The Role of Telecommunications Services in Regional Economic Growth: Evidence from ECOWAS Zone

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ABSTRACT

This study aims to investigate the effects of telecommunication infrastructure on economic growth in ECOWAS countries. The analysis in this article focuses on the effects of telecommunications infrastructure in terms of demand, supply and effects on per capita income. From the point of view of empirical strategy, the triple least square (3SLS) technique is used. This technique provides coefficients for all structural equations and endogeneity bias. The results show that the increase in telecommunications infrastructure raises operators' revenues and therefore their earnings. Thus, the results show the positive effect of the expansion of both mobile and fixed telephone infrastructure on per capita income. As for implications, it will be necessary to strengthen the role of regulatory authorities both in their ability to ensure competition in the sector and in the promotion of infrastructure to bring countries closer to achieving the objective of universal services.

Keywords: *Telecommunications infrastructure, Regulator, 3SLS, ECOWAS.*
JEL Classification: *F15; L96; H54; O10.*

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Highlights of this paper

- This study aims to investigate the effects of telecommunication infrastructure on economic growth in ECOWAS countries.
- The results show that the increase in telecommunications infrastructure raises operators' revenues and therefore their earnings.

1. INTRODUCTION

Changes in technology have a significant role in the economic development process. The difference in the traditional theoretical economic framework for analyzing economic growth, whereby changes in technology were left as an inexplicable residue, recent literature on growth has highlighted that changes in technology do depend on the rate of economic growth (Rudra *et al.*, 2017).

The telecommunications sector importance has becoming increasingly obvious by associating the share of telecommunications revenues in GDP in some regions of the world. In Sub-Saharan Africa telecommunications services accounted on average for 4.8% of total GDP while in the European Union it contributes about 3.1%. Mobile telecommunications profoundly influence the way users' network among themselves and is important externalities to the economic activities that use them. It is worth noting the ever-increasing number of companies in the field of telephony and the advent of new business models and new modes of communication. The input of mobile telecommunications infrastructure to economic growth for developing countries appears to be lower than for developed countries, suggesting growing returns from the adoption of mobile technology (Gruber and Koutroumpis, 2011).

Since the 1990s, the literature on information and communication technology (ICT) infrastructure and its impact on economic growth has become increasingly abundant. Many researchers have hypothesized that ICT infrastructure (including telecommunications) reduces the cost of obtaining information and the variable costs of market participation (Norton, 1992). These authors highlight the effects of infrastructure improvements on reducing transaction costs, increasing production in firms in different sectors (Roller and Waverman, 2001). Roller and Waverman (2001) examined how telecommunications infrastructure affects economic growth in twenty-one OECD countries over a twenty-year period. They jointly estimated a micro model for investment in telecommunications with a macro production function. Their results show a positive and significant causal relationship between telecommunications infrastructure and economic growth, especially when there is a critical mass of telecommunications infrastructure. The effect is even more pronounced when the critical mass appears to be at a level of telecommunications infrastructure that is close to that providing universal service.

Comparison of the ICT effects on growth across countries shows that the yearly input of mobile telecommunications infrastructure growth in developed nations is more than 50 per cent higher than in developing countries. With regard to the various policies resulting from the recommendations, it should be noted that there is a need to offer extra support for mobile telecommunications infrastructure in order to achieve a better level of economic development. For example, the compatibility and adequacy between Information and Communication Technologies (ICTs), in particular the Internet and its applications, has led to a reduction in the costs of disseminating technological information products and the development (or emergence) of many new telecommunications services in developing countries.

Therefore, investment in ICTs including telecommunications infrastructure and related sectors delivers significant profits to the entire economy. According to the World Bank (2003) about $230 billion is invested by the private sector in telecommunications infrastructure in low-income countries for 10 years starting from 1993, and countries with well-regulated competitive markets received the largest share of investment. It is also important to note that the literature on the link between telecommunications and economic growth is not prolific enough. The telecommunications sector as a whole has been derestricted as well as the market structures in this area have become competitive. As a result of the introduction of competitive policies, the prices of telecommunications services have fallen significantly, creating a kind of revolution in the telecommunications sector.

Table-1. Evolution of the cost of one minute of local mobile phone call, weekend rate (in USD) in ECOWAS countries.

Country	2008	2009	2010	2011
Benin	0,36	0,34	0,2	0,21
Burkina Faso	0,42	0,4	0,36	0,19
Cape Verde	0,46	0,43	0,42	0,44
Ivory Coast	0,33	0,21	0,19	0,21
Gambia	0,16	0,19	0,19	0,1
Ghana	0,15	0,1	0,1	0,09
Guinea	0,07	0,07	0,06	0,06
Guinea-Bissau	0,4	0,32	0,32	0,32
Mali	0,25	0,23	0,22	0,23
Niger	0,37	0,41	0,39	0,28
Nigeria	0,25	0,28	0,23	0,23
Senegal	0,2	0,18	0,17	0,18
Togo	0,5	0,16	0,15	0,3

Source: ITU data 2013.

From the table above, it can be seen that telephone call costs are on a downward trend in UEMOA countries as well as in the rest of the ECOWAS region. This information remains an indicator of the evolution of the telecommunications sector in the area. However, other indicators can be used to illustrate this progress. These include line installation costs, internet services, internet speeds, the number of subscribers to mobile and fixed telephone operators, investments in the sector, etc. These indicators show how the level of penetration and the cost of access are changing. Beyond that, they also indicate the quality of regulation in the sector, especially since regulatory authorities should guarantee a competitive environment, ensure the quality of services and therefore the effectiveness of efforts towards universal services.

Telecom technology has spread rapidly in the sense that in nations in Sub-Saharan Africa, there has been a shift from second-generation mobile phone systems to a more advanced generation. In ECOWAS countries, we are now in the third and fourth generation of technology. However, Garbacz and Thompson (2007) highlighted the fact that telecommunications in developing countries continue to be poor. This result essentially raises the issue of investment in telecommunications infrastructure and the influence of infrastructure on economic growth (or per capita income), while keeping in mind the great potential of the African continent as a telecommunications market.

There are significant of empirical studies, which specifically have tried to see the influence of telecommunications infrastructure on the economic growth in OECD countries considering the bidirectional causality of the relationship (Roller and Waverman, 2001). For their part, Waverman *et al.* (2005) found that mobile phones positively impact on economic growth, which is twice as high in developed countries when compared to that in developing countries. In addition, research on 44 African countries shows that telecommunications are a important driver of economic growth in the sense that investments in the sector generate significant returns, thus boosting economic growth. To achieve this, panel data are and the technique of the Generalized Moment Method (MMG) to capture dynamic effects and control endogeneity problems, Batuo (2015).

However, studies on the analysis of this relationship in developing countries, particularly ECOWAS countries, are almost limited. The goal of this research is to highlight the effects of telecommunications infrastructure on economic growth in ECOWAS countries. In terms of value-added, the analysis in this article focuses on the effects of telecommunications infrastructure in terms of demand, supply and effects on per capita income. However, it should be noted that issues of telecommunications market structure are not addressed but that the lack of information on the level of investments made leads to the use of a proxy measure in terms of supply and demand for these telecommunications services. From the point of view of empirical strategy, the triple least square (3SLS) technique is used. This technique provides coefficients for all structural equations and endogeneity bias. The results show that the increase in telecommunications infrastructure raises operators' revenues and therefore their earnings. Thus, the results show the positive impact of the expansion of both mobile and fixed telephone infrastructure on per capita income.

The rest of the article is divided into four main sections. The first covers the stylized facts on the telecommunications sector in ECOWAS countries, namely the penetration rates of fixed and mobile telephony and high-speed Internet access. The second concerns previous research on the issue of telecommunications infrastructure. The third section deals with the estimation method adopted and the main results. The last section is devoted to the conclusion.

2. STYLIZED FACTS ON TELECOMMUNICATIONS SERVICES IN ECOWAS

Investments are a key factor in determining production at the global level. Thus, investments in a sector or at the global level are expected to lead to an increase in per capita output. Telecommunications infrastructure, considered an important driver of economic activity, is also a source of improved per capita income and therefore a source of economic growth.

The mobile phone penetration rate of ECOWAS countries in relation to the level of per capita income is shown by Figure 1. The analysis shows that Ghana, Côte d'Ivoire, have the highest penetration rates, while Niger and Sierra Leone have a relatively low rate. In relation to national income per capita, a positive correlation can be suspected. However, taking the example of Cape Verde, which has a significantly high per capita national income compared to other ECOWAS countries, has almost the same number of mobile phone users per 100 inhabitants.

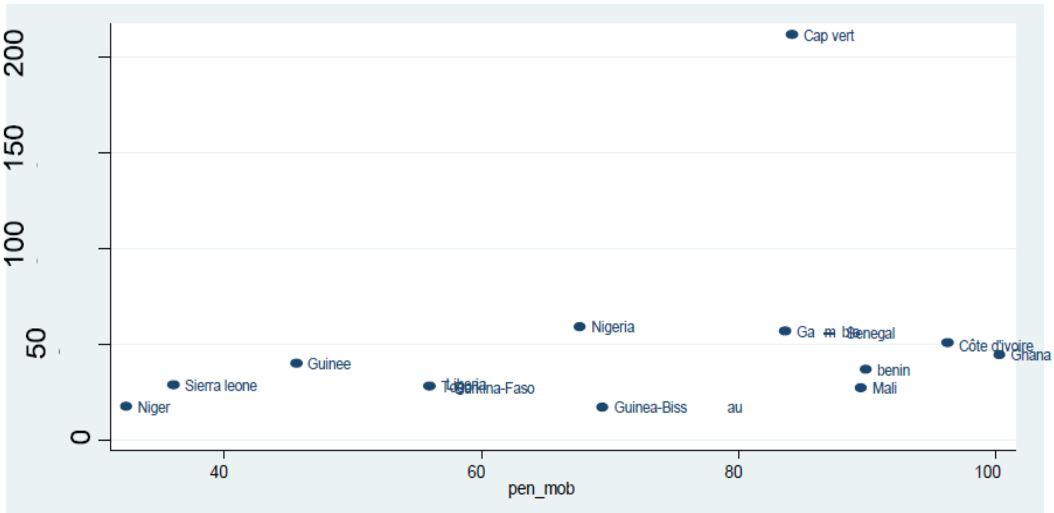

Figure-1. Mobile phone penetration rate in ECOWAS in 2012.

Source: WDI data, 2014.

With regard to fixed telephone use, Figure 2 shows for ECOWAS countries, the fixed telephone penetration rate in relation to the level of per capita income. The analysis shows that Cape Verde has the highest penetration rate, unlike Niger and Guinea Bissau and all the other countries in the Community area, which have a relatively low rate. In relation to national income per capita, one can also suspect a positive correlation. Taking the example of Cape Verde, which has a significantly high per capita national income compared to other ECOWAS countries, it is the only country with the highest number of fixed telephone users per 100 inhabitants.

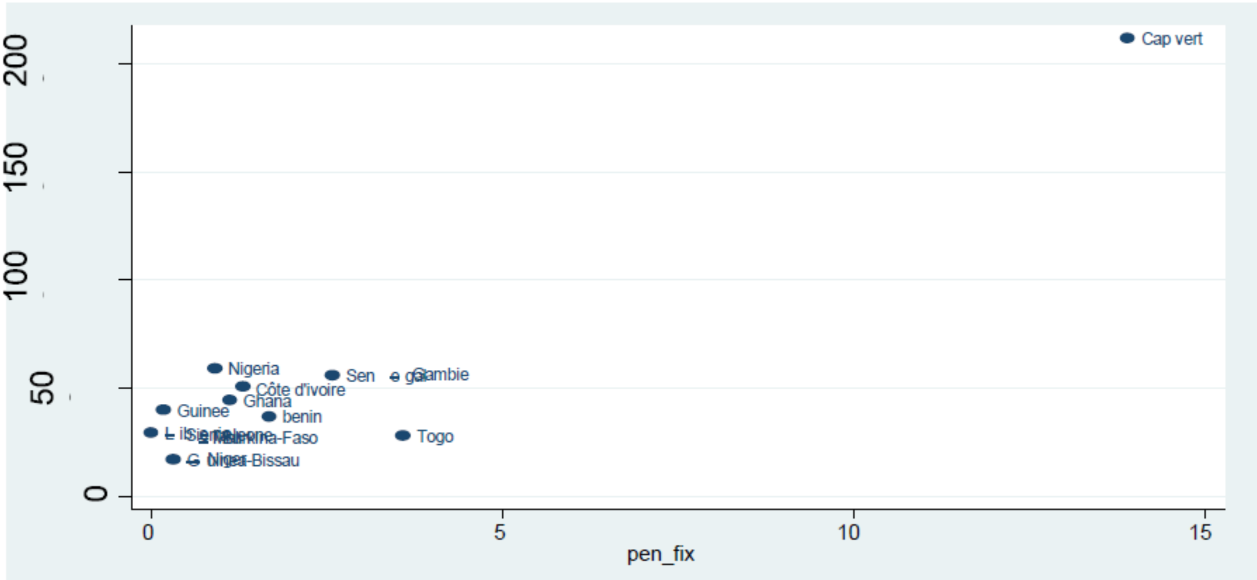

Figure-2. Fixed telephone penetration rate in ECOWAS in 2012.

Source: ITU and WDI data, 2014.

In terms of Internet access, averagely, below 5% of the population are able to access the Internet in the ECOWAS community space Figure 3. With the exception of Ghana, Nigeria, Cape Verde, all other countries have less than ten out of 100 people who have access to the Internet via WIFI.

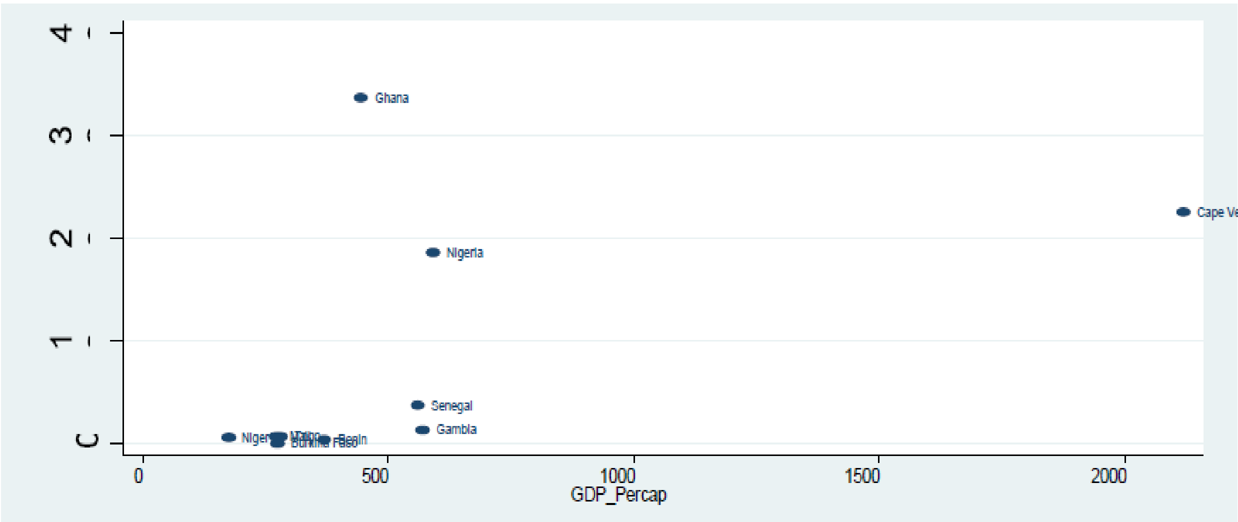

Figure-3. Rate of Wi-Fi Internet access in ECOWAS in 2012.

Source: ITU and WDI data, 2014.

From the above, it appears that penetration rates of fixed and mobile phones and the Internet remain very low in ECOWAS countries. Cape Verde, however, is the only country that has performed well in terms of population coverage in terms of telephone and Internet access[1]. Information and communication technologies (ICT) have played an important role in this progress. In 2005, the Cape Verdean government liberalized this sector and took measures to encourage competition. The incumbent operator, Cabo Verde Telecom (CV Telecom), was partially privatized in 1995. Since then, the government's shares have been gradually sold, so that today only 3% of them remain in public hands. CV Telecom is the leading Internet service provider.

As in many other ECOWAS countries, the number of fixed telephone lines in Cape Verde has remained virtually unchanged in recent years. In contrast, the number of mobile phone subscribers increased by almost 40% in just one year, from 108,858 in 2006 to 152,212 in 2007. According to International Telecommunications Union, there are now two mobile phone operators in the country: CV Telecom and T+, which is part of the Teylium Telecom group, active throughout West Africa. T+, which began serving the main island of Santiago in 2007, had therefore planned to serve the entire country by the end of 2008.

Considering the penetration rates of telecommunications services as the result of investments in telecommunications infrastructure, it is worth noting their low level in the Community area. Thus, efforts are being made at the regional and continental levels to improve infrastructure in general and the telecommunications sector in particular.

PIDA is a continental program that aims to design and implimeng visions, strategies, policies and program for infrastructure development at the regional and continental levels: energy, transport, water, telecommunications and ICT. The main aim of PIDA is to promote socio-economic development and the reduction of poverty in Africa through the implementation of integrated regional infrastructure networks. The PIDA sector study will provide a foundation for the development of a vision for infrastructure development in Africa, based on strategic objectives and sectoral policies. The idea is to prioritize regional and continental investment programs (Energy, transport, water, telecommunications and ICT) in the short, medium and long term, until 2030. The program is led by the African Union Commission (AUC), the NEPAD Secretariat and the AfDB. In PIDA, the ICT program will establish an enabling environment for the development of terrestrial optic infrastructure and the establishment of Internet exchange points in countries without such infrastructure. It will connect each country to two different submarine cables to take advantage of capacity expansion.

3. LITERATURE REVIEW

In his method to the stages of economic growth, Rostow (1960) suggests that telecommunications importance goes hand in hand with the complexity and intensification of trade caused by the expansion of industrial production. The development of goods leads to a rise in the flow of information for which telecommunications are essential supports and transmission channels. The correlation among the development of the telecommunications network and economic growth has been the subject of empirical studies.

Numerous researches have focused straight on the impact of telecommunications infrastructure on economic growth. Among them, Jipp (1963) the pioneer in the field, who, using data from different countries, finds a positive relationship between the two variables. Therefore, studies that have attempted to analyze the connection between telecommunication infrastructure development and growth have used different econometric methods to find empirical evidence on a robust and meaningful relationship between telecommunication infrastructure and growth.

[1] This performance would be due to the quality of regulation and the willingness of the public authorities to let the private sector operate as the leading actor in the sector.

[2] Source: ITU/ICT Eye

The results of some early studies that have measured the performance of public infrastructure (Aschauer, 1989) have often suffered from simultaneity and misleading correlation bias. Other studies have been done using early difference approaches or focusing on aggregating smaller data (Hulten and Schwab, 1984; Aaron, 1990). The reverse causality approach, which underlies the two-way link between growth and infrastructure, has also played a key role in this debate (Munnell, 1992).

Hardy (1980) was the first to analyze telecommunications effect on development utilizing distinctive groups from 45 nations. He categorizes nations into developed and developing nations and finds that telecommunications have a reasonably noteworthy effect on financial development in less developed nations than in developed nations. The study findings are indeed supported by the reality that the penetration rate of telecommunications services remains moderately more within the slightest created nations. Bee and Gilling (1976) showed that the impact of telecommunications on development is subject to the different stages of growth of the nation or region considered. To do this, they constructed three indexes: a telephone index that characterizes the availability and use of telephone facilities, an economic performance index and a development index. Their study shows an intense association between the telephone index and that of economic performance and explains the role of the input of telecommunications on economic growth (see (Batuo, 2015)).

The problematic of inverse causality has been addressed in the literature in two dissimilar manners: simultaneous equations and estimates of instrumental variables. Both methods have weaknesses and strengths. The strength of instrumental variable regression is that it can be estimated with a single equation, nevertheless the single equation needs valid instrumental variables, i.e. variables that correlate with the independent variable in question, but not with the dependent variables. This technique, very often, poses significant challenges to the reliability and consistency of estimators. On the other hand, simultaneous equation system modelling does not suffer from problems of adequate instrument selection, but it needs the description of a model of more than one equation.

Applying the Granger causality test, and Sims' modified test to the link between economic growth and telecommunications infrastructure investment over the period 1958 to 1988, Cronin *et al.* (1991) identified a process by which investments in development infrastructure can promote economic growth and this growth increases the demand for telecommunications infrastructure. Madden and Savage (1998) empirically examined the relationship between telecommunications infrastructure investment, gross fixed investment and economic growth for a sample of transition countries in central and southern Africa. Their result shows a strong relationship between the two variables without being able to establish a causal relationship.

Roller and Waverman (2001) utilized the simultaneous equation method by mutually assessing a micro-model for telecommunications investment by a macro production function for the OECD group of nations for the period 1970-1990. Their study findings suggested a solid causal connection between telecommunications infrastructure as well as productivity, and further, they specify that this only happens once telecommunications services arrived to a certain threshold, which is almost the level of universal services.

Haynes *et al.* (2004) examined the role of telecommunications infrastructure in the long-term economic growth of 29 regions in China over a 17-year period from 1986. Using panel data, they used a dynamic fixed-effects model to test the relationship between regional economic growth and telecommunications infrastructure. They find that telecommunications are statistically significant and positively correlated with real GDP per capita in China. This result has been confirmed by earlier studies by Datta and Agarwal (2004) which indicate that telecommunications infrastructure has a significant and positive role in economic growth using similar data from Roller and Waverman (2001) on 22 OECD countries. They used a dynamic panel data method that corrects biases caused by variables omitted in a cross-sectional regression equation. They also included country-specific fixed effects. Their findings show a significant and positive correlation between telecommunications infrastructure and economic development after controlling for a number of other factors.

In a study on the effects of telecommunications in developing countries, Waverman *et al.* (2005) used a variant of the four-equation model and an endogenous growth approach. Their study is cross-sectional and did not take into account the fixed effects of countries in the econometric analysis and consequently could not control for annual variations and large inter-country. Consequently, these authors have confined themselves to a simple equation model derived from Barro (1991) work, which assumes convergence between the poorest and richest countries. The methodology takes infrastructure averages (penetration rate) over the study period and regresses to GDP, investment to GDP ratio, average education measures and others.

Sridhar and Sridhar (2006) based on the model used by Roller and Waverman (2001) study the simultaneous link between telecommunications and economic development, by means of data for developing countries. These authors, using triple least squares (3SLS), evaluated a system of equations that endogenizes economic growth and telecom penetration as well as the provision of telecommunications services. They find that there is a significant impact of mobile telecommunications on national income, taking into account the effects of capital and labour. The impact of telecommunication penetration on total output is significantly lower for developing countries than the figure reported for OECD countries, dispelling the hypothesis of convergence of investment effort levels. The model of the four equations obtained is quite demanding in terms of available data. However, it provides an explicit methodology that addresses the problem of bi-directional causality.

Kathuria *et al.* (2009) assessed the effect of mobile phone introduction on economic development in all India. They also used a changed version of the Roller and Waverman (2001) model to assess a structural model with 3 equations for 19 states of India from 2000 to 2008. They basically analyzed the link by which mobile phones affect growth and the constraints that limit their impacts. They found that Nations with a high mobile phone penetration rate can expect faster growth and as a result, there is a critical threshold of a 25% penetration rate beyond which the effect of mobile phones on development is improved by the impacts of the network. Telecom networks are more subject to network effects[2] than other types of infrastructure: the impact on growth is greater if a significant threshold of the network size is reached. However, the authors found considerable variation between urban and rural areas and between rich and poor households in cities.

Lee *et al.* (2009) are among a few researchers who have focused their study on the effects of mobile phones on economic development in Sub-Saharan Africa. They have corrected the problem of endogeneity between economic growth and telephone expansion by using GMMs and have also considered the degree of durability between mobile

[2] Network services are by nature services that generate network effects, also known as positive network externalities. That is, the usefulness or satisfaction derived from a network service depends positively on the number of users of that service. According to Katz and Shapiro, (1985) these network effects can be of different kinds. First, network effects can have a direct impact on the quality of the services offered and the usefulness for each user. Thus, the interest of the telephone for a subscriber depends positively on the number of contacts (individuals or companies connected to the network) with whom he or she can communicate. These direct effects are found in all communications networks (voice and data networks). They play for fax, e-mail, fixed and mobile phones... Then, network effects can indirectly affect the quality and variety of services offered on the network. Thus, the more users there are in a network, the more services will be offered on that network. Each new user makes the network more attractive to service providers and can encourage them to improve their existing services or launch new services. (See Pénard, Raynaud and Saussier (2003))

phones and fixed lines such as Waverman *et al.* (2005). They found that the marginal influence of mobile telecommunications services is even quite significant in areas where landlines are scarce.

However, in previous studies, the authors did not test telecommunications prices on growth. In some countries, telecommunication infrastructure may exist but access prices are so high, which would hinder their use and therefore low usage. Under these conditions, telecommunications infrastructure will not contribute to reducing transaction costs or improving productivity and thus improve the competitiveness of the economy.

Addressing the issue of infrastructure from a global perspective, Kane (2011) in his study on physical infrastructure and economic growth in the WAEMU, cites the example of Côte d'Ivoire, where mobile telephone has been introduced since 1996, with CFAF 130 billion of investment for a turnover of CFAF 700 billion, it now ranks first in the tertiary sector with 14 million subscribers and 3700 jobs. He stressed that in Côte d'Ivoire, as everywhere in the WAEMU, telecommunications contribute to the development of the economic activity. In ten years, the sector has recorded nearly CFAF 1000 billion (more than one billion five hundred million euros) of investments. It contributes 6% of GDP. In 2009, the telephone sector generated a turnover of 692 billion CFA francs or more than one billion euros. The results of his study show, however, that for WAEMU countries, the contribution of transport, electricity and sanitation infrastructure to economic growth is higher than that of telecommunications infrastructure.

The results of the most recent work, in particular, the Batuo (2015) work on 44 African countries, show that telecommunications are a major driver of economic growth in the sense that investments in the sector generate significant returns, thus boosting growth. In its research, Batuo mobilizes panel data and uses the Generalized Moment Method (MMG) technique to capture dynamic effects and control endogeneity problems.

From all the above, it can be deduced that the review of existing empirical literature has positively shown empirical evidence that investment in telecommunications infrastructure improves the efficiency of economic activity that increases productivity and at the same time economic growth, which in turn stimulates demand for telecommunications infrastructure. This article analyses the effects of telecommunications infrastructure on economic growth in ECOWAS countries in order to examine how telecommunications services can be used to support regional economic growth.

4. ANALYSIS MODEL AND METHOD

4.1. Theoretical Framework of the Model

In disparity to the traditional economic-theoretical framework for analyzing economic development, where changes in technology has been left as an unexplained residue, recent advance literature has emphasized the dependence of economic growth rates on technological change. Technological progress can be achieved through a diversity of canals that include the transformation of ideas and the implementation of new technologies both at home and abroad. The main aim of these developments is the improvement of telecommunications infrastructure and usage Figure 4 (Rudra *et al.*, 2017).

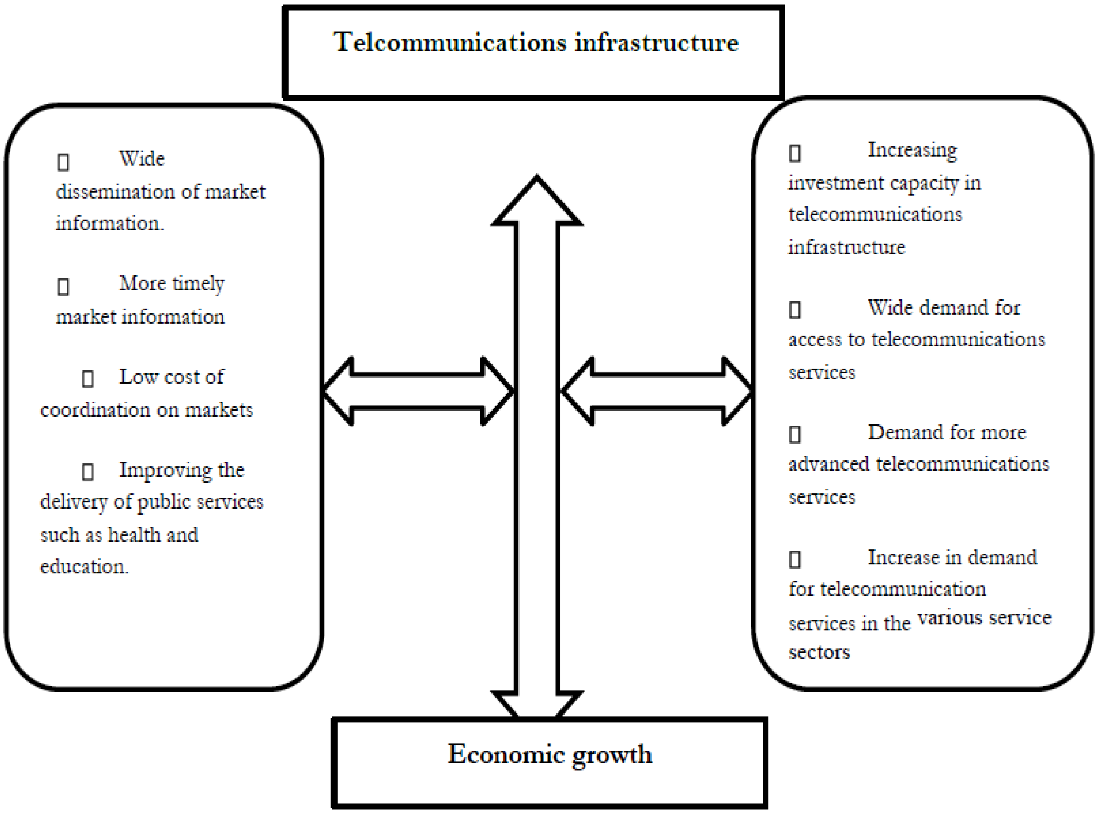

Figure-4. Theoretical framework linking telecommunications infrastructure and economic growth.

4.2. Empirical Model, Variable and Data

From an empirical point of view, we will start from the model developed by Gruber and Koutroumpis (2011) in order to analyze telecommunication infrastructures in terms of both supply and demand. This model is composed of an aggregated production function that relates national income GDP_{it} which takes into account the factors of production in each country over time; in particular, the capital stock (K)the work (L) and the stock of fixed and mobile telecommunications infrastructure. The stock of mobile telephone infrastructure is preferred to invest in mobile telephone because consumers are more likely to demand telecommunications infrastructure that is the result of the investment made. There is an explicit knowledge of telecommunications capital, approximated to mobile infrastructure in terms of mobile lines (Lines_Mob). As for the variable capturing fixed lines (Lines_Fix), $_{it}$ is used to control the other telecommunications infrastructures that will be built in other periods (t) and country specific effects.

The aggregate production function is as follows:

$$GDP_{it} = (K_{it}, L_{it}, Lignes_{Mobit}, Lignes_{Fixit}) \qquad (1)$$

Real GDP is thus a function of labour input, capital stock, fixed and mobile line infrastructure. However, the labour coefficients (L) and capital (K) could be typical of production functions, the coefficient of mobile penetration in Equation 1 estimates the unidirectional causality of mobile infrastructure to aggregate production. But the results of the estimates can be biased in the sense that we do not know that there is an inverse causality between the two variables. In order to solve this problem, by exploring the possibility of the existence of effects of mobile telecommunications infrastructures on real production and its opposite direction, we will specify a model composed of three equations including the equation of demand, supply of mobile telecommunications infrastructures, as well as a production infrastructure function. In this exercise, fixed-line infrastructure is always considered as a control variable to capture the effects of other infrastructure.

Thus, the function of mobile infrastructure demand is as follows:

$$Mob\_Pen_{it} = h(GDPC_{it}, MobPr_{it}, URB_{it}, Fix_{Penit}) \quad (2)$$

The demand Equation 2 indicates that mobile penetration is a function of GDP per capita (GDPC) of the standard price for network connection service (MobPr) the population density (URB) and the penetration rate of fixed telephone lines (Fix_Pen). From this equation, one would expect a negative price elasticity and a positive income elasticity (consumer demand for telecommunications services tends to increase with their income level). Urbanization, an indicator of population density, would have a positive effect on demand in urban areas where the sector has a very large share of economic activity and the urban population is more willing to take technological innovations into account. Fixed-line penetration captures the effects of the network and a positive effect is expected since a large number of fixed lines increase the usefulness of mobile phones since there is an interconnection between fixed and mobile lines.

As for the mobile infrastructure supply function, we use the following function, based on the model developed by Gruber and Koutroumpis (2011):

$$Mob\_Rev_{it} = g(MobPr_{it}, URB_{it}, GDPC_{it}). \quad (3)$$

The modelling of the telecommunications infrastructure supply is not always static. It is contingent to a big extent on the choices of policy measures like the licensing of Spectrum radio and the settings that link them, in specific, the cost of the license, the number of licenses and the way in which prices are controlled. Supply is also subject to socio-economic and demographic variables. As a result, Equation 3 can be considered as a formalized depiction on the supply side. It associates the aggregate mobile telephone income in a nation by mobile operators to fee levels during this period, income and urbanization levels. These parameters influence the potential or existing operators as well as supply dynamics in the telecommunications market. Under normal conditions, the price should have a positive sign, reflecting a positive slope in the supply curve. Similarly, the per capita income level should also positively affect supply, just as it is less expensive for firms to offer mobile telephone services in high-density urban areas compared to rural areas.

The production function of mobile infrastructures is as follows:

$$\Delta \boldsymbol{Mob\_Pen_{it}} = \boldsymbol{k}(\boldsymbol{Mob\_Rev_{it}}) \quad (\mathbf{4})$$

Infrastructure Equation 4 indicates that the annual variation in mobile penetration is a function of mobile revenues, taken as a proxy for the capital invested in the country over a year (Gruber and Koutroumpis, 2011). The expected sign of this relationship is supposed to be positive. Mobile telecommunications is technologically different from fixed-line telecommunications, but for the latter, there is a mapping of subscribers and favourable infrastructures such as telephone lines. With mobile infrastructures, this device is more flexible because a single base station can serve a relatively large number of subscribers.

However, to ensure quality service, mobile service providers must ensure that infrastructure is insufficient proportion to subscribers. Accordingly, the change in penetration levels would be due to the variation in infrastructure that has been previously used and is being used by the citizens of a given country. There may also be the invested capital shares that are not yet realized or used by subscribers. Infrastructure evolution is modelled as a function of income, which could be the main source of funding for infrastructure progress by mobile phone companies.

Equations 2, 3 and 4 endogenize mobile telecommunications infrastructure by highlighting the supply and demand for telecommunications services. To this end, the econometric specification of the model is as follows:

- Equation of the production function

$$\boldsymbol{GDP_{it}} = \boldsymbol{\alpha_1 K_{it}} + \boldsymbol{\alpha_2 L_{it}} + \boldsymbol{\alpha_3 Lignes\_Mob_{it}} + \boldsymbol{\alpha_4 Lignes\_Fix_{it}} + \boldsymbol{\varepsilon_{1it}} \quad (\mathbf{5})$$

- Equation of demand

$$Mob\_Pen_{it} = \beta_1 MobPr_{it} + \beta_2 URB_{it} + \beta_3 GDPC_{it} + \beta_4 Fixe\_Pen_{it} + \varepsilon_{2it} \quad (6)$$

- Supply equation

$$Mob\_Rev_{it} = \gamma_1 MobPr_{it} + \gamma_2 URB_{it} + \gamma_3 GDPC_{it} + \varepsilon_{3it} \quad (7)$$

- Production equation for mobile infrastructure production

$$\Delta Mob\_Pen_{it} = \delta Mob\_Rev_{it} + \varepsilon_{4it} \quad (8)$$

Table-2. Description of the variables.

Variable	Description of the variable	Data source
GDP	Gross domestic product	WDI
GDPC	Gross domestic product per capita	WDI
Mob_Rev	Mobile phone revenue	ITU
Mobile phone penetration	Percentage of the population who subscribed and activated their phone between the last 9 months	ITU
Fixed telephone penetration	Percentage of the population who have subscribed to fixed telephone service	ITU
Urbanization (%)	Rate of urbanization	WDI
Capital stock	Gross fixed capital formation	WDI
The stock of labour force	The labour force in thousands of the population	WDI

4.3. Estimation Technique

As this is a three-equation system, the appropriate estimation technique to be used is the 3SLS method. This technique will make it possible to take into account both the system dimension and the resolution of regressors' endogeneity problems in the models. In recent empirical studies, the consideration of endogeneity and simultaneity problems requires the use of several methods such as the least square double (2SLS), the Generalized Moment Method (GMM) and the least square triple (3SLS). One of the advantages of the 3SLS is that it makes it possible to estimate all the parameters of the model at the same time and because it takes into consideration a probable correlation between the error terms of the structural shape of the model. The 2SLS and GMM models estimate the equation by equation model while the 3SLS simultaneously estimates all the coefficients of all the equations in the system.

5. ECONOMIC POLICY OUTCOMES AND IMPLICATIONS

From the data in Table 1 of the Annex, it can be seen that the average Gross Domestic Product of ECOWAS countries is about seven billion. However, some countries in the region have a very low GDP of 128 million compared to nearly 100 billion for others. Investment is valued differently within the region as it averages $1.21 billion while it ranges from $7 million to $14.4 billion in the same area. The workforce is about 68% of the total population size. It can be seen that in the ECOWAS region, there are 1.8 telephone lines per 100 people. The rate of urbanization remains relatively low in the area. It is on average 39% in the Community but varies from 15% to 63% from one country to another. GDP per capita is $413 on average in the ECOWAS region. The fixed telephone penetration rate appears to be very low in some ECOWAS countries compared to 15% in other countries. It is on average 1.79% in the area, which is very low. Communication costs in the mobile segment are centred on $0.23 in the Community. The telecommunications sector generates an average of $234 million in the ECOWAS region see Appendix 1.

From a production perspective, in terms of results, there is a positive and significant relationship at the 5% threshold for investment. Any increase in investment of 1% leads to an increase of 0.01% in Gross Domestic

Product (GDP). As for mobile telephone lines, they have a positive and significant impact on GDP. Indeed, if the lines undergo a 1% increase, then the Gross Domestic Product increases by more than 0.28%.

Table-3. Results of estimates using the 3SLS estimator.

Variables	(1) (2)	(2) (3 Mobile_Income	Income_hbt penetration
Mobile_Price	0.220*		0.279
	(0.131)		(0.260)
Fixed_Price	-0.414**		
	(0.167)		
MO_pop	-0.458		
	(0.345)		
Pen_mobile	0.281**		
	(0.124)		
Pen_Fixed	0.0728	1.851***	0.685
	(0.181)	(0.475)	(0.671)
Investment	0.0181		
	(0.113)		
Rev_cap		4.982***	4.921**
		(1.387)	(1.964)
Rate_Urb		5.289***	6.888***
		(1.044)	(1.477)
Constant	6.765***	12.13**	22.56***
	(1.815)	(5.871)	(8.347)
Observations	119	119	119
R-squared	0.303	0.78	0.38

With regard to demand, prices in the mobile segment, the urbanization rate and the penetration rate in the fixed sector make a positive contribution to the penetration rate in the mobile segment. Indeed, any increase in one price unit in the mobile segment leads to an increase in the penetration rate of 2.07. Theoretically, one should expect a decrease in demand as a result of a price increase. However, in the case of the telecommunications market in ECOWAS countries, it should be noted that the mobile segment is largely dominated by the duopoly. This, given that the incumbents' market share remains relatively high, gives them a certain ability to influence the price level.

The urbanization rate has a positive impact on the mobile penetration rate. Thus, any 1% improvement in urban areas leads to a 5.3% increase in the penetration rate. Urbanization is accompanied by the establishment of infrastructure. The fixed and mobile segments are closely linked as the 1% increase in the fixed segment's penetration rate leads de facto to a 1.85% increase in the mobile penetration rate. The interconnection between fixed and mobile networks means that fixed telephone users do not find it inconvenient to connect with those on the mobile network and vice versa.

From a supply perspective, purchasing power and urbanization rates positively affect the income generated by telecommunications in the mobile segment. In concrete terms, any 1% increase in the level of per capita income generates an increase in the income of this sector of about 5%. These results confirm the study by the International Telecommunication Union (2004) on the gain made by mobile telephone operators in Africa and particularly in the ECOWAS region. The income generated by the mobile segment grows by more than 6% for any 1% increase in the urbanisation rate in the Community.

In terms of results, two economic policy implications. Focusing on the role of regulatory authorities in achieving universal service objectives in ECOWAS countries, it will be necessary to strengthen the role of regulatory authorities both in their ability to ensure competition in the sector and in the promotion of infrastructure. The ECOWAS States must, therefore, move towards the effective implementation of Community telecommunications policies as these countries have made commitments with regard to additional acts on telecommunications.

6. CONCLUSION

The objective of this research is to highlight the importance of investment in telecommunication infrastructure in ECOWAS countries. Indeed, the ever-increasing role of telecommunications services in economic activity is well established. These services are therefore considered vital to economic growth. This importance has been highlighted by the treaties, in particular, the revised ECOWAS treaty on universal access/universal services. The analyses in this article cover the impacts of telecommunications infrastructure in terms of demand, supply and impact on per capita income. The results show that the increase in telecommunications infrastructure raises operators' revenues and therefore their earnings. The results also show the positive impact of the expansion of both mobile and fixed telephone infrastructure on per capita income. In view of the results achieved, it is desirable that ECOWAS countries continue efforts to expand the telecommunications sector for better coverage with a view to improving access to telecommunications services for businesses and populations in general. In this context, the role of regulatory authorities in these countries must be strengthened in order to ensure a competitive environment and to encourage operators to provide greater territorial coverage and therefore greater penetration for both fixed and mobile phones and Internet use.

REFERENCES

Aaron, H.J., 1990. Discussion of why is infrastructure important. Is there a shortfall in public capital investment. pp: 51-63.

Aschauer, D.A., 1989. Is public expenditure productive? Journal of Monetary Economics, 23(2): 177-200.Available at: https://doi.org/10.1016/0304-3932(89)90047-0.

Barro, R.J., 1991. Economic growth in a cross section of countries. The Quarterly Journal of Economics, 106(2): 407-443.

Batuo, M.E., 2015. The role of telecommunications infrastructure in the regional economic growth of Africa. The Journal of Developing Areas, 49(1): 313-330.Available at: https://doi.org/10.1353/jda.2015.0005.

Bee and Gilling, 1976. Empirical observations on the role of telecommunication on socio-economic development. Africa Network for Capacity Building and Knowledge Building and Knowledge Exchange in ICT Policy, Regulation and Application.

Cronin, F.J., E.B. Parker, E.K. Colleran and M.A. Gold, 1991. Telecommunications infrastructure and economic growth: An analysis of causality. Telecommunications Policy, 15(6): 529-535.

Datta, A. and S. Agarwal, 2004. Telecommunications and economic growth: A panel data approach. Applied Economics, 36(15): 1649-1654.Available at: https://doi.org/10.1080/0003684042000218552.

Garbacz, C. and J.H.G. Thompson, 2007. Demand for telecommunication services in developing countries. Telecommunications Policy, 31(5): 276-289.Available at: https://doi.org/10.1016/j.telpol.2007.03.007.

Gruber, H. and P. Koutroumpis, 2011. Mobile communications: Diffusion facts and prospects. Communications and Strategies, 77(1): 133-145.

Hardy, A.P., 1980. The role of the telephone in economic development. Telecommunications Policy, 4(4): 278-286.Available at: https://doi.org/10.1016/0308-5961(80)90044-0.

Haynes, K.E., Q. Xie and L. Ding, 2004. Political geography, public policy and the rise of policy analysis. In Applied Geography. Dordrecht: Springer. pp: 69-93.

Hulten, C.R. and R.M. Schwab, 1984. Regional productivity growth in US manufacturing: 1951-78. The American Economic Review, 74(1): 152-162.

International Telecommunication Union, 2004. Strategy, Policy Unit, & New Initiatives Programme. The ITU New Initiatives Programme: Shaping the Future Mobile Information Society. International Telecommunication Union.

Jipp, A., 1963. Wealth of nations and telephone density. Telecommunications Journal, 30(1): 199-201.

Kane, S.C., 2011. Physical infrastructure and economic Growth in the WAEMU', Economic and Monetary Review, BCEAO, No. 9 - June 2011.

Kathuria, R., M. Uppal and Mamta, 2009. India: The impact of mobile phones, moving the debate forward. Vodafone Policy Paper Series, 9.

Katz, M.L. and C. Shapiro, 1985. On the licensing of innovations. The RAND Journal of Economics, 16(4): 504-520.

Lee, S., J. Levendis and L. Gutierrez, 2009. Telecommunications and economic growth: An empirical analysis of Sub-Saharan Africa, Universidad del Rosario, Facultad de Economía, Working Papers 64.

Madden, G. and S.J. Savage, 1998. CEE telecommunications investment and economic growth. Information Economics and Policy, 10(2): 173-195.Available at: https://doi.org/10.1016/s0167-6245(97)00020-6.

Munnell, A.H., 1992. Policy watch: Infrastructure investment and economic growth. Journal of Economic Perspectives, 6(4): 189-198.Available at: https://doi.org/10.1257/jep.6.4.189.

Norton, S.W., 1992. Transaction costs, telecommunications, and the microeconomics of macroeconomic growth. Economic Development and Cultural Change, 41(1): 175-196.Available at: https://doi.org/10.1086/452002.

Pénard, T., E. Raynaud and S. Saussier, 2003. Dual distribution and royalty rates in franchised chains: an empirical analysis using French data. Journal of Marketing Channels, 10(3-4): 5-31.Available at: https://doi.org/10.1300/j049v10n03_02.

Roller, L.-H. and L. Waverman, 2001. Telecommunications infrastructure and economic development: A simultaneous approach. American Economic Review, 91(4): 909-923.Available at: https://doi.org/10.1257/aer.91.4.909.

Rostow, W., 1960. The stage of economic growth: A non communist manifesto. London: Cambridge University Press.

Rudra, P.P., M.B. Arvin, M. Nair, J. Mittal and N.R. Norman, 2017. Telecommunications infrastructure and usage and the FDI–growth nexus: Evidence from Asian-21 countries. Information Technology for Development, 23(2): 235-260.Available at: https://doi.org/10.1080/02681102.2016.1217822.

Sridhar, K.S. and V. Sridhar, 2006. Telecommunications and growth: Causal model, quantitative and qualitative evidence. Economic and Political Weekly, 41(25): 2611-2619.

Waverman, L., M. Meschi and M. Fuss, 2005. The impact of telecoms on economic growth in developing countries. The Vodafone Policy Paper Series, 2(3): 10-24.

World Bank, 2003. World development indicators online (WDI Online), 2003. Washington, DC: World Bank. Available from http://www.worldbank.org [Accessed May 2004].

Appendix-1. Table of descriptive statistics on variables.

Variable		Mean	Std. Dev.	Min	Max	Observations
gdp_pe~p	overall	413.3262	338.1696	58.08326	2118.872	N = 255
	between		340.5502	58.08326	2118.872	n = 250
	within		2.543962	387.9305	438.7486	T-bar = 1.02
tx_urb	overall	39.06049	10.86135	15.6736	63.3242	N = 255
	between		10.87115	15.6736	63.3242	n = 250
	within		.2397724	36.69759	41.28179	T-bar = 1.02
inv_gdp	overall	19.66056	10.13934	2.883165	61.27027	N = 255
	between		10.07363	2.883165	61.27027	n = 250
	within		.4071277	17.10774	23.71798	T-bar = 1.02
Density	overall	69.22607	43.35463	7.499717	182.5855	N = 255
	between		42.84806	7.499717	182.5855	n = 250
	within		1.012734	59.86484	79.14223	T-bar = 1.02
fixed_price	overall	.1179226	.1233498	0	1.074943	N = 221
	between		.1239362	0	1.074943	n = 216
	within		.0013911	.1034498	.1306091	T-bar = 1.02315
pen_mob	overall	20.04977	25.81181	0	100.2838	N = 254
	between		25.98655	0	100.2838	n = 249
	within		.4758353	14.6374	24.73593	T-bar = 1.02008
pen_fix	overall	1.799728	3.230363	.0002356	15.58938	N = 255
	between		3.260249	.0002356	15.58938	n = 250
	within		.0265947	1.605319	2.109881	T-bar = 1.02
mob_rev	overall	2.34e+08	8.82e+08	0	6.48e+09	N = 255
	between		8.90e+08	0	6.48e+09	n = 250
	within		967133.2	2.29e+08	2.44e+08	T-bar = 1.02
pen_mob	overall	20.04977	25.81181	0	100.2838	N = 254
	between		25.98655	0	100.2838	n = 249
	within		.4758353	14.6374	24.73593	T-bar = 1.02008