it challenging to use digital technologies to promote economic development.

A global analysis by the ITU (2022) showed that 76% of people in urban areas use the internet, compared to only 39% in rural areas. In Europe, 87% of the population in urban areas use the internet, compared to 80% in rural areas. In America, these values stand at 83% and 60%; in the Arab States, they correspond to 76% and 42%. In the Asia-Pacific region, internet users in urban areas account for 75%, while there are only 39% of internet users in rural areas; in Africa, these values stand at 50% in urban areas and 15% in rural areas. The analysis also showed that young men use the internet more than adults, and internet usage is related to education. In Africa, internet usage in urban areas is about 3.5 times higher than in rural areas, explained by low infrastructure and literacy rates. Most of the population in rural areas in the EAC is still poorly paid; at the same time, the migration of new graduates to urban areas further reduces ICT familiarity in rural communities.

Despite these challenges, the rapid growth of the digital economy could significantly affect the economic development of EAC countries. Business leaders, policy makers, and other parties of interest must understand the extent to which these economies are supported or hindered by the new digital economy. Identifying potential challenges and opportunities of the digital economy within the EAC will help in formulating effective strategies to maximize benefits while addressing any potential negative impacts. Therefore, it is necessary to carry out extensive research on the impact of the digital economy on the economic growth of EAC countries; hopefully, this will serve as a basis for policy-making toward the development of a sustainable economy in the area. An earlier World Bank report has shown that increasing the broadband access ratio by 10% leads to a directly proportional increase in GDP by 1.35%.

Also, previous research showed that the cost of access is the key factor hindering the growth of the internet economy in developing countries. The ITU stated that the initial cost of fixed broadband is often equivalent to a quarter of the average income in the developing world.

While Africa accounts for approximately 15% of the world population, it represents only 6% of global internet users, indicating that high costs are preventing the continent from achieving the critical mass necessary to generate significant economic gains from the internet (Nyirenda-jere & Biru, 2015). Consequently, it is imperative to thoroughly investigate the effects of mobile phone and internet use on the economic development of the EAC member states. By examining the critical variables that affect ICT adoption and its effects on economic development in the EAC countries, this research aims to inform businesses and policymakers on sustainable economic development.

3. Research question

- Has mobile phone penetration boosted economic growth in the East African community, considering that most of the population uses feature phones (instead of smartphones) and lives in rural areas?
- Has internet penetration, as a component of ICT, contributed to economic growth in EAC countries? We analyze the impact of how economic indicators have changed alongside ICT adoption.

Here, mobile phone and internet use are considered the first tools with which most of the EAC population gains access to e-commerce and digital financial services. Africa currently shows significant progress in digitalization, with the number of internet users increasing from 0.79% in 2002 to 31.77% in 2019. Additionally, the number of fixed telephone subscribers increased from 3.46% in 2002 to 3.76% in 2019 (Kouladoum et al., 2022). However, internet and mobile phone use is still a relatively new development in technology and may reinforce the digital divide, as most phones sold in Africa are feature phones rather than multifunctional smartphones, due to cost, low network capacity, and widespread illiteracy (Carmody, 2012).

Most of the population living in EAC countries continues to use mobile phones mostly to maintain social relations. By contrast, in developed countries, mobile phones are highly integrated in daily economic activities, as electronic payment systems. The cost of such exclusion has been shown to be higher in rural rather than urban areas (Warren, 2007).

4. Literature review

Literature reviews are an appealing form of research, generating new knowledge by reviewing, critiquing, and synthesizing representative literature on a topic in an integrated way such that new frameworks and perspectives are created. Literature reviews help to identify central issues or methodological problems (Torraco, 2016). In the same perspective, Thomas Kuhn stated that research has to be informed by existing theory by saying that "science advances with great strides, not because scientists change their minds, but because they die and the generations that come after them are better informed".

In understanding the impact of mobile phones and internet access, different theories and previous works were examined. The starting point here is the neoclassical growth theory by Robert (1956) and Solow (1957), who introduced the production function that incorporates capital accumulation, labor force growth, and technological progress as determinants of growth. We focus on the endogenous growth theory, which emerged with Romer (1989) as an advancement over neoclassical approaches. This theory posits that economic growth results primarily from internal processes within the economy, such as investment in human capital, innovation, and knowledge. In the same vein, technological

change has been considered as the single most important parameter for growth and labor productivity (Abramovitz, 1986; Kendrick, 1956).

Simione & Li (2021) demonstrated how prior research has mostly corroborated the benefits of digitalization for productivity and growth. According to the literature review, the impact varies depending on the industry, gender, skill level, and degree of digitalization. Research has demonstrated that, particularly in developed nations, digitalization has had a significant impact on labor market outcomes, productivity, and economic development among sectors.

Numerous studies conducted in developed nations show that employment is positively impacted in the services sector, where operations are more difficult to automate (Acemoglu, 2023; Autor & Dorn, 2009). According to Tisdell (2017) and Akerman et al. (2015), ICT adoption impacts economic development by improving productivity. Paunov & Rollo (2016) showed that digitalization is associated with highly productive firms and competent employees in carrying out non-routine duties (Akerman et al., 2015). A study examining the contribution of diverse ICT fixed and mobile wideband services on economic development showed that a 10% increase in fixed broadband coverage is expected to increase GDP growth by 1.21% in developed countries and 1.38% in developing countries. The impact of ICT adoption made life easier during the COVID-19 pandemic, with countries with broadband penetration able to limit the effects of the pandemic on economic growth (e.g., China).

Digital economy through mobile phone use has become the main economic form, following the agricultural economy and industrial economy. According to Enowbi Batuo (2015), using the same methods as Datta & Agarwal (2004) by examining telecommunication and economic growth, investing in telecommunication contributes significantly to economic development. Changes in production methods, lifestyle, and governance have impacted the world's economic landscape. Thus, creating a suitable environment is necessary to stimulate those deployments. Jung (2020) conducted a study on institutions and telecommunication investments in 13 European countries from 2007 to 2015 and revealed a correlation between institutional quality and telecommunication investment. At the same time, the study showed that since institutional quality depends on the quality of connectivity through an investment in telecommunication, it is important for underdeveloped countries to concentrate on connectivity quality in order to reach and boost institutional quality. However, according to Farhadi et al. (2012), who examined the impact of ICT use on economic growth in 159 countries from 2000 to 2009, the ICT contribution is greater in developed nations than in undeveloped countries; for the latter, implementing new policies encouraging the development and use of ICT could be a way to benefit from it and promote economic growth.

A study by Usman et al. (2021) examined the effects of ICT on energy consumption and economic growth in Bangladesh, India, Pakistan, and Sri Lanka between 1990 and 2018. Their findings show that only India is obtaining long-term economic benefits from ICT. Another study by Asongu et al., Rahman (2020) found that ICT impacts the service sector but does not directly impact the agriculture and manufacturing sectors.

Buys et al. (2009) showed that the likelihood of having a cell phone tower in a specific area is positively and highly correlated with certain demand factors, including per capita income and population density, as well as the level of competition in the nation's mobile phone market. Additionally, mobile phone service is adversely correlated with higher elevation, steeper slopes, and distance from large urban centers and significant road factors, which are similarly correlated with higher expenses. Empirical evidence suggests that these factors partially explain the rollout of mobile phone service within countries as well (Beuermann et al., 2012).

Many studies have tried to evaluate the transformational developmental impacts of new ICTs, particularly mobile phones, on Africa. However, such studies neglect other structural dynamics and the contradictory impacts of mobile phones, which can increase—but sometimes decrease—economic growth (Carmody, 2012). Here, we examine the impact of mobile phones on the economic development of EAC countries and the contribution of ICTs through internet access to GDP per capita. A growing number of studies have demonstrated that the decrease in mobile phone–related communication costs has real economic advantages, enhancing labor productivity and agricultural markets as well as the well-being of producers and consumers in certain situations and nations (Aker, 2008; Klonner & Nolen, 2008).

Simione & Li (2021) conducted a study on the impact of internet penetration on real GDP per capita, with mixed findings obtained. For the first time, an instrumental variable was used, and the authors discovered that such influence is not statistically significant. Nevertheless, when they changed the instrumental variable to the capacity of the cables, there was a significant and large impact.

The use of mobile phones to acquire information allowed Senegalese farmers to boost the price of their products, while Angolan herders were able to use GPS technology to identify their livestock. The OECD report (Organization for Economic Cooperation and Development) stated that if the advantages gained from ICT are distributed to every economic sector, they could result in welfare gains and economic growth or sustainability on a national scale. An important consideration for maximizing the benefits of ICT application for developing nations was brought to light by an EIU (Economist Intelligence Unit) study in 2004, with the target of determining the relationship between ICTs and economic development in developed and developing countries, between 1995 and 2002. The results showed a high positive correlation between ICTs and economic growth in developed countries, but not in developing ones. Thus, in developing nations, it seems that ICTs are not exploited effectively in order to allow these new technologies to positively impact the economy. This is associated with the challenges that developing countries face, namely that investments in ICT need to compete with the basic necessities. Investment in ICTs requires adequate infrastructure, which results in high debt burdens and constitutes an expensive affair (Fong, 2009).

A report by Telecommunication & Conference (2010) showed that mobile phone penetration relates to the income level of the population and to how the country facilitates competitiveness. The problem remains that most countries where mobile phone performance is poor relative to per capita income have limited competition. Although the mobile phone industry in Africa has recently experienced remarkable growth, it may be challenging to maintain this growth rate, since ICT users and subscribers are likely to originate from rural areas, where most of the lower-class population is concentrated. In this market, delivering service is challenging because of the high infrastructure expenses. For example, in most EAC rural areas, telecommunication companies have to set up network antennas. Due to the lack of electricity, these antennas use fuel to operate, which is an imported product whose availability depends on the availability of foreign currency. Such communities are characterized by low-income levels, and increasing taxes on communication services, which would have a significant impact on ICT use, would also raise the cost and discourage or limit massive adoption.

Several EAC countries apply an excise duty on mobile and fixed communications. In many countries, calls are very expensive due to the combination of VAT and excise taxes. EAC clients are also very sensitive to the price, as every little change can greatly affect them. In Africa, the following policy issues have to be solved in order to advance the use of mobile phones and their development as means of mobile broadband: taxation, roaming, and anti-monopolistic regulations. Internet connection

is also much more expensive in African countries than in other countries: connectivity is more than 40% of gross national income per capita, hence being a major barrier to the development of a massive ICT (Telecommunication & Conference, 2010).

By creating new jobs and cancelling others, ICTs affect the labor market both adversely and positively (Simione & Li, 2021). Akerman et al. (2015) noted that wideband availability resulted in job loss and wage cuts for the low-skilled population. Additionally, emerging markets, developing countries, and developed economies are all highly influenced by the job substitution effect. Gillett et al. (2006) and Klonner & Nolen (2008) showed that ICTs positively impact employment both in developed and developing countries. The connection between mobile telecommunication and economic development has been analyzed comprehensively, but little has been done in the EAC community. This gap in research is the goal of this study.

5. Theoretical hypothesis

5.1. Theoretical information on mobile phone use and economic development

Digital economy through mobile phone use has become the main economic form, following the agricultural and industrial economies. However, there is a divide between countries (and within the EAC countries) regarding mobile phone penetration, which massively helps to close the digital divide and foster the digital economy. Mobile phone adoption is considered a key factor in increasing productivity and achieving higher growth. As such, investment in telecommunications networks is crucial.

In this context, Amaghionyeodiwe & Annansingh-Jamieson (2017) examined the impact of mobile phone technologies on economic growth and employment by using GMM; their findings showed that mobile phone technology significantly impacts economic growth. Lee et al. (2012) used a special linear GMM estimator and reported that mobile phones play a major role in the economic development of 44 Sub-Saharan countries. They also underlined that the impact of mobile phone use on economic development increases wherever landline phones are rare.

According to the study of Klonner & Nolen (2008), women are the primary drivers of employment increases in South Africa due to the mobile phone network. At the individual and firm levels, Franklin et al. (2009) found that digitalization is linked to disparate productivity improvements that favor innovation. According to Gruber & Koutroumpis (2010), mobile telecommunication diffusion strongly contributes to GDP and productivity growth. In EAC, most of the population does not have computers; as such, the main tool to use the internet or obtain knowledge about ICTs is to use a mobile phone.

Based on all reviewed literature, we formulate the first hypothesis, which posits that widespread mobile phone usage could enhance communication, access to financial services, and market connectivity, which in turn contribute to overall economic expansion.

Hypothesis 1: Increased mobile phone use can promote economic growth in EAC countries.

5.2. Internet and economic growth

While diminishing returns may occur from individual factors of production, such as capital, other avenues for growth can arise from comparative and competitive advantages embedded in the knowledge base. These advantages may result from technology adoption due to the fact that new technologies are not always available or fully utilized. Clarke & Wallsten (2006) revealed that internet

usage does not have a positive relationship with economic development. They have also observed that internet access and internet use are more prevalent among enterprises in high-income countries. The impact of internet usage is greater among users than enterprises, and internet penetration remains limited in developing nations. However, access to the internet is more advantageous for enterprises in developed countries.

Recent cross-country panel data analyses have evidenced that the internet affects trade by reducing distance in trade, thereby facilitating economic development through e-commerce (Meijers, 2003). Similarly, Tripathi & Inani (2016) sought to find out whether internet usage influences economic growth in Sub-Saharan Africa. They found that while internet usage positively impacts long-term economic growth, it is detrimental to the short-term economic progress. These insights can greatly shape the formulation of internet and economic growth plans in Sub-Saharan African countries. Many countries are now aware of the reality and importance of the internet in promoting economic growth and are contributing to growth through the adoption of effective internet policies.

Despite these efforts, Sub-Saharan African countries are among the most disconnected from the rest of the world in terms of internet availability. Maximizing the benefits of the information and communication transformation requires EAC countries to improve the business environment and invest in education, health, and governance. In the absence of these fundamentals, new technologies have not increased worker productivity or reduced income disparity. Countries that pair technology investments with other economic liberalization tend to realize digital dividends such as higher growth rates, increased employment opportunities, and quality services.

Since the use of mobile phones and the internet has established itself as a significant force that is influencing the world, it would be interesting to analyze such impact on EAC countries, where the potential use of mobile phones and the internet is still unknown. This study aims to evaluate the impact of mobile phones on the economic development of EAC nations and the potential role of the internet in driving progress. Previous works have pointed toward the internet as an element in ICT. Sadorsky (2012) and Saidi et al. (2017) incorporated internet connection as one element of ICT and showed a positive correlation between ICTs, energy, and economic growth. Telecommunication infrastructure plays a crucial role in enabling user access to the internet. On the other hand, Bakari & Tiba (2020) pointed out that the internet has an insignificant effect, especially in the long run. Similarly, Maurseth (2018) noted that the impact of the internet on growth was negative and statistically significant.

During the past two decades, researchers have devoted considerable effort to investigating the impact of ICTs on income growth per capita, using cross-sectional or panel data at the national level using different methodologies, different data sets, and different sample periods. Most empirical studies affirmed that enhanced use of ICTs results in improved per capita GDP, employment, and productivity regardless of the country. The effect of ICT on labor productivity was estimated by Schreyer (2002) for the seven developed countries of the G7. The research revealed that ICT investment played an important role in labor productivity from 1990 to 1996. Gillett et al. (2006) also concluded that broadband development positively influenced economic growth, employment, and IT expansion in the US. However, Van Gaasbeck et al. (2007) showed a negative impact of broadband on business growth, even as it contributed positively to the economy and job creation.

Hypothesis 2: Higher levels of internet penetration leads to increased economic growth in the EAC.

5.3. Urbanization and economic growth in EAC

The role of cities is becoming increasingly significant as global urbanization accelerates, with entrepreneurship driving business creation and wealth. Many countries across the globe are interested in urbanization since it is an indicator of the progress of a country. Khoshnevis & Golestani (2019) explored the effect of urbanization on the social and economic functions of rural and urban areas, observing that economic shifts in developing countries are physically expanding urban regions. Chang & Brada (2006) showed how the concept of urbanization relates to the concept of economic development; urban regions are relieved from transportation costs due to the high population density and concentrated manufacturing, facilitating economies of scale. This allows urbanization to coexist with development and economic prosperity.

Some authors argue that causality flows from economic development to urbanization, with urbanization contributing only marginally to further development (Liu et al., 2015). As a result, the household registration system reform must be accelerated to facilitate urbanization and thereby facilitating regional economic development. This study, which evaluated 28 provinces in China, revealed that economic growth enhanced urbanization in more than half of the provinces; however, its impact was minimal in others.

Hypothesis 3: Higher urbanization rates could spur rapid economic expansion.

6. Research method

6.1. Data presentation

This research starts by employing panel data analysis, in which the random effect model is used, based on the Hausman test. In the second section, time series analysis through the ARDL model is used to capture the impact of mobile phones and the internet on economic development. Data were collected from the International Telecomm Union, World Bank development indicators, and the International Monetary Fund (IMF). Data ranges from 2007 to 2021, corresponding to the entrance of Burundi and Rwanda into the EAC. Data is from six EAC countries (Burundi, Rwanda, DR Congo, Tanzania, Uganda, and Kenya); the countries and the study period were chosen based on constraints on other periods and countries, such as Somalia and South Sudan. The multivariate framework uses variables such as per capita economic growth in percentage (GDPperCap), internet penetration (IT_Users), mobile phone penetration (Mob_Users), and urban rate (Urban_Rate). These variables are converted into their natural logarithms before use. As data ranges from 2007 to 2021, a panel data analysis and time series analysis are the most appropriate.

To better determine the impact of ICT on economic growth and the relationship between the study variables, first, we use panel data analysis and then run the Breusch–Godfrey/Wooldridge test, the Breusch–Pagan test, and the Hausman test for diagnostics. At the same time, different techniques such as the ADF test (Augmented Dickey–Fuller), the PP test (Phillips–Perron), and the KPSS test (Kwiatkowski–Phillips–Shin–Schmidt) are used to study and explore the association between variables. The study also uses ARDL for cointegration examination and the error correction term (ECT) to analyze short-run and long-run dynamic relationships.

This study employs the endogenous growth model modified into a time series, which includes mobile phone penetration as a determinant of economic growth.

Table 1. Descriptive statistics.

Variables	Observations	Mean	Std_Dev	Min	Max	Skew	Kurtosis
Year	90	2014	4.34	2007	2021	0	−1.25
GDPperCap	90	743.63	430.36	170.70	2,069.66	1.04	1.01
Mob_Users	90	51.11	25.78	3.39	122.79	0.24	−0.20
IT_Users	90	8.75	7.90	0.37	31.63	1.09	0.21
Urban_Rate	90	24.83	10.11	9.86	46.23	0.51	−0.76

Table 1 shows that the number of observations for each variable is 90. In GDP per capita, the mean is 743.62, which is slightly lower than that of developed countries. Therefore, the ICT can still be seen as relatively low. Regarding mobile phone penetration and internet coverage, the mean is 51.11 and 8.75, respectively, showing increased use of digital technology in the region, even though this increase differs between countries. Based on the skewness measures, it is established that GDP per capita SK = 1.04, mobile phone user SK = 0.24, and internet SK = 1.09. Looking at the positive skewness, some countries could present values higher than the average, increasing the mean. The standard deviation for GDP per capita is also high (430.36), which implies a fluctuation in economic mobility between countries. Among the users of mobile phones (mean = 25.78) and the internet (mean = 7.90), fluctuations in standard deviations indicate variation between countries.

This table shows the economic and social conditions across the countries. The variability in GDP per capita, mobile phone users, and internet penetration suggests significant disparities, while the low electricity access indicates areas needing development.

6.2. Equation related to panel data analysis

Panel data (known as longitudinal or cross-sectional time-series data) is defined as a dataset in which the behavior of entities (*i*) is observed across time (t) (Torres-Reyna, 2007). The same author specifies that panel data deals with omitted variable bias due to heterogeneity in the data in order to control unobserved variables that are correlated with predictors. However, Xu et al. (2007) defined a panel dataset as a cross-sectional timeseries dataset, which provides repeated measurements of a certain number of variables over a period of time on observed units, such as individuals, households, firms, cities, and states.

The general panel model equation is as follows,

$$Y_{it} = \alpha + \beta X_{it} + \varepsilon_{it} \tag{1}$$

where

Y_{it} is a dependent variable for entity *i* at time t.

α is the intercept.

X_{it} is a vector of independent variables for entity *i* at time t.

ε_{it} is the error term for entity *i* at time t.

From the general equation, the random effect model equation can be derived as follows:

$$ln(Y_{it}) = \alpha i + \beta\, ln(X_{it}) + u_i + \varepsilon_{it} \tag{2}$$

where

ln is the natural logarithm.

u_i is a random effect specific to entity *i*.

The differenced and transformed equation can be written as:

$$\Delta\, ln(Y_{it}) = \alpha + \beta \Delta\, ln(X_{it}) + u_i + \varepsilon_{it} \quad (3)$$

where
$\Delta\, ln(Y_{it})$ is the first difference of the log of the dependent variable.
u_i represents the entity-specific effects.
ε_{it} is the idiosyncratic error term.

6.3. Equation related to the ARDL model

The general time series equation is described as follows:

$$Y_t = \alpha + \beta X_t + \varepsilon_t \quad (4)$$

where
Y_t is the dependent variable (GDPperCap) at time t.
α is the intercept (constant).
β is the coefficient.
X_t represents the independent variables (Mob_Users, IT_Users, Urban_Rate).
ε_t is the error term.
The modified model introduces the lagged variable and becomes:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 X_t + \varepsilon_t \quad (5)$$

where Y_{t-1} is the lagged dependent variable (GDPperCap)

In our study, GDP per capita evaluates economic growth. This model includes the lagged value of the dependent variable, meaning that the past influences the current situation of the dependent variable. Apart from the dependent variable (GDP per capita), the independent variables are mobile phone users, internet users, and urban rate. All variables are transformed into a logarithmic form before conducting any test.

Applying the log form in Equation 2 by ignoring the intercept, it becomes:

$$\ln (Y_t) = \beta_1 \ln (Y_{t-1}) + \beta_2 \ln (X_t) + \varepsilon_t \quad (6)$$

As we use the ARDL model in our analysis, this formula is expected to be useful. The equation becomes:

$$\Delta\, ln(Y_t) = \alpha + \sum_{i=1}^{p} \beta_i \Delta\, ln(Y_{t-i}) + \sum_{i=0}^{q} \gamma_j \Delta\, ln(X_{i-j}) + \varepsilon_t \quad (7)$$

where
ΔY_t represents the changes in the dependent variable (GDPperCap).
γ_j are coefficients for the lagged changes in independent variables.
$\Delta\, X_{i-j}$ represent the first difference of independent variables.
We estimate the short-run dynamic with the following equation:

$$\Delta\, ln(Y_t) = \alpha + \beta_1 \Delta\, ln(Y_{t-1}) + \sum_{i=0}^{q} \gamma_j \Delta\, ln(X_{i-j}) + \lambda(Z_{t-1}) + \varepsilon_t \quad (8)$$

where
$\Delta\, ln(Y_t)$ represents the first difference of the logarithm of the dependent variable.

$\Delta\, ln(Y_{t-1})$ represents the lagged first difference of the logarithm of the dependent variable.
λ is the coefficient reflecting the speed of adjustment to the long-term equilibrium.
Z_{t-1} represents the long-term relationship (cointegrating equation) expressed in levels.

7. Results and discussion

7.1. Panel random effect model

Random effect models assume that the entity's error term is not correlated with the predictors, which allows for time-invariant variables to play a role as explanatory variables. This study combines different methods, including a random effect model, in order to capture how ICT indicators such as mobile phone and internet use affect economic development. to contribute to the knowledge and inform policymakers on which points they may focus.

Table 2. Random effect model results.

Dependent variable	Differenced Log GDP per Capita
Diff Log mobile phone users	−0.050
	(0.039)
Diff Log IT users	0.355***
	(0.036)
Diff Log urban rate	−0.434
	(0.268)
Constant	0.009
	(0.025)
Observations	89
R2	0.663
Adjusted R2	0.651
F Statistic	167.331***

Note: *p < 0.1; **p < 0.05; ***p < 0.01; diff means the first difference that makes the variables stationary.

As shown in this table 2, the panel random effect shows a coefficient of −0.050, indicating that for every 1% increase in mobile phones, the differenced log GDP per capita decreases by 0.050%. However, this coefficient is not statistically significant. As such, we do not have evidence to affirm that changes in mobile phone penetration have a meaningful impact on GDP per capita. However, the coefficient of internet users (0.35) is positive. This positive relationship is statistically significant at a level of confidence of 0.01%. This empirical finding suggests that a 1% unit increase in internet penetration results in a differenced log GDP per capita increase of 0.35%, which means that internet penetration contributes significantly to economic development. This empirical finding agrees with the endogenous theory by Schiliro (2019), in which the globalization processes, the emergence of the industrial revolution, and the role of human capital through its learning capacities are the main factors influencing growth. This theory assumes that technological changes contribute to economic development.

Nevertheless, urbanization has a negative relationship with GDP per capita. However, this is not statistically significant. This means that different activities have to be incorporated in order to profit from urbanization by increasing the return. Based on the results of the random effects model, the first hypothesis in this paper, suggesting that increases in mobile phone penetration can promote economic

growth in EAC, is not confirmed. However, the second hypothesis regarding internet penetration is confirmed theoretically and empirically.

7.2. Autoregressive distributed lag model

Unit root test result for the augmented Dickey–Fuller test

Table 3 shows the ADF test results. The findings show that one variable (Mob_Users) is stationary in level I (0), since its statistic test with intercept and trend is greater than the critical value (−3.45) at the 5% level. This leads us to reject the null hypothesis, suggesting that the series has a unit root, meaning it is not stationary. In this case, the test shows that this variable is integrated at level I (0). However, all the remaining variables, such as GDPperCap, IT_Users, and Urban_Rate, are integrated in the first difference I (1). Since the variable Mob_Users is integrated at the level, and the remaining variables are integrated after the first difference, we proceed with the ADRL model.

Table 3. ADF test results.

Variable names	ADF statistical test	Critical value 5pct	Decision at 5%
(LGDPperCap)	−2.32	−3.45	I (1)
D(LGDPperCap)	−6.77	−1.95	
LMob_Users	−4.71	−3.45	I (0)
LIT_Users	−3.06	−3.45	I (1)
DLIT_Users	−7.01	−1.95	
LUrban_Rate	−2.36	−3.45	I (1)
DLUrban_Rate	−5.89	−1.95	

Source: Author's computation in RStudio. L denotes the natural logarithm, and D indicates the first difference of the variables.

Table 4. Philip–Perron test.

Variable names	Philip-Perron statistical test	Critical value 5pct	Decision at 5%
LGDPperCap	−2.32	−3.46	I (1)
DLGDPperCap	−10.61	−3.46	
LMob_Users	−5.10	−3.46	I (0)
LIT_Users	−2.95	−3.46	I (1)
DLIT_Users	−10.32	−3.46	
LUrban_Rate	−2.51	−3.46	I (1)
DLUrban_Rate	−9.20	−3.46	

Source: Author's computation in RStudio.

Similar to the ADF test, the Philipp–Perron test shows that only one variable, Mob_Users, is integrated at level I (0). Other variables (GDPperCap, IT_Users, and Urban_Rate) need to be differenced in order to become stationary. However, when changed to the first difference, all variables become integrated at first difference I (1) with the statistic test with intercept and trend greater than -3.46 at 5% of critical value. Thus, we reject the null hypothesis of non-stationarity at first difference in the series.

Table 5. KPSS test.

Variable names	KPSS statistics	Critical value 5pct	Decision at 5%
LGDPperCap	0.17	0.146	I (1)
D LGDPperCap	0.05	0.146	
LMob_Users	0.14	0.146	I (0)
LIT_Users	0.10	0.146	I (0)
LUrban_Rate	0.09	0.146	I (0)

Source: Author's computation using RStudion.

The KPSS test shows a mixed integration in the sense that variables like Mob_Users, IT_Users, and Urban_Rate are integrated at level I (0), since their statistic test is less than their critical values at 5%. However, the variable GDPperCap is not stationary in level; thus, we conduct the first difference and it becomes stationary.

Table 6. ARDL model of cointegration relationships for long term.

Variable	Coefficient
d_GDPperCap	1.000
d_Mob_Users	7.1054×10^{-15}
d_IT_Users	0
d_Urban_Rate	105.261

Source: Author's computation using RStudio. d means the first difference.

Table 6 represents different cointegrating relationships, where the coefficients show the strength and direction of the relationships between variables. It indicates how much the independent variables influence the response variable (GDP per capita); a positive coefficient means that the variable is associated with GDP per capita in the long run. For example, an increase in urbanization positively impacts GDP per capita, while other variables have a positive impact with negligible effect. Based on this result, these variables positively correlate with GDP per capita in the long term. Focusing on the sign of the coefficient, positive and statistically significant coefficients mean that the variable has a positive impact on GDP per capita. Urban_Rate has a significant impact, which means that an increase in Urban_Rate is associated with an increase in economic growth. Policymakers should prioritize investments in energy infrastructure to facilitate economic activities and improve GDP per capita.

Table 7. Short-term dynamics.

Dependent variable	ECT coefficient	Standard error	Significance level
d_GDPperCap	−1.0017	0.249	*** (statistically significant with $p < 0.01$)
d_Mob_Users	−1.183	0.272	*** (statistically significant with $p < 0.01$)
d_IT_Users	−0.958	0.214	*** (statistically significant with $p < 0.01$)
d_Urban_Rate	0.0008	0.0004	* (statistically significant with $p < 0.1$)

Source: Author's computation using RStudio. *: $p < 0.1$, **: $p < 0.05$, ***: $p < 0.01$.

This table provides the error correction terms and their significance, indicating how quickly each variable adjusts to return to the equilibrium. Based on the results from this table, all variables are statistically significant, meaning that the variables adjust toward their long-run equilibrium after short-term shocks. For example, GDP per capita has a coefficient (−1.0017) that is statistically significant at the 1% level. This suggests that any deviation from the long-term equilibrium in GDP per capita will adjust negatively, indicating a strong tendency for GDP per capita to return to equilibrium. Thus, urban

rate has a positive coefficient (0.0008) statistically significant at the 10% level, which means that urbanization has an immediate positive impact on GDP per capita.

Table 8. Lagged value effect on GDP per capita.

Lagged variable	ECT coefficient	Significance
d_GDPperCap (−1)	−0.038	Not statistically significant
d_Mob_Users (−1)	6.9892	Not statistically significant
d_IT_Users (−1)	14.5116	*** (statistically significant at $p < 0.01$)
d_Urban_Rate (−1)	4.5991	*** (statistically significant at $p < 0.01$)

Source: Author's computation using RStudio.

This table shows whether the previous period impacts the current situation. We can see that the lagged values of Internet_Users and Urban_Rate have a significant positive impact on economic development, indicating that a 1% increase in Internet_Users and Urban_Rate is associated with an increase of 14.5% and 4.6%, respectively, in GDP per capita of the current situation, statistically significant at $p < 0.01$. The statistics of these two variables in the previous period promote economic development in the current situation.

Table 9. Model diagnostic results for panel data.

Test	Chi-squared	p-value
Breusch–Godfrey/Wooldridge for serial correlation	17.099	0.25
Hausman	2.5988	0.627
Breusch–Pagan for heteroskedasticity	BP = 6.7866	0.1476

Source: Author's computation using RStudio.

This diagnostic model is used to check if there is serial correlation and heteroskedasticity, and to determine which model to adopt between fixed effects and random effects. According to the residuals test, there is no serial correlation since the p-value of the statistic test is higher than the critical p-value at 5%. Thus, $0.25 > 0.05$. The same occurs regarding the heteroskedasticity test; the p-value is higher than 0.05. Hence, we do not have evidence to reject the null hypothesis that suggests that there is no serial correlation and heteroskedasticity.

However, regarding the Hausman test, since the p-value is higher than the critical p-value, it shows that we have to adopt the random effects model instead of the fixed effects model.

Figure 1 shows the way in which mobile phones and the internet together contribute to economic development, as shown by our empirical results. Figure 1 reinforces such results and provides a general view on how these two parameters may interact in order to boost income for the East African population from technological advancements. Here, we see that one single parameter is not enough to reach the target. To reach GDP growth and job creation, a combination of both elements integrated into economic activities is required. However, the main issue for East Africa could be the fact that mobile phones and the internet are used for maintaining social relations among families, primarily using Facebook and WhatsApp. Since the general focus here is the limitation of using applications that require broader internet access, the consequence here becomes the lack of integration of mobile phones and the internet into economic activities, as those applications are not popular.

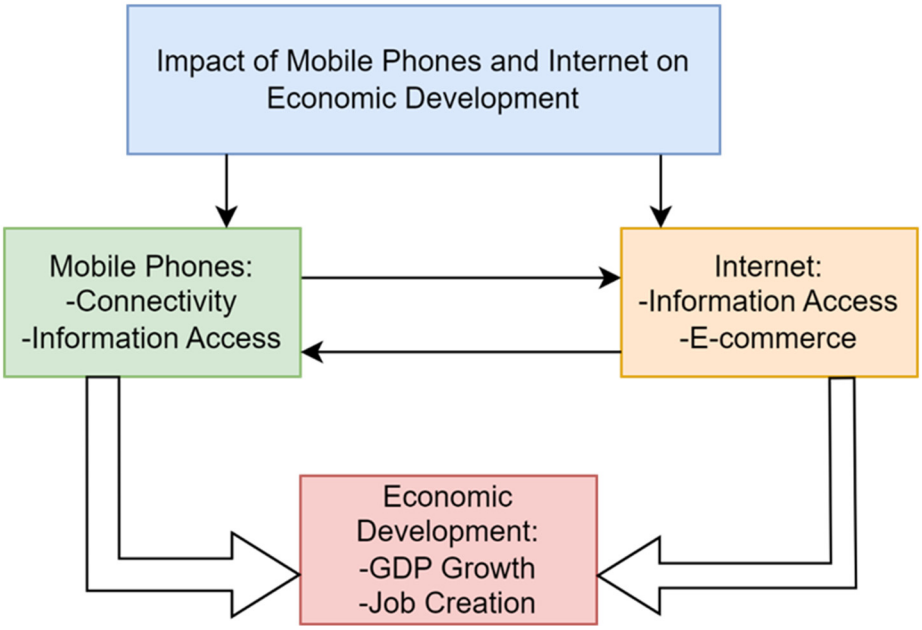

Figure 1. Schema of ITC impact on economic development. Source: Author's computation using draw.io.

8. Conclusions

In this study, we investigated the contribution of mobile phones and the internet to economic development in East African Community countries. The study used the random effects model, ARDL for error correction term (ECT) for short-run, and cointegration relation examinations for long-run dynamics. Using the random effect model, findings reveal that mobile phone penetration does not contribute positively to economic development. These statistics can be explained by stating that the EAC population still presents dominant illiteracy rates in the ICT domain; also, most use feature phones. Both factors together result in mobile phones being seen as luxury items. However, the same model reveals that internet penetration contributes significantly to economic development in the EAC. Policymakers must implement rules to aid the telecommunication sector by providing adequate infrastructure in order to stimulate investors and reduce import taxation and other related services. This could, in return, increase the smartphone penetration rate and contribute significantly to the economic development of the region. On the other hand, increasing the penetration rate is not sufficient; there is also a need to create the necessity of using mobile phones regularly; in other words, it is necessary to integrate mobile phone use into economic activities, and not only to maintain social relations.

Moreover, the results from both ARDL for short-run and error correction term with long-run cointegration relations reveal that mobile phone and internet penetration contribute to economic development in the EAC. However, concerning the lagged value impact, only lagged values from internet penetration have an impact on the current situation. Most of the population uses feature mobiles instead of smartphones, which do not need to be connected before use; also, most applications developed related to money transfer do not demand an internet connection, for example, to send or to receive money. Policymakers need to provide new systems for economic activity, such as electronic payment systems and online shopping; these could then contribute to economic development. At the same time, they should prioritize investments in infrastructure and education to support economic

activities, providing a greater component of GDP per capita, and demand urban planning and inclusive service provision to fully accomplish the efficiency potential.

Future researchers should further investigate the actual barriers against internet penetration in the EAC and also evaluate the different purposes for which mobile technology is used, beyond simple social interactions, such as m-commerce, m-banking, and m-agriculture, among others.

Data availability statement

The data supporting the findings are available on World Bank database.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare no conflict of interest.

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