# The Economic Impact of Telecommunications in Egypt

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**Abstract**

The Egyptian telecommunication sector grew by 17% during the second quarter of the fiscal year 2020/21, the highest among all sectors in the economy, proven to be remarkably resilient in the face Covid-19 pandemic and the Delta variant. Using quarterly time-series dataset over the period 2000 – 2019, the study estimates the direct economic impact of telecommunications on economic growth measured by the revenues generated by the sector and the indirect economic effect (or spillover) of telecommunications on the economy by employing a structural econometric model based on an aggregate production function, a demand function, a supply function, and an infrastructure function to detect causality and examine long-run relationships between variables. This study uses two measures of telecommunications, mobile unique subscribers and mobile broadband capable device penetration to quantify the spillover effects of mobile telecommunications on the economy. Statistics show that telecommunications sector's revenue comprised 4.4% of GDP, reflecting the direct effect of telecommunications on the economy. Additionally, according to the structural model, mobile unique subscribers and mobile broadband capable device penetration significantly contributed to the Egyptian GDP growth between 2000 and 2019. More specifically, the estimation results show that for every 1% increase in penetration in mobile unique subscriber penetration and mobile broadband capable device adoption, the average annual contribution to GDP growth is estimated to increase by 0.172% and 0.016%, respectively. On this basis, this study provides policy recommendations related to maximizing investment in network utilization including mobile, Internet services, and fixed broadband subscriptions. Research extensions would include testing the significance of complementarities such as improving governance measures and building human capacity for both households and firms, which are necessary to boost the impact of telecommunication on economic growth in Egypt.

**JEL classification:** L96, O33, O47
**Keywords:** Telecommunications; ICTs; Economic Growth; Egypt

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## 1. Introduction

As the COVID-19 pandemic continues to strongly affect economies worldwide, developing countries such as Egypt have suffered greatly. During times of economic downturn, it is important to discover innovative ways to boost the economy and provide assistance to citizens. The telecommunications industry has historically been very successful in Egypt and is a possible source for economic growth and relief from the effects of the COVID-19 pandemic. In order to explore this possibility, it is important to understand the economic impact that telecommunication has on Egypt. In addition to providing possible economic relief for the nation, the government has formulated Egypt Vision 2030, which is a plan that aims to implement sustainable development practices and principles in all areas of the country (MPED 2021). Furthermore, the government hopes to build a Digital Egypt, which will act as a major vehicle for achieving the goals set in Egypt Vision 2030. As Egypt pursues a digital society, they have also implemented a plan, ICT 2030, to further invest and develop information and communications technology (ICT) within the country (MCIT 2021a). As Egypt plans to implement ICT throughout the country, it is important to understand the relationship that exists between ICT and the country's economy. The growth of telecommunication surely will facilitate the realization of the digital transformation goal, especially to build economic resilience in the face of the COVID-19 pandemic. Therefore, the purpose of this paper is to determine both the *direct* and *indirect* economic impact of the telecommunication industry on Egypt.

In order to further investigate this relationship, the paper first reviews existing literature to determine the economic impact of the telecommunication industry on the economy as a whole (section 2). Section 3 presents a descriptive analysis of Egypt's economy to highlight significant aspects that deserve further examination. Section 4 presents the data used in the study and section 5 illustrates the estimation results with the application of the structural model. The study then relies on the key empirical findings to provide relevant policy recommendations in section 6.

## 2. Research Review

As technology quickly advances, it is critical to deploy telecommunications networks to help people stay connected and informed. In the current digital age, it is more important now than ever to increase the speed and quality of digital communication worldwide, especially for developing countries that may suffer more severely from the digital divide. The digital divide is a gap between people who can enjoy the benefits from accessing modern information and communications technology and people who do not have access. Technologies include but are not limited to fixed and especially mobile telephony, personal computers and smartphones, fixed and mobile broadband, as well as TV. Sherif (2009) explains that there are four aspects of the digital divide, which are people, information, knowledge, and technology. This divide comes as a result of inaccessibility to digital knowledge; however, governments can implement ICT in a variety of ways and tackle this issue of knowledge and accessibility disparities, as ICT is known for its flexibility and ability to be used in a wide range of occasions. Currently, the Egyptian government plans to implement ICT in multiple approaches with the intent of increasing economic growth. Some of the ICT applications that Egypt plans to implement include remote delivery of healthcare through applications that send out notifications to help citizens stay engaged with their health and cloud computing by hosting workshops and conferences (Oxford Business Group, 2020). The possibilities of applications like these reveal that ICT has a great potential to exert a significant impact on economic development and consumer welfare, and even more so for developing countries such as Egypt.

As a result of telecommunications playing a larger role in everyday life, its economic benefits have been a prominent point of discussion. The most significant relationship that has been researched is the impact that broadband and the telecommunications industry as a whole have on economic development. In fact, there is existing literature that supports the notion that ICT facilitates economic growth, particularly for developing countries. The study of Madden and Savage (2000) finds that across countries there is a significant positive relationship between telecommunications and economic growth. On a

similar note, Markova (2009) finds that investing in telecommunications infrastructure encourages economic growth, and there are higher returns on telecommunications infrastructure rather than on solely telecommunications investments. Chakraborty and Nandi (2011), who take a step further, find that the relationship between the telecommunications infrastructure investment and per capita growth depends on the level of a country's development. Lesser-developed countries have per capita growth that has a stronger correlation with fixed line tele-density; this strong relationship even holds for emerging countries. while relatively more developed countries have a weaker correlation between the two. In addition to research done on the relationship between telecommunications infrastructure and economic growth, more studies have been conducted to discover the relationship between telecommunication and other economic indicators such as the impact on entrepreneurship (Alderete, 2019), the contribution of mobile broadband to country GDP (Eisenach and Kulick, 2020), the impact of mobile broadband on state GDP (Edquist et. al, 2018), the impact of broadband speed on enterprise productivity (Mack and Faggian, 2013), and the impact of broadband speed on job creation (Katz et. al, 2010), just to name a few. It is also important to note the multitude of studies that focus on the relationship between specifically broadband and economic factors, as broadband is an important stepping stone for achieving robust and sustainable telecommunications infrastructure.

Another common finding of these studies is the concept that while telecommunications may have a direct contribution to job creation through employment and improved services, the externalities produced by an increase in telecommunications infrastructure or optimization of existing infrastructure contribute significantly to economic change and/or growth. These findings and the fact that there are positive externalities from improving the telecommunications sector are significant to exploring the economic impact of telecommunications on Egypt due to the country's widely expanded telecommunications sector, which is hoped to continue to grow. Some of these positive externalities may include a change in employment and/or business productivity and development, which are both topics that are increasingly being studied as they relate to changes in the telecommunications sector. In addition to studying the impact that the transition to 4G had on the United States Economy, Eisenach and Kulick (2020) also found that the deployment of the technology led to a significant increase in employment as well as output.

In addition, there are a multitude of studies that have similar findings to the aforementioned papers and assist with furthering the idea that ICT and telecommunications contribute significantly to economic development. Among all, many studies on the economic impact of telecommunications on economic development have focused on countries with less developed telecommunications sectors. For instance, Katz and Koutroumpis (2012) study the economic impact of telecommunications in Senegal and find that mobile phones had a measurable impact on economic growth, whereas they fail to find the impact that broadband technology had on the economy since it was still in early adaptation at the time of the study. Some recommendations they proposed are higher connection speeds through more advanced cellular technology or fixed broadband networks. Katz conducted more research which supported these findings. Specifically, Katz and Jung (2020a) found that the telecommunications sector generates significant direct and indirect improvements in economic growth in Guinea.

However, these countries, unlike Egypt, have relatively lower telecommunication and ICT infrastructure. In the case of other Middle East and North African (MENA) countries with telecommunication trends more similar to those of Egypt, research suggests that the contribution of broadband penetration to economic growth remains at comparable levels. Katz and Callorda (2015a) studied the economic impact of telecommunications in Jordan and found that fixed broadband, wireless broadband, broadband penetration and GDP growth have a positive correlation, but with diminishing returns. They also found that the strength of economic impact varies by technology, where fixed broadband had the highest strength of economic impact. They later found similar results in Morocco (2015b) and Tunisia (2015c), two other MENA countries. Additionally, Pradhan, et al. (2017) studied the relationship between broadband penetration, financial development, and economic growth in Arabic countries between 2001 and 2013. They found a long-run equilibrium relationship between broadband

penetration, financial development (which they represent as a variety of economic indicators) and economic growth.

The time that Egypt has spent on the investment of ICT is significantly longer than their peers, which has helped the country to create a strong infrastructure for reliable telecommunications systems. Between 1985 and 1995, the government had a public-private partnership, which focused on developing their infrastructure, and established various information projects and centers that focused on socioeconomic development (Sherif 2009). Since then, Egypt has continued to keep ICT and its telecommunications sector in its primary vision as the country setting its long-term strategic plans, such as putting it at the forefront of Egypt Vision 2030 to boost economic growth as previously mentioned (Oxford Business Group, 2020).

Since Egypt has one of the strongest telecommunications industries among its MENA counterparts, it would be expected that the country would benefit from developing the telecommunications sector further. Broadband follows similar technologies in its trend of diffusion. Technologies such as the fax machine, the telephone, and the internet, most recently, exhibit "network effects", whereby the benefit that the user gets from the products depends on how many other users are using the product. Research on network economies shows those products that exhibit network effects exhibit a long period of slow growth followed by explosive growth (Shapiro et al., 1998). The point at which the product transitions into the state of explosive growth is called the "critical mass" level. One study that aims to estimate the critical mass point of the diffusion of mobile telephone technology defines critical mass as the point at which further diffusion of the technology occurs without a change in its price. The study goes on to argue further that the trend of mobile technology penetration is generalizable to newer technologies that exhibit network effects (Grajek, 2010). Another study that aims to quantify the effect of broadband penetration tests for the critical mass point by including in the model dummy variables for having reached at least 10% and 20% broadband penetration rate and finds that significant positive effect of broadband penetration on economic growth does not emerge until after the 10% threshold is passed (Czernich et al., 2011). A different study identifies the critical mass point at a 30% level of penetration (Gruber et al., 2011).

Czernich's study also found, however, that past the 20% penetration level, the effect on economic growth of further penetration does not exceed significantly that of the 10% level. This finding is in line with other studies that find that technologies that exhibit network effects, in addition to having a critical mass point at which diffusion rates grow quickly and significantly, also exhibit a "saturation effect" or "diminishing returns to scale". One study that empirically assesses the diffusion trajectory of ICT technologies in 46 developing countries in the period of 2000-2011 argues that ICT technology diffusion can be visualized by an S-shaped curve that shows the movement between four phases. The first phase is that same one referred to earlier, characterized by slow growth followed by the explosive growth of the second phase. Then, when the inflection point is passed, the third growth phase is entered showing slower growth. Finally, the final phase is the stabilization phase when the growth eventually stops. The study finds that the data for mobile communication technology fits the S-shaped curve neatly for most of the lower and middle-income countries studies. In the case of Internet users however, the study finds that most of the countries studied are in the first phase of the S-shaped pattern (Lechman, 2014). Along the same lines, the study by Qiang (2009) measures the economic impact of broadband penetration in both developing and developed countries and finds that the coefficient for broadband penetration in lower-middle income countries is statistically significant at the 10% level while that of high-income countries is statistically significant at the 1% suggesting that lower-middle income countries have not reached the critical mass point for broadband penetration. Additionally, and in congruence with the saturation phase of the S-shaped curve, the study finds that per 10 percentage point increase in broadband penetration, low-middle income countries are associated with an economic growth effect of 1.38 percentage points while high income countries are associated with a 1.21 percentage points increase, which implicitly supports the saturation effect hypothesis

In the case of Egypt, the well-established and strongly funded ICT sector and the adamant policy initiative to further expand the sector promises an explosion of growth with further investment in telecommunications. Internet usage in most developing countries, including Arab states close to Egypt in culture, history, and geography, are either in the slow first stage of growth or in the beginning of the explosive second stage of growth. Morocco for example, saw the greatest increase in Internet usage from 2000 to 2011-- from 0.69% of the population to 51% (Lechman, 2014). It is not hard to imagine that the case could very well be the same for many lower-middle income countries 10 years later in 2021, including Egypt.

Nevertheless, some studies also suggest that ICT and telecommunications may have potential negative impacts on economic development, particularly for the developing countries. Freeman and Soete (1997) as well as Aghion and Howitt (1998) discuss in their studies that the growth of ICT leads to technical change that can impose labor savings, which causes the elimination or reduction of certain unskilled jobs and harms the employment rate. Other studies point out that ICT enables developed countries to gain greater comparative advantages, raising their overall competitiveness globally at the expense of the developing countries (Nour, 2002). However, when breaking ICT into individual parts, some of its drawbacks could be offset by the benefits brought by mobile networks and broadband technology. The expansion of mobile networks could lead to the creation of employment, as the employment has significantly increased with an enhanced wireless network in a region of South Africa (Klonner and Nolen, 2010) and in Malawi (Batziillis et al., 2010). Moreover, a more efficient mobile network renders job search and application process easier and more convenient, which helps more people to find suitable jobs in the labor market. The broadband technology, on the other hand, helps businesses to improve their productivity by adopting more efficient business processes, such as inventory optimization and marketing (Katz and Jung, 2020b). Thus, the improvement of broadband penetration could potentially facilitate the enterprises of developing countries to compete with those of more developed countries.

Overall, while existing literature generally concludes that telecommunication has a positive economic impact, our study will take Egypt as a specific case and provide additional insights about the direct and indirect effects of Egyptian telecommunication sector on the economy as well as how should this sector proceed in the COVID-19 pandemic to achieve the Egypt Vision 2030.

## 3. Descriptive Analysis

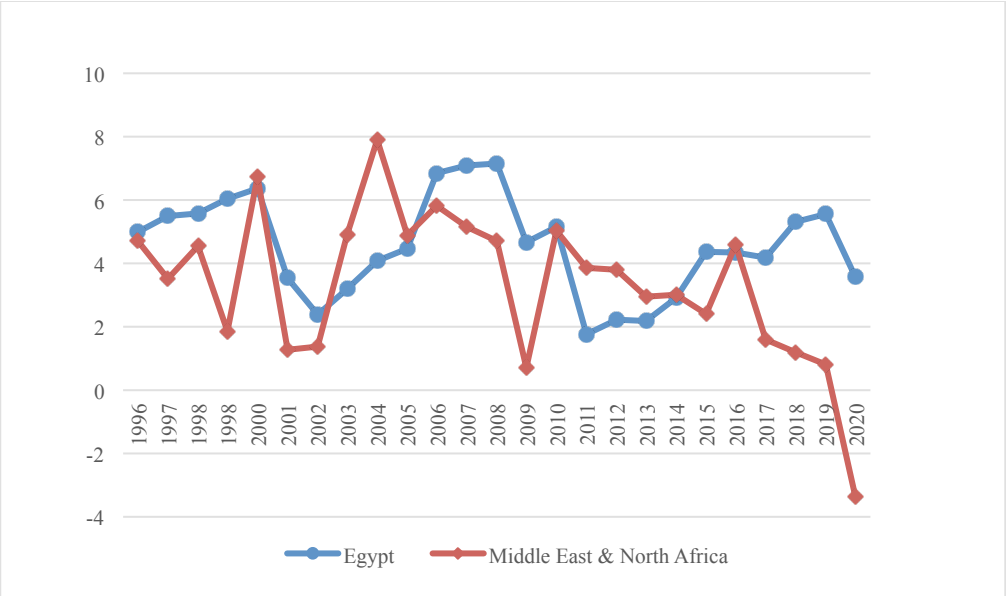
### Country overview

While we have discussed the presence and significance of ICT and the telecommunications sector in Egypt, it is important to further discuss some of the characteristics that compose Egypt's economy.

The World Bank classifies Egypt as a "lower-middle income" economy. While expected to remain positive, the economic growth of the country has declined from 5.6% in 2019 to 3.3% in the fiscal year 2020/21. Due to the emergence of the Delta covariant and the increase in the COVID-19 cases, the growth is projected to further decline until the end of 2021 before its estimated rebound of 5% in the fiscal year 2021/22, according to the World Bank (2021b). In particular, private consumption in short run remains constrained, while poverty, inequality, and unemployment rate are expected to increase, World Bank (2020).

Since 1996, Egypt has had a cyclical GDP growth rate, which is most likely due to various changes in government throughout the years, such as the Egyptian Uprise of 2011 (Britannica, 2020) which led to multiple changes of power and was likely a cause of the significant decrease in GDP growth rate as seen in Figure 1. The overall trend, however, shows that the economic growth of Egypt has generally outperformed that of the MENA region, except for the early-2000s and early-2010s (Figure 1).

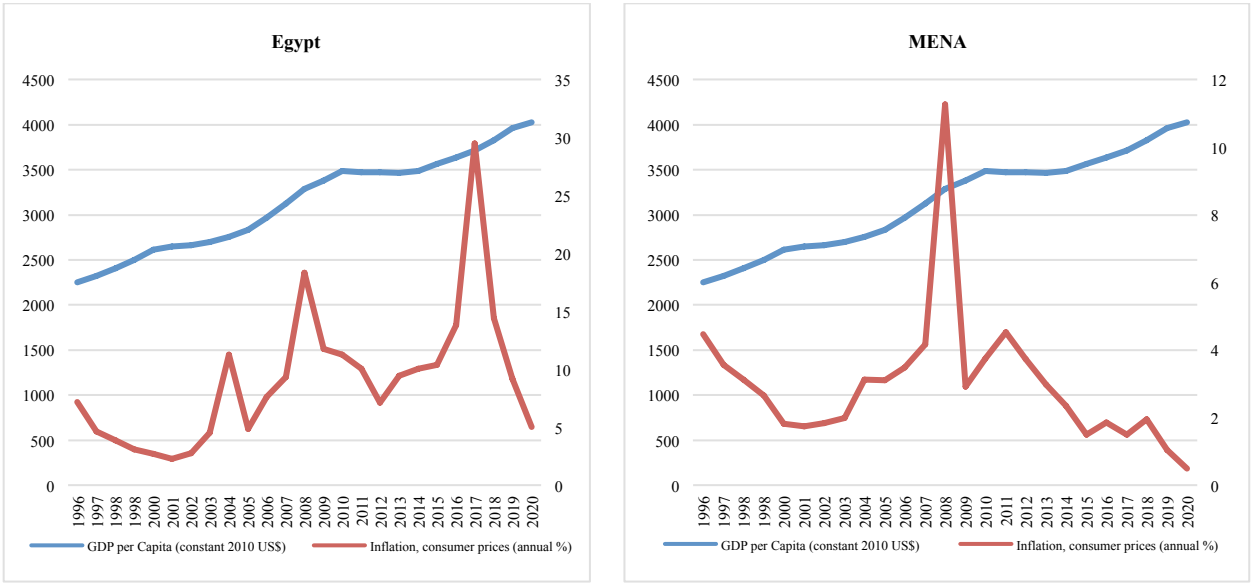
**Figure (1): Egypt and MENA Region GDP Growth (%)**




*Source: Authors: Based on WDI, 2021*

While Egypt has exhibited a healthy growing GDP, the Delta variant and COVID-19 pandemic have put this growth at tremendous risk. The World Bank (2021a) predicts that Egypt will experience an increase in inflation reaching 7.5% in 2022, which has recently been significantly higher than the MENA region's inflation, as shown in Figure 2.

**Figure (2): Egypt and MENA Region GDP per capita and Inflation**



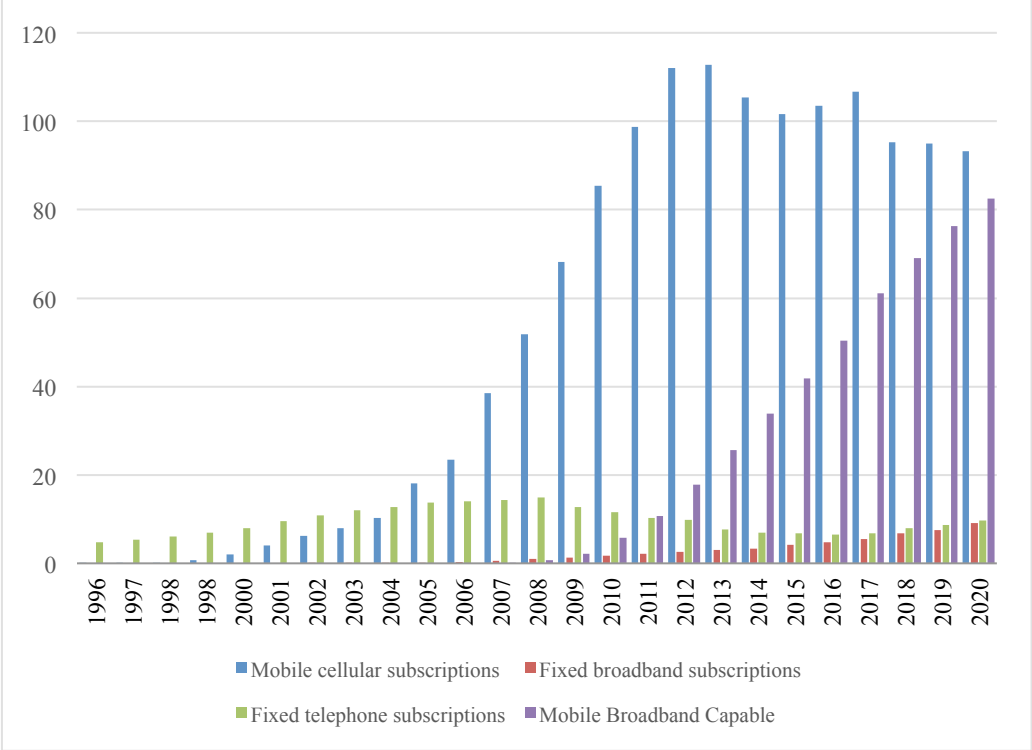
*Source: Authors: Based on WDI, 2021*

As for the fiscal balance, the recently established fiscal consolidation is expected to be disrupted temporarily, such that the budget deficit has widened to LE459 billion, which is equivalent to 9% of GDP by the end of June 2020, (Trading Economics, 2021). The pandemic imposes multi-dimensional social and economic crisis to the country, highlighting the need of advancing the human capital agenda and strengthening social protection.

### *The telecommunications sector*

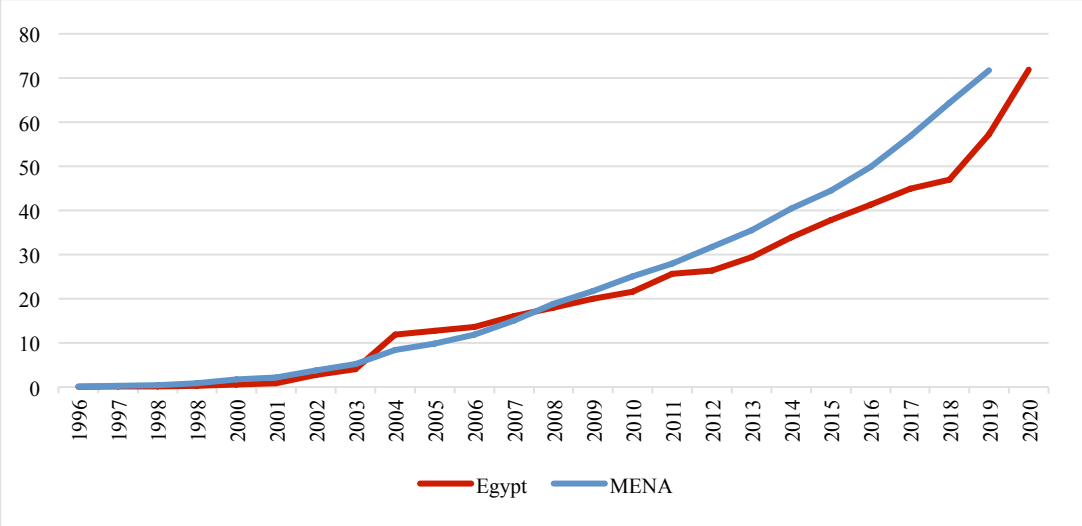
In terms of telecommunication, Egypt exhibits strong adoption in terms of subscribers of telecommunication systems. As presented in Figure 3 the most common subscription in Egypt is that of mobile services, reaching about 98 subscribers (per 100 people) in 2020, followed by mobile broadband capable reaching about 83 subscribers (per 100 people), while fixed broadband is still growing (MCIT, 2021c). Compared to the entire MENA region, the population using the Internet in Egypt is growing at a slow rate reaching about 72% in the year 2020 (see figure 4).

**Figure (3): Mobile Telephony, Fixed Broadband, Mobile Broadband Capable, and Fixed Telephone Subscribers in Egypt**




*Source: Authors: Based on WDI, 2021 and GSMA 2020.*
*Note: All variables are per 100 people.*

**Figure (4): Individuals using the Internet in Egypt (% of population)**




*Source: Authors: Based on WDI, 2021*

Aside from the significant numbers of telecommunication service subscribers, the telecommunications sector has contributed notably to Egypt's GDP. According to the International Trade Administration (ITA), the ICT sector contributed to 4.4% of the Egyptian GDP in the fiscal year 2019/20 compared to 3.5% in 2018/19 (ITA, 2021). In addition to its contribution to the GDP, offering robust ICT based services has spillover effects in the form of increasing equal and equitable access to telecommunication services to Egyptian citizens (United Nations, 2021). The Ministry of Planning in Egypt reports that the information technology sector grew by 17% during the second quarter of the 2020/2021 fiscal year and had the largest growth rate among all Egyptian economic sectors (Daily News, 2021). Additionally, the sector is expected to grow by 20.5% during the fiscal year 2021/22 (Moneim, 2021). Hence, the telecommunications sector plays a major role in Egypt's economy, and has the potential to positively impact the economy in multiple ways.

## 4. Data

To examine the direct and indirect effect of the ICT industries on the Egyptian economy, the study constructs a panel of 18 relevant variables presented in Table 1. The data sources are primarily the World Bank World Development Indicators (WDI) database, Penn World Tables, GSMA Intelligence, the International Telecommunication Union, and the Federal Reserve Economic Data. From these sources, data relevant to Egypt is sourced for a time period spanning the years from 2000 to 2019. The data is taken on a quarterly basis to construct a quarterly time series study. In the case in which data is not available on a quarterly basis, constant growth is assumed on the annual level and the quarterly level data is calculated and presented accordingly.

**Table 1: Variables, Sources, and Definitions, Egypt 2000 – 2019**

| Item | Variable | Comments | Source |
|---|---|---|---|
| 1 | GDP | Data converted to quarterly frequency by assuming constant annual growth rate (CAGR) within each year. | World Bank World Development Indicators |
| 2 | | Data converted to quarterly frequency by assuming constant annual | World Bank World |

| | | | |
|---|---|---|---|
| | Gross Fixed Capital Formation | growth rate (CAGR) within each year. | Development Indicators |
| 3 | Labor | Human capital index, based on years of schooling and returns to education; see Human capital in PWT9. Data converted to quarterly frequency by assuming constant annual growth rate (CAGR) within each year. | Penn World Tables |
| 4 | Mobile unique subscribers' | Total mobile unique subscribers. A '*unique mobile subscriber'* is defined as an individual person that can account for multiple '*mobile connections'* (i.e SIM cards). | GSMA Intelligence |
| 5 | Mobile Broadband Capable device penetration | Penetration of devices capable of attaining broadband access. | GSMA Intelligence |
| 6 | Population | Data converted to quarterly frequency by assuming constant annual growth rate (CAGR) within each year. | World Bank World Development Indicators |
| 7 | Rural population | Data converted to quarterly frequency by assuming constant annual growth rate (CAGR) within each year. | World Bank World Development Indicators |
| 8 | GDP per capita | GDP per capita (constant 2010 US$). Data converted to quarterly frequency by assuming constant annual growth rate (CAGR) within each year. | World Bank World Development Indicators |
| 9 | ARPU | Average revenue per connection in dollars. Used as a proxy for mobile price. | GSMA Intelligence |
| 10 | Mobile Broadband Price | Data-only mobile broadband 1.5 GB Price basket in dollars. | International Telecommunications Union |
| 11 | HHI Mobile | Industrial concentration index for overall mobile services | GSMA Intelligence |
| 12 | HHI Broadband | Calculated as the sum of the squares of the 3G technology market shares. It is used as a proxy for the mobile broadband model. | GSMA Intelligence |
| 13 | Mobile Revenue | Total revenue of Orange, Vodafone, and Etisalat. | GSMA Intelligence |
| 14 | Mobile Broadband Capable Revenue | Calculated by multiplying total mobile broadband capable times data-only mobile broadband 1.5 GB Price basket in dollars. | Authors Calculation |
| 15 | Oil price | Global Price of Brent Crude. | FRED |

## 5. Estimation Results

Following the existing literature (Roller and Waverman, 2001; Koutroumpis, 2009; Katz and Callorda, 2020; Katz and Jung, 2021), to detect causality, estimate the impact of mobile technology, and examine long-run relationships between variables, the study employs a structural econometric model using Simultaneous Equation Systems, that allows the error term to be correlated and explicitly assessed. The model consists of four equations; aggregate production function, demand function, supply function, and infrastructure function. While the first equation estimates the country's aggregate economic performance, the last three controls for possible reverse causality. The model is defined as follows:

- Aggregate production function: $GDP_t = a_1K_t + a_2Labor_t + a_3Mob\_Pen_t + a_4Shock_t + \varepsilon_{1t}$
- Demand function: $Mob\_Pen_t = b_1Rural_t + b_2GDPpc_t + b_3\ Mob\_Price_t + b_4HHI_t + \varepsilon_{2t}$
- Supply function: $Revenue_t = c_1\ Mob\ \_Price_t + c_2GDPpc_t + c_3HHI_t + \varepsilon_{3t}$
- Infrastructure function: $\Delta\ Mob\_Pen_t = d_1Revenue_{t+} \varepsilon_{4t}$

where the Gross Domestic Product growth rate is represented by the first variable GDP, K is the gross fixed capital formation, Mob_Pen is the mobile penetration, Shock is the oil price shock, Rural is the rual population, GDPpc is the per capita GDP, Mob_Price is the price of the mobile service, HHI is

the industrial concentration index, Revenue is the total revenue of mobile providers. All variables are in logarithms.

With regards to the aggregate production function, two models are presented. Both models run a multivariate regression analysis, but where one tests the effect of mobile unique subscriber penetration on GDP growth, the other tests the impact of mobile broadband capable device penetration instead. In their respective models, the coefficients of mobile unique subscriber penetration and mobile broadband device penetration are both statistically significant, affirming the correlation between both independent variables and GDP growth rate. The relationship between GDP and ICT penetration is positive in both cases, indicating that increase in penetration is associated with increase in economic growth in Egypt. More specifically, a one unit increase in mobile subscriber penetration is associated with a 0.172% increase in GDP growth rate while the same increase in broadband penetration is associated with a 0.016% increase, holding all other variables constant. The high coefficient in mobile telephony could be driven by the fact that this technology is the primary access mode for a large portion of the Egyptian population. The low mobile broadband coefficient could relate to fixed broadband already capturing a portion of the economic effects.

Additionally, all other variables, fixed capital formation, labor, and oil price, are positively associated with GDP growth rate as well at different levels of statistical significance and to different degrees. Labor has the largest expected impact in both models, increasing GDP growth rate by 0.612% and 2.32% for each unit increase in mobile subscriptions and broadband penetration, respectively. Oil Price has a positive and statistically significant impact, although, small effect on GDP in both models and gross fixed capital formation more strongly affects GDP, holding all else constant, in the model that considers broadband penetration in the place of mobile subscriptions.

**Table 2. Econometric impact of mobile telecommunications**

| | ***[I]*** | ***[II]*** |
|---|---|---|
| ***Aggregate production function*** | ***Log (GDP)*** | ***Log (GDP)*** |
| Log (Mobile unique subscriber penetration) | 0.172*** | |
| | (0.021) | |
| Log (Mobile BB Capable device penetration) | | 0.016*** |
| | | (0.005) |
| Log (Gross Fixed Capital Formation) | 0.019*** | 0.232*** |
| | (0.006) | (0.016) |
| Log (Labor) | 0.612** | 2.316*** |
| | (0.224) | (0.138) |
| Log (Oil price) | 0.002* | 0.016*** |
| | (0.002) | (0.003) |
| ***Demand function*** | ***Log (Mobile unique subscriber penetration)*** | ***Log (Mobile BB Capable penetration)*** |
| Log (Rural Population) | 3.48*** | -1.239*** |
| | (0.452) | (0.059) |
| Log (GDP per capita) | 5.048*** | 7.448*** |
| | (0.417) | (0.370) |
| Log (Mobile ARPU) | -0.030** | |
| | (0.014) | |
| Log (Mobile BB price) | | -0.815*** |
| | | (0.137) |
| HHI Mobile | -0.091* | |
| | (0.050) | |
| HHI 3G | | -3.342*** |
| | | (0.350) |
| ***Supply function*** | ***Log (Mobile Revenue)*** | ***Log (Mobile BB Capable Revenue)*** |
| Log (GDP per capita) | 2.844** | 6.605*** |

| | | |
|---|---|---|
| | (1.291) | (0.338) |
| Log (Mobile ARPU) | -0.602** | |
| | (0.252) | |
| Log (Mobile BB price) | | 0.282** |
| | | (0.133) |
| HHI Mobile | -1.70** | |
| | (0.715) | |
| HHI 3G | | -3.438*** |
| | | (0.341) |
| ***Infrastructure function*** | ***Mobile unique subscriber adoption growth*** | ***Mobile Capable adoption growth*** |
| Log (Mobile Revenue) | -0.037*** | |
| | (0.004) | |
| Log (Mobile BB Revenue) | | -0.142*** |
| | | (0.001) |
| Observations | 77 | 50 |
| Quarter Fixed Effects | Yes | Yes |
| Years | 2000q4-2019q4 | 2007q2-2019q4 |
| R-Squared first equation | 0.9493 | 0.9981 |

*Note: ***, **, * significant at 1%, 5% and 10% critical value, respectively. Numbers in parenthesis are standard errors of the coefficients.*

The two demand functions determine which variables and how they affect mobile unique subscriber penetration and broadband capable penetration. Mobile average revenue per connection (ARPU) and the industrial concentration for mobile services (HHI) have a negative relationship to mobile subscriber penetration. In other words, expected demand for mobile subscriptions decreases as the index for the concentration of mobile services increases and/or the average revenue per connection increases. However, a one percent increase in GDP growth rate leads to about 5.05% increase in demand for mobile subscriptions and a higher magnitude of 7.45% for broadband penetration. Similarly, a one percent increase in rural population is associated with 3.48% increase in mobile subscriptions. This result indicates that with increasing deployment of mobile broadband in rural areas, there is growing percentage of the population that has access to broadband only through mobile technology, which positively affects demand. On the other hand, broadband price, 3G concentration, and rural population are negatively correlated with broadband demand; indicating the fact that rural areas are associated with lower incomes and lack of coverage, that reduce the possibility of acquiring broadband services, therefore negatively affecting demand.

The two supply functions examine how different variables affect mobile subscription and broadband supply, proxied by mobile revenue and mobile broadband-capable revenue. Mobile ARPU and HHI mobile are negatively correlated with mobile subscription supply, whereas GDP per capita has a positive effect. Broadband supply, on the other hand, has a positive relationship with mobile broadband price as well as GDP per capita and is negatively correlated with broadband price. Here, too, all the coefficients are statistically significant, affirming the direction in which the variables move in relation to one another and the way in which they do so.

The infrastructure function is a univariate regression model that tests the relationship between revenue and the change in penetration. The regression determines that a one percent increase in mobile revenue decreases growth in mobile subscriptions by 0.037% at a statistically significant level. Similarly, a one percent increase in broadband revenue decreases broadband growth by 0.142%. Both of these coefficients are statistically significant at the 1% level.

## 6. Conclusions

The purpose of this paper was to study the economic contribution of telecommunications in Egypt. In addition to compiling descriptive statistics of the sector's direct effects, the paper presents empirical evidence based on econometric analysis of the spillover of mobile telecommunications on the whole Egyptian economy. Both in terms of mobile unique subscribers (voice and data) and mobile broadband enabled devices, the study provides compelling evidence of said effects, which are consistent with the research literature.

Policy implications of these findings should be focused on maximizing mobile penetration to achieve economic benefits. They range from putting in place initiatives aimed at increasing network deployment to stimulating a reduction in prices, both variables having an impact on increasing adoption. Along the potential policies, a reduction in telecommunications sector specific taxation could act as stimulating the increase of capital investment (Katz and Jung, 2021). Similarly, allowing mobile operators to share passive and active infrastructure would help them further deploy networks in rural areas. All these potential initiatives should be supported by the promotion of competition among operators.

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