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Information and communication technology penetration level as an impetus for economic growth and development in Africa

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ABSTRACT

Africa is an emerging, frontier economy that is gradually becoming a gold miner of the fourth industrial revolution (industry 4.0) to achieve speedy economic growth and development. Through the transmission channel of technological drive that relies on the penetration of modern communication means (information and communication technology [I.C.T.]). It is on this basis that this study examines the performance of I.C.T., economic growth and development in Africa. In capturing I.C.T. performance; penetration of I.C.T. indicators – mobile telephone, fixed-line telephone and Internet access subscriptions are used as measurements and reduced to a single index through principal components analysis (P.C.A.). Economic growth and development is measured with the real gross domestic product and the human development index (H.D.I.), respectively. The data for this study were sourced from the international telecommunication union (I.T.U.) and world development indicators from the World Bank databases. The results show that mobile telecommunication is growing faster than other telecommunication indicators and I.C.T. penetration has positive impacts on economic growth and development in Africa. The study, therefore, recommends that simultaneous investments are required in the fixed-line and Internet access telecommunications in Africa in order to fully tap into the optimal impetus of I.C.T. penetration for economic growth and development in Africa.

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1. Introduction

Africa is an emerging, frontier economy for exploiting the fourth industrial revolution (industry 4.0[1]) and enhancing speedy economic growth and development. Achieving

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rapid inclusive and sustainable growth via industry 4.0 relies on the extent of the 'smartness' of the African economies. Optimal interconnectivity of these countries is a result of the adoption of modern communication means (information and communication technology [I.C.T.]). Studies recommend a mutual causal-relationship between I.C.T. and growth and development nexus (Bahar, 2018; David, 2019; Pradhan et al., 2015). Other studies depict the telecommunication-/I.C.T.-led growth nexus (Asongu & Le Roux, 2017; Bahar, 2018; Ghosh, 2017; Haftu, 2019; Kumar et al., 2016; Vu, 2017; Wamboye et al., 2015). The essence of telecommunication/I.C.T. and research and development (R.&.D.) to growth and development in Africa are reported as the mechanism for achieving: (1) 'smart society' where digital provision minimises inequalities and disparities in the African region (Maresova et al., 2018); and (2) improved labour productivity growth (Tiruneh et al., 2017; Wamboye et al., 2016). Although in the African context, to achieve growth and development, some challenges such as foreign aid/capital, poor social entrepreneurship and sustainability/business models, among others, have been identified in the literature (inter alia: Goyal et al., 2014, 2016; Goyal & Sergi, 2015; Wamboye et al., 2013, 2014; Wamboye & Sergi, 2019). Consequently, African governments must deal with them in order to complement the importance of I.C.T. to Africa's growth and development.

Since the late 1990s, Africa has experienced an upward swing in terms of I.C.T. infrastructural development, when most African economies deregulated and liberalised the telecommunications sector (Song, 2015). The market forces, through the interaction of demand and supply, have stimulated telecommunications' infrastructural investment in Africa. Investors around the world see Africa as an investment hub and destination, due to the availability of markets in terms of population, and emerging markets in terms of a higher rate of return on investment (David, 2013):

During the past two decades, the telecommunications sector in Africa has experienced radical, technical and productivity changes due to the technological revolution associated with the development of wireless, mobile communication systems and the liberalization process. This has attracted a large amount of investment capital from both the public and the private sectors. Moreover, rapid diffusion has been pushed by sharply reduced costs and increased capacity. (Batuo, 2015)

As a result, total mobile penetration has more than doubled in the African region since 2000. Indeed, countries such as Nigeria, South Africa, Uganda, Democratic Republic of Congo and Cote d'lvoire have more mobile communications than fixed lines (ITU, 2018).

Most studies viewed I.C.T. measurements as disjointed indicators in which the bond in I.C.T. proxies are not linked together, but in reality their investments are highly causative. Bonding the connectivity in I.C.T. indicators (connected mobile lines, connected fixed lines and access to the Internet) in a single measurement in the form of an index in this study. Real gross output in the African region measures economic growth and the human development index (H.D.I.) is a measure for economic development in this study. Given the above, does I.C.T. stimulate growth and development in Africa? This is the question that this study seeks to answer through a stylised fact analysis. Previous studies have failed to identify this gap in the literature.

The central target of this study is to holistically determine the status quo of I.C.T. penetration, economic growth and development in Africa. This study conducted a stylised fact analysis for the research variables (economic development, economic growth and I.C.T. penetration [composite index of telecommunication (C.I.T.)]) in Africa using descriptive analytical framework (bar chart, line graphs, percentage and average index computation) and threshold analysis in Africa.

The other sections of this study are a literature review, performance of telecommunication services in Africa, ranking of telecommunication development index in Africa, economic growth performance in Africa, economic development in Africa, impact of telecommunication on economic growth and development in Africa, descriptive statistics and partial correlation analysis and a conclusion.

2. I.C.T., economic growth and development: impetus review

The Science, Technology and Innovation (S.T.I.) drive of the eighteenth century birthed the Industrial Revolution which accounted for a proportionate increase in the economies of scale that lead to rapid economic growth and development.[2] Technological advancement theories narrate how innovations and technologies enhance productivity, growth and distributions (Romer, 1986, 1990; Solow, 1956). More recent studies on I.C.T. penetration and growth/development were captured at country or regional level. Recent empirical studies dissect and measure I.C.T. penetration and economic growth/development based on the income level of economies. Dynamics in the discourse of I.C.T. as it relates to economic growth/development has gained more importance since the beginning of the fourth industrial revolution (industry 4.0) due to capacity of efficiency and potential possess by technologies. Embracing the revolution of I.C.T. for growth/development in developing countries has been point of discourse since the late 1990s which rapid sustainable inclusive growth/development relied on (Vu, 2017). Zhang and Li (2018) depict the significant role of regional I.C.T. access on entrepreneurial performance in China. In other climes, entrepreneurial productivity is directly related to national gross output growth and indirectly to the standard of living (Palvia et al., 2018). Different views emerge about the influence of I.C.T. diffusion on growth and development depending on the stage of development in an economy.

Niebel (2018) asserts that gains from investment in I.C.T. is viewed from the perspective of levels of economic strength – developing, emerging and developed economies for 59 countries (19 developing countries, 22 emerging countries and 19 developed countries). The study employed panel regression and confirmed that a positive relationship exists between investment in I.C.T. and growth in developed countries. The developed countries gained more from I.C.T. as the return to I.C.T. is larger than that of developing and emerging countries.

Haftu (2019) measures I.C.T. penetration with mobile phone and Internet access as they drive gross domestic product (G.D.P.) per capita in sub-Saharan Africa (S.S.A.) countries. The study sample panel of 40 countries using the robust two-step system G.M.M. reported the positive and significant role of mobile communication penetration on G.D.P. per capita in the region, but the reverse is true for Internet penetration. Asongu and Le Roux (2017) reported the enhancement of inclusive

human development through increasing I.C.T. (mobile phone, Internet and telephone) using the instrumental variable Tobit regression in 49 S.S.A. countries. Links between broadband penetration and economic growth shows that fixed and mobile Internet broadbands exert a positive impact on economic growth (Bahar, 2018; Ghosh, 2017).

Kumar et al. (2016) measure I.C.T. with Internet subscription, fixed broadband connections, mobile cellular subscription, high technology export and telephone lines and measured growth with G.D.P. at constant 2005 U.S. dollars in China. The study employed the A.R.D.L. bounds and Yamamoto Granger non-causality framework and found that the effect of I.C.T. on growth is positive and significant. Though mobile cellular and telephone lines shared mutual links with growth in China (Kumar et al., 2016). Latin American countries shared resemblance qualities, like that of China, in terms of impact of investment in I.C.T. on economic growth (Hofman et al., 2016). Hwang and Shin (2017) employed growth accounting and computable general equilibrium (C.G.E.) models to capture the role of I.C.T. on growth in the past and future respectively. The results show that I.C.T. investments play a significant role in economic growth in Korea. Latif et al. (2018) consider the panel framework of Brazil, Russia, India, China and South Africa (B.R.I.C.S.) on the causal relationship between economic growth, I.C.T. and other macroeconomic variables. The panel fixed effects, F.M.O.L.S., D.O.L.S. and group-mean estimator techniques robust to heterogeneity were employed to capture the long-run elasticities between economic growth and I.C.T. The results show that long-run positive elasticities exist between I.C.T. and economic growth in B.R.I.C.S. countries. Regionally, impacts of I.C.T. on economic growth gains significant attention in the work of Mohammed and Sulong (2017) employed pooled mean group (P.M.G.) model and assert that I.C.T.s (fixed line, mobile phone and Internet penetration) are positive and significant to growth in most of the income categories, but that mobile phone is more robust.

In the study of developed countries, Bahar (2018) considers the panel of 34 Organisation for Economic Co-operation Development (O.E.C.D.) and used panel V.A.R. techniques to evaluate the linkages between economic growth, I.C.T.s. and R.&.D. intensity. The study found mutual feedback causality between economic growth and I.C.T. penetration but unidirectional causality runs from I.C.T. penetration to R.&.D. intensity in O.E.C.D. countries. Das et al. (2018) carried out a study on the nexus between I.C.T. penetration, financial development and economic growth in lower income countries (L.I.C.s) and lower middle-income countries (L.M.I.C.s) using system generalised method of moments (S.G.M.M.) in order to control for endogeneity problems. In developing countries, I.C.T. penetration has a positive and significant impact on economic growth and I.C.T.-finance joint effect is found to be positive in L.I.C.s but insignificant in L.M.I.C.s.

Pradhan et al. (2018) examine the long-run relationship between I.C.T. and per capita real G.D.P., proxy for economic growth using panel vector error correction models (P-VECM) for G-20 countries. The study found that long-run equilibrium exists between economic growth and I.C.T. (fixed broadband and Internet users) in G-20 countries. In another study, mutual short-run and long-run equilibrium relationships exist between economic growth and I.C.T. infrastructure in Asian countries in which panel V.A.R. is employed to ascertain causality directions (Pradhan et al., 2015).

In summary, the empirical literature revealed that I.C.T. penetration drives growth and development in developed and developing countries depending on the extent of investment in I.C.T. Most of the literature employed econometric techniques that mostly have their applicability flaws. In order to navigate around the flaws that may the attached to econometric techniques, this study simply employed stylised fact analysis using descriptive and trend analysis to depict the importance of I.C.T. penetration on economic growth and development in Africa.

3. Methodology

3.1. Conceptual framework

From the Figure 1, the framework guiding the relationship between I.C.T. penetration, economic growth and development in this study is developed, where the causal-effect flows from I.C.T. (mobile communication, fixed-line telephony and Internet access) to economic growth (real G.D.P. and G.D.P. per capita) and economic development (H.D.I., life expectancy and per capita income).

These relationships further influence the prosperity of African countries and in turn that enhances movement along the ladder of the stages of development from traditional society to high mass consumption economies (Rostow, 1960). With I.C.T., the speed of economic growth and development are expected to be rapid due to efficiency potential possessed by 'smart process' as seen in the case of industry 4.0.

3.2. Data and measurement

This study employs the in-depth descriptive statistical techniques to capture the performance of I.C.T. penetration, economic growth and development in Africa. The

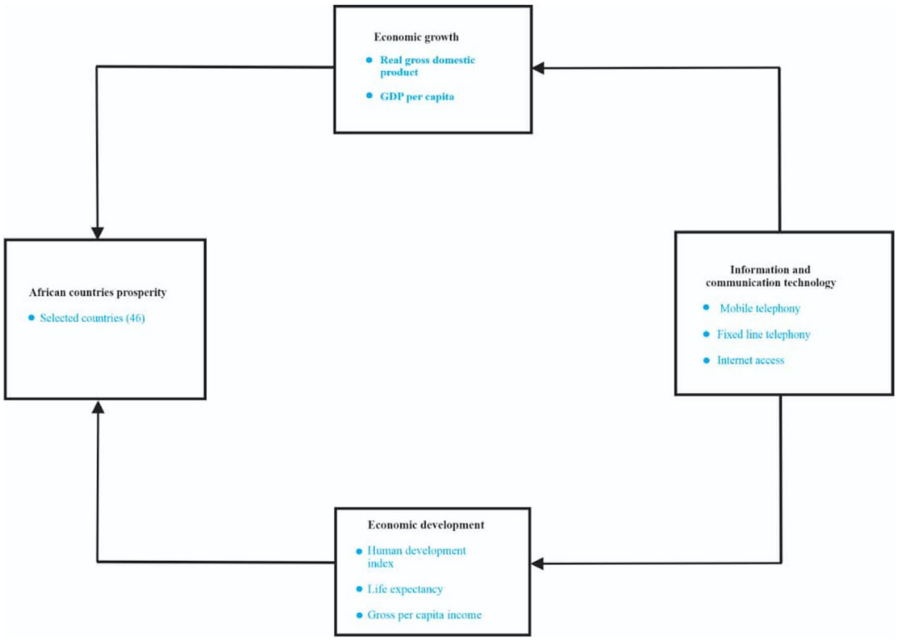


Figure 1. I.C.T., economic growth and development interaction.

C.I.T. is the measure for I.C.T. penetration which comprises mobile communication, fixed-line telephony and Internet access subscription in Africa. The C.I.T. is derived with principal component analysis (P.C.A.) which differs from other studies' measurements of I.C.T. penetration. Whilst economic growth and development are proxied by G.D.P. at market prices (constant 2010 U.S.$) and H.D.I. respectively and the data were sourced from various sources as shown in Table 1.

The data set of 46 African countries (as shown in Table 2) from 2000 to 2016 were explored for analysis in which a valid conclusion is drawn. The scope of this study is determined by the availability of data and the data were sourced from various secondary issues. In the instances of missing data, interpolation and extrapolation were employed. Thus, indicators for this study are as follows:

3.2.1. Measuring I.C.T. penetration

This study adopted the method of measurement employed by Pradhan et al. (2014) and David (2019), measuring I.C.T. penetration in Africa through CIT, which comprised of mobile communication, fixed lines and access to the Internet to capture the holistic activities of the I.C.T. adoption and development. The P.C.A. is used to achieve single index for connected mobile lines, connected fixed lines and access to the Internet.

The P.C.A. is a process of taking high dimension sets of indicators and transforming them into new indices that capture information on a different dimension and are mutually uncorrelated (Akanbi, 2015). To derive an aggregated index for infrastructure stocks, the first eigenvectors (loading matrix) from the P.C.A. are used as the required weights and therefore the following linear combination exists:

$$CIT = \alpha_1 \text{mob}_{\text{line}} + \alpha_2 \text{fixed}_{\text{line}} + \alpha_3 \text{internet}_{\text{access}} \quad (1)$$

where α_1, α_2, and α_3 are the eigenvectors (weights) from the P.C.A.: mob_line, fixed_-line and internet_access are the three synthetic I.C.T. penetration (C.I.T.).

3.2.2. Measuring economic development

Economic development measurement is one of the most critical and highly debated issues in economic analysis. Recent empirical studies show that economic development is a multidimensional indicator that reflects the qualitative expansion of countries (Haq, 1995; Sen, 1999; UNDP, 2010). There are several indicators of economic development: gross national income per capita, income inequality (poverty rate), level of food security, access to adequate health facilities and literacy level. These indicators are compressed by Haq (1995) to the H.D.I. The H.D.I. measures the average attainment in key dimensions of social and economic development: long and healthy life, being knowledgeable and have a decent standard of living. It is the geometric mean of normalised indices for each of the three dimensions (Haq, 1995; Sen, 1999; UNDP, 2010).

This study used the H.D.I. as an indicator for economic development since it includes both the social and economic dimension of countries. It ranges between 0 and 1, the closer the value to 1, the more developed the economy becomes.

Table 1. Summary of data set.

Variable	Indicator	Variable description	Unit of measurement	Source of data
HDI	human development index	proxy for economic development	Index	
GDPPC	real gross domestic product	GDP at market prices (constant 2010 U.S.$) as a proxy for economic growth	U.S.$ billions	World Bank, 2016
mob_line	connected mobile lines	penetration of connected mobile lines	%	International Telecommunication Union, 2016
fixed_line	connected fixed lines	penetration of connected fixed and CDMA lines	%	International Telecommunication Union, 2016
internet_access	access to Internet bandwidth	percentage of population with access to the Internet	%	International Telecommunication Union, 2016
CIT	composite index of telecommunication	principal component value of penetration of connected mobile lines, penetration of connected fixed and CDMA lines and percentage of population with access to the Internet as a proxy for ICT penetration	Index	Author's computation, 2018 (based on data collected from I.T.U. database, 2016)

Table 2. Selected African countries.

1. Algeria	13. Djibouti	25. Libya	37. Sierra Leone
2. Angola	14. Egypt	26. Madagascar	38. South Africa
3. Benin	15. Equatorial Guinea	27. Malawi	39. Sudan
4. Botswana	16. Eritrea	28. Mali	40. Swaziland
5. Burkina Faso	17. Ethiopia	29. Mauritius	41. Tanzania
6. Burundi	18. Gabon	30. Morocco	42. Togo
7. Cameroon	19. Gambia	31. Mozambique	43. Tunisia
8. Central African Rep.	20. Ghana	32. Namibia	42. Uganda
9. Chad	21. Guinea	33. Niger	45. Zambia
10. Congo (Dem. Rep.)	22. Kenya	34. Nigeria	46. Zimbabwe
11. Congo (Rep.)	23. Lesotho	35. Rwanda	
12. Côte d'Ivoire	24. Liberia	36. Senegal	

Therefore, the closer the value of H.D.I. to 0, the more underdeveloped the economy becomes.

3.2.3. Measuring economic growth

The economic barometer of a country lies in the strength of its real G.D.P. There are many different methods used to measure how fast the economy is growing. Barro and Sala-I-Martin (1995) and Buterin et al. (2017) measure economic growth through rate of real per capita G.D.P. with the perception of inclusive growth, better maintenance of the rule of law, smaller government consumption, longer life expectancy, more male secondary schooling and higher levels of schooling, lower fertility rates, and improvements in the terms of trade are the determinants of economic growth. This approach is comprehensive and sometimes cumbersome, especially for developing countries due to the inclusion of social indicators in the determinants of economic growth which defines the inclusiveness of the economic growth. The most common way to measure the economy is the real G.D.P. (Škare & Stjepanović, 2013; Stankovska et al., 2016; Verbič & Polanec, 2014). This includes the value of the total output with the inclusion of the change in price level. The real G.D.P. approach forms the rationale for this study due to its simplicity in its application. Thus, the G.D.P. at market prices (constant 2010 U.S.$) from the World Bank indicators are used in this study.

4. Result and analysis

4.1. Performance of telecommunication services in Africa

4.1.1. Telephone lines subscription

The study measures I.C.T. penetration based on the development of telecommunication in Africa which serves as the telephone lines subscription. The development of telecommunication is evaluated through the index of penetration of connected mobile lines, penetration of connected fixed lines and percentage of population with access to the Internet as calculated with P.C.A. Thus, Figure 2 presents the trend of telecommunication development in Africa.

The average telecommunication development for African countries from 2000 to 2016 is shown by panel (a). The results show that Mauritius has the highest average C.I.T. with 75.81, followed by South Africa with 69.15 average C.I.T., Libya with

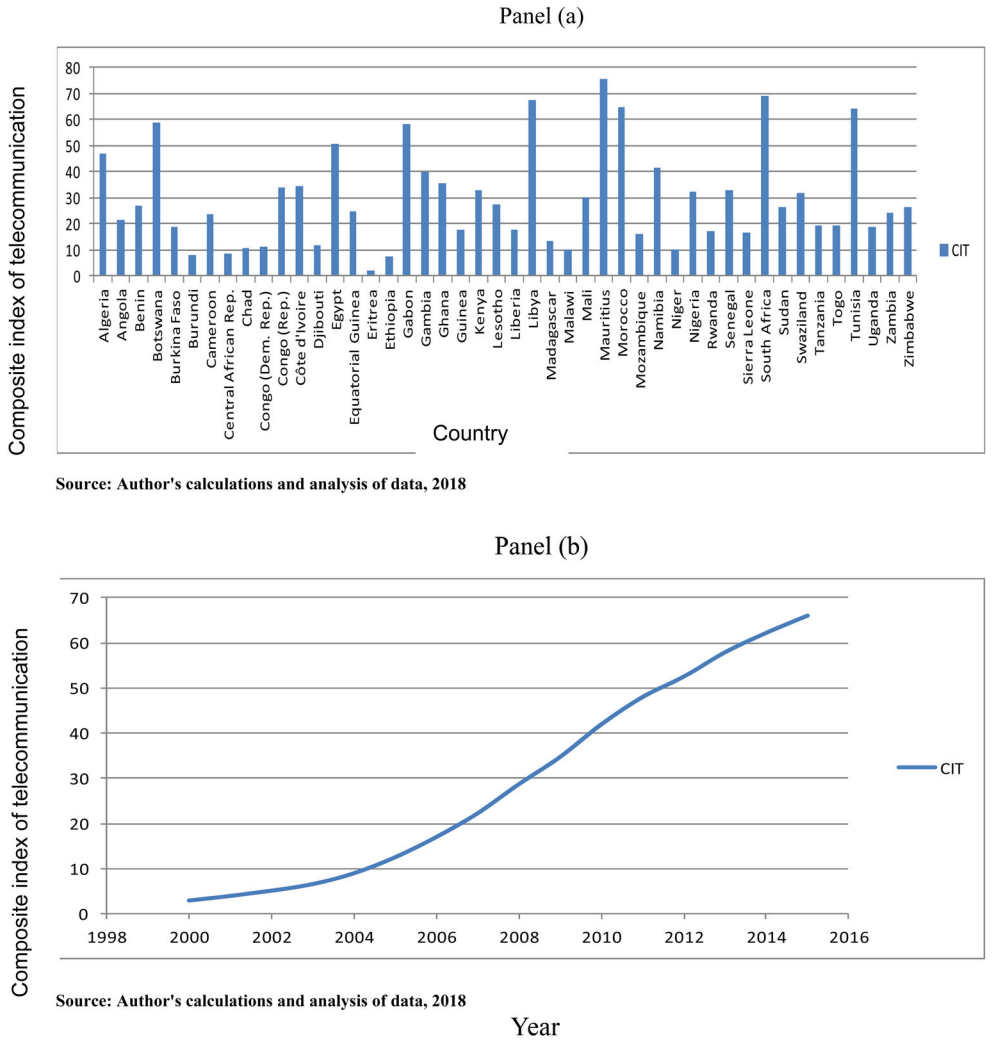


Figure 2. Trend of I.C.T. penetration (composite index of telecommunication) in Africa.
Panel (a): Source: Author's calculations and analysis of data, 2018.
Panel (b): Source: Author's calculations and analysis of data, 2018.

67.24, Morocco with 64.97 and Tunisia with 64.32. These countries were able to peak at an average above 60 average C.I.T. in Africa between 2000 and 2016.

Panel (b) of Figure 2 depicts the trend of average C.I.T. from 2000 to 2015 for 46 African countries. The results revealed that the average C.I.T. stood at 2.99 in 2000, and increased to 12.57 in 2005. The average C.I.T. in Africa further increased to 65.99 in 2015. The investment in I.C.T. is responsible for the positive trend in average C.I.T. in Africa. However, the average C.I.T. stood at 65.99 in 2015 but some countries attained this index while some were unable to. Some of the countries attaining 65.99 index at some point are analysed further, though rate of growth of C.I.T. differs by countries.

The top countries in the C.I.T. in Africa are: Algeria, Botswana, Congo (Rep.), Côte d'Ivoire, Egypt, Gabon, Gambia, Ghana, Kenya, Lesotho, Libya, Mali, Mauritius,

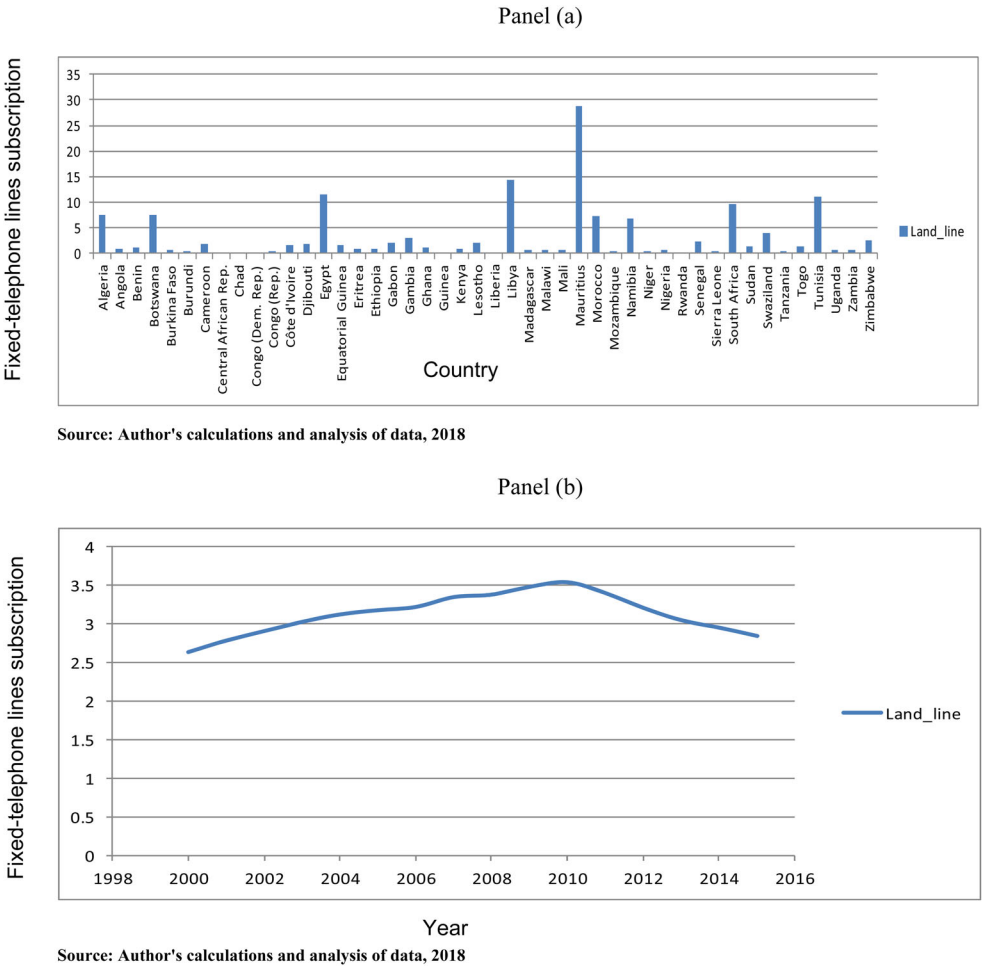


Figure 3. Trend of Fixed telephone subscription in Africa, 2000–2016.
Panel (a): Source: Author's calculations and analysis of data, 2018.
Panel (b): Source: Author's calculations and analysis of data, 2018.

Morocco, Namibia, Nigeria, Senegal, South Africa and Tunisia, from 2000 to 2016. These countries' C.I.T. reached at least 65 on the C.I.T.

These results revealed that most of the North African countries reached the transition process in telecommunication development in Africa before S.S.A. countries, except for Mauritius. The results depict that Libya's telecommunication development index reached at least 70 in 2008, Mauritius in 2007, Morocco in 2008 and Tunisia in 2008. The transition era for most of the S.S.A. countries was 2010, when most S.S.A. countries attained a C.I.T. of at least 65.

4.1.2. Fixed telephone lines subscription

Figure 3 shows the trend of average fixed telephone line penetration in Africa from 2000 to 2015. The results are presented in panel (a) and panel (b) to assess both cross-section and time series effect on the spread of land lines in Africa. Panel (a) shows the average index of fixed telephone lines penetration in Mauritius is the

highest with 28.88, the closest to that is Libya with 14.47 index of fixed telephone penetration.

The findings further revealed that Egypt had an average of 11.65 index of fixed telephone lines penetration and Tunisia had an average of 11.12. These results revealed that Mauritius, Libya, Egypt and Tunisia are the countries with average double digit index of fixed telephone penetration in Africa for 2000–2015. Panel (b) shows the time series average trend of fixed telephone penetration in Africa from 2000 to 2015. The results show that average fixed telephone penetration stood at 2.63 in 2000, increased to 3.555 in 2010, but decreased to 2.84 in 2015. The continuous decline in fixed telephone lines penetration in Africa is a result of preference for mobile telephones in Africa. Though, some countries at some point had an index of fixed/C.D.M.A. telephone penetration above the average.

The empirical results from individual countries' perspectives revealed that Mauritius has the highest index in Africa from 2000 to 2015. In 2000, the fixed line index of Mauritius stood at 23.7 and increased to 31.5 in 2010 but decreased to 30.31 in 2015. The decline is due to mass spread of mobile telecommunication lines in Africa and the convenience attached to mobile telecommunication. The North African country Libya attained 20.33 index of fixed lines penetration in 2010, but since then has declined to 10 in 2015. The empirical results show that Mauritius and Libya were the only countries in Africa with at least 20 index of fixed line penetration in Africa.

4.1.3. Mobile telephone lines subscription

The penetration of mobile communication in Africa from 2000 to 2016 is measured by Figure 4. The chart in panel (a) displayed the average mobile line penetration in selected African countries from 2000 to 2015. The results revealed that Libya had the highest average mobile telephone penetration with 91.61 index, followed by Gabon with 87.30 index, South Africa with 85.94 index, Botswana with 82.83 index, Mauritius with 77.19 index, Tunisia with 72.57 index, Morocco with 71.11 index and Algeria with 60.54 index. The result implied that for every 100 citizens of these countries 92 have mobile phone in Libya, 87 in Gabon, 86 in South Africa, 83 in Botswana, 77 in Mauritius, 72 in Tunisia, 71 in Morocco and 61 in Algeria, for the average period between 2000 and 2016.

The panel (b) shows the annual average mobile line penetration for 46 selected African countries for the period 2000–2016. The result revealed that mobile telephone penetration was at its lowest ebb with 2.12 index in 2000, but increased to 9.91 index in 2004. The rise continued in 2008 with 38.83 index and 2008 was the turnaround year for some African countries, like Libya, when mobile telephone penetration peaked at 100 index. The average index of mobile telephone penetration further rose to 87.22 in 2015. Though, some countries' mobile telephone index is above the average for Africa. These results revealed that 2008 was the turnaround year for mobile communication in Africa in which Libya alone was able to peak at least at teledensity of 100 and 2010 sees more entrants to the benchmark of mobile line teledensity of 100 in Africa.

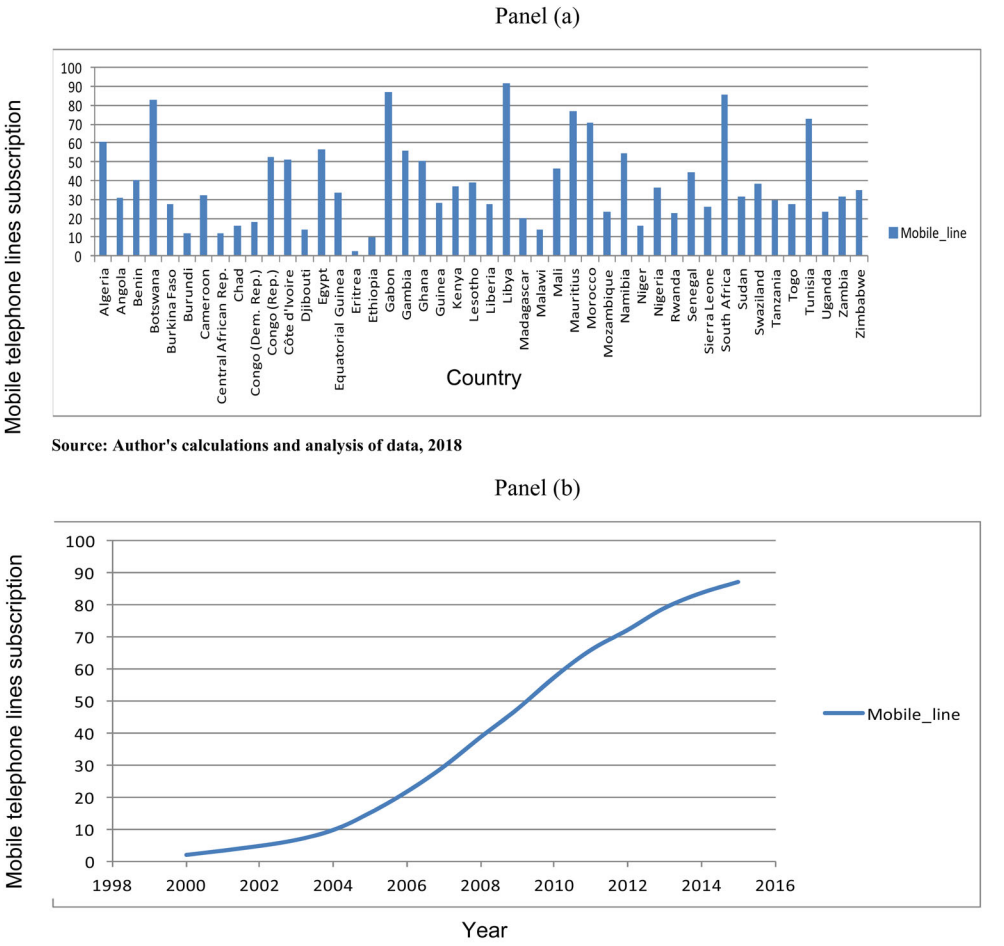


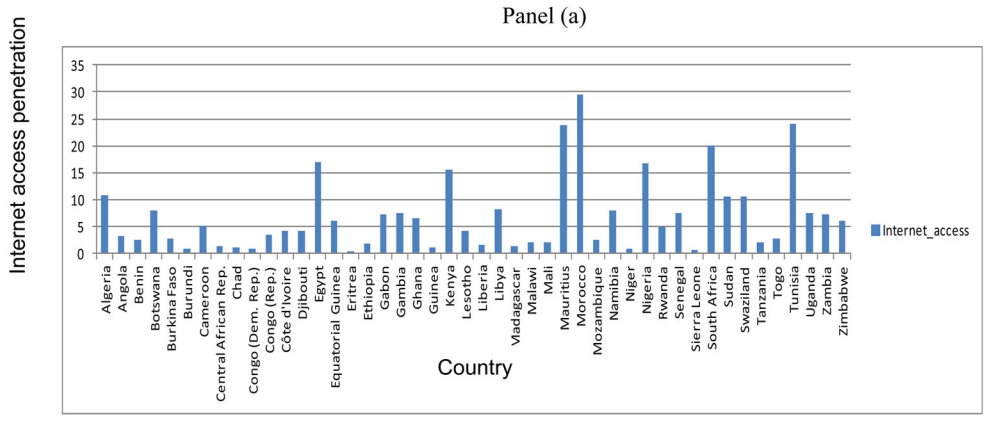
Figure 4. Trend of mobile telephone subscription in Africa.
Panel (a): Source: Author's calculations and analysis of data, 2018.
Panel (b): Source: Author's calculations and analysis of data, 2018.

4.1.4. Internet access subscription

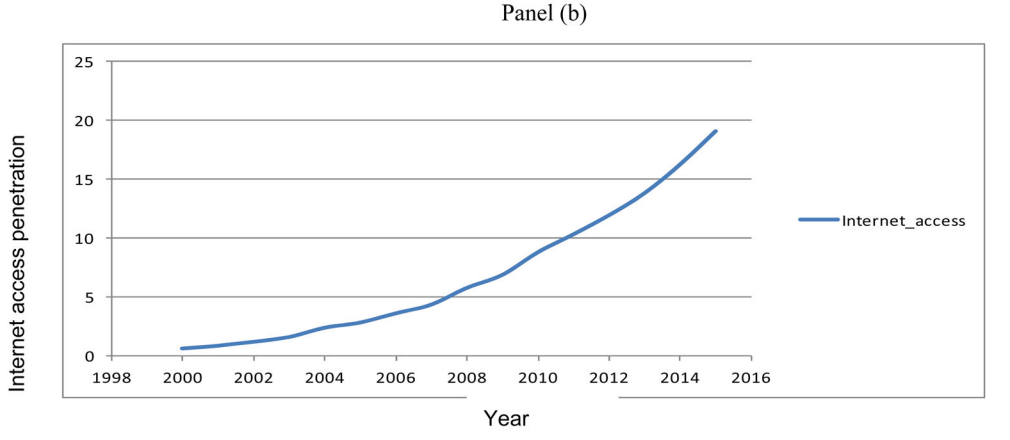
The Figure 5 shows the penetration of Internet access in Africa from 2000 to 2016 using the average index.

Panel (a) shows the cross section trend of average Internet access penetration depict that Morocco had the highest average Internet access penetration index with 29.60, followed by Tunisia with 24.03, Mauritius with 23.9, Egypt with 17.09 and Nigeria with 16.71. These countries were able to attain at least an average index of 15 Internet access penetration within the years under study, 2000–2015.

Panel (b) shows the trend of average Internet access penetration index across this time in Africa. The results show that Internet access penetration index stood at 0.66 in 2000 and increased to 3.64 in 2006. The increasing trend in average Internet access penetration index in 2010 with 10.36 and further increased to 19.12 in 2015. However, levels of Internet access penetration differs country by country. The data



Source: Author's calculations and analysis of data, 2018



Source: Author's calculations and analysis of data, 2018

Figure 5. Trend of Internet access penetration in Africa.
Panel (a): Source: Author's calculations and analysis of data, 2018.
Panel (b): Source: Author's calculations and analysis of data, 2018.

revealed that only six countries were able to reach the benchmark of Internet access index of 45 set for this study, those countries are Kenya, Mauritius, Morocco, Nigeria, South Africa and Tunisia. Kenya's (East Africa) Internet access penetration reached 45.62 index in 2015 and that is the highest the country has achieved. Mauritius's Internet access index attained 50.14 in 2015, the highest penetration the country has achieved. The Internet access spread of Morocco attained 52 index in 2010, increased to 56.8 in 2014 and further rose to 57.08 in 2015. Nigeria's (West Africa) Internet access penetration reached 47.44 index in 2015, this is the highest the country has attained. South Africa's Internet access spread initially peaked at 46.5 index in 2013, increased to 49 in 2014 and further increased to 51.92 in 2015. Tunisia's Internet access stood at 46.16 in 2014 and rose to 48.52 in 2015.

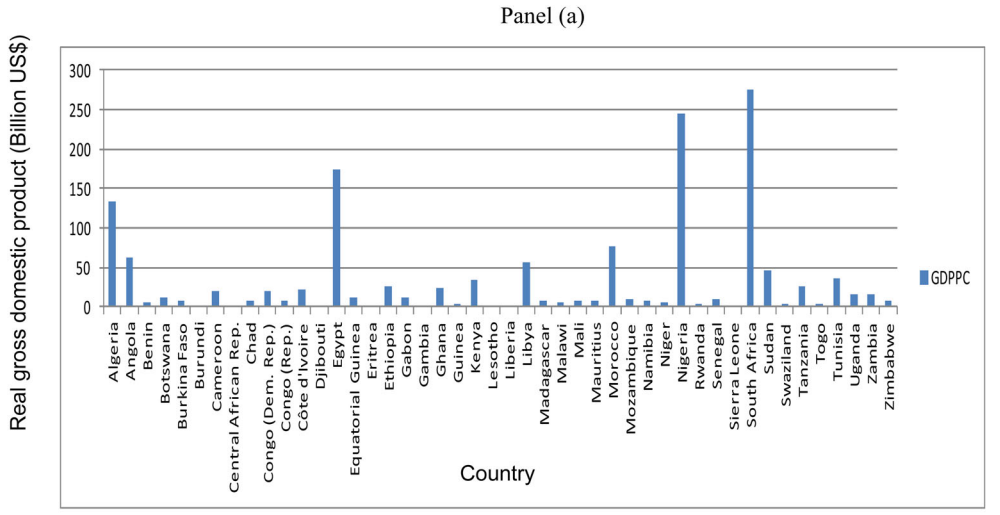
The empirical results show that Internet access is still at the emerging stage in Africa due to high cost of I.T. infrastructures in Africa. There is less competition in the I.T. industry when compared with Europe, North America, Asia and the Middle East, and government restrictions in some African countries are also a factor.

4.2. Economic growth performance in Africa

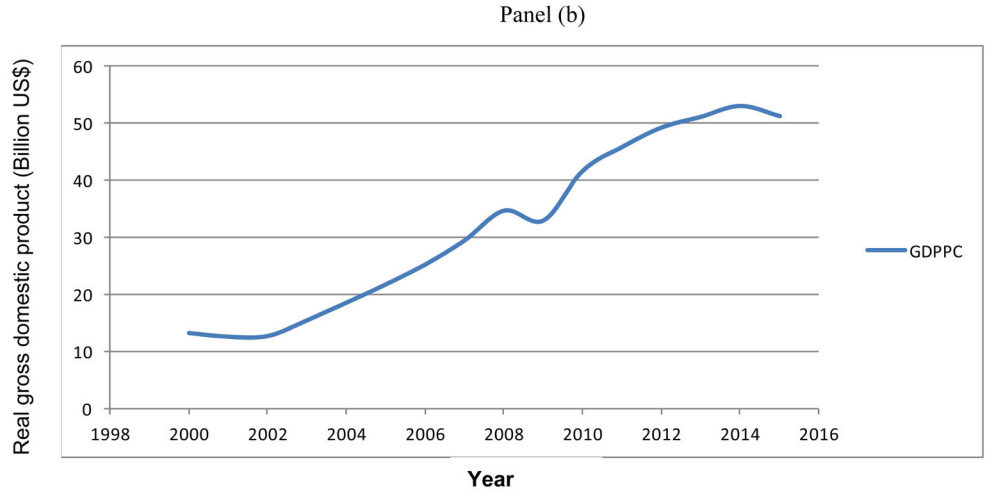
The growth of the economic activities in Africa is used to measure the size of the African countries in terms of value of all goods and services produced from 2000 to 2016. This study measures economic growth with G.D.P. at market prices of constant 2010 U.S.$. The G.D.P. at the purchaser's price is the sum of gross value added by all resident producers in the economy, plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources. Data are in constant 2010 U.S.$. Dollar figures for G.D.P. are converted from domestic currencies using 2010 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used. The G.D.P. worth of a nation shows the economic worth of that nation. The trend of worth of the African economy is presented in Figure 6.

Panel (a) in Figure 6 shows the average real G.D.P. of African countries which is the measure for economic growth from 2000 to 2016 in this study. The results revealed that South Africa had the highest average real G.D.P. of U.S.$275.63 billion and Nigeria had an average real G.D.P. of U.S.$244.45 billion. These two countries were able to achieve an average real G.D.P. of more than U.S.$200 billion between 2000 and 2015. The North African countries Egypt and Algeria attained an average real G.D.P. of U.S.$133.97 billion and U.S.$173.42 billion respectively within the period under study. These countries, South Africa, Nigeria, Egypt and Algeria, were the four biggest economies in Africa between 2000 and 2016.

Panel (b) in Figure 6 shows the trend of average real G.D.P. in Africa from 2000 to 2015. The empirical result revealed that the average real G.D.P. stood at U.S.$13.17 billion in 2000 and rose to U.S.$34.67 billion in 2008 but declined to U.S.$32.95 billion in 2009 as result of disinvestment in Africa due to world economic crisis of 2008. The economies of Africa bounced back in 2010–2014 where the average worth of African economies stood at U.S.$53.07 billion, but shrunk in 2015 to U.S.$51.29 billion due to energy (crude oil) and commodity prices in the international market that sees declined in the revenues of biggest players of African economy like Nigeria, Algeria and South Africa. There are some countries at a point during 2000–2015 that the real G.D.P. is above the average value for the whole of Africa. The results show that most of African countries' G.D.P.s are below U.S.$100 billion, except Algeria, Angola, Egypt, Libya, Morocco, Nigeria and South Africa. They are able to achieve the height of at least U.S.$100 billion of G.D.P. Algeria attained a G.D.P. worth U.S.$103 billion in 2005 which increased to U.S.$214 billion in 2014 but fell to U.S.$167 billion in 2015, this amounted to a 21.96% fall in G.D.P. value in 2015. Angola achieved a G.D.P. worth U.S.$104 billion in 2011, which increased to U.S.$127 billion in 2014 but dwindled to U.S.$103 billion in 2015, this amounted to a 18.9% drop in G.D.P. value in 2015. The G.D.P. worth of Egypt stood at U.S.$107 billion in 2006, increased to to U.S.$331 billion in 2015. The G.D.P. value of Libya stood at U.S.$160 billion in 2015, the record value of G.D.P. ever attained by the country and the economy grows at 331% in 2015 in relation to 2014. The G.D.P. worth of Morocco was U.S.$101 billion in 2011, which increased to U.S.$110 billion



Source: Author's calculations and analysis of data, 2018



Source: Author's calculations and analysis of data, 2018

Figure 6. Trend of real gross domestic product in Africa.
Panel (a): Source: Author's calculations and analysis of data, 2018.
Panel (b): Source: Author's calculations and analysis of data, 2018.

in 2014 but nosedived to U.S.$101 billion in 2015, this is an 8.18% shrink in G.D.P. value in 2015. Nigeria's G.D.P. worth stood at U.S.$112 billion in 2005, increased to U.S.$568 billion in 2014 but declined to U.S.$481 billion in 2015, the decline amounted to a 15.32% shrink in the economy in 2015. The G.D.P. value of South Africa stood at U.S.$136 billion in 2000, increase to U.S.$351 billion in 2014 but dropped to U.S.$315 billion in 2015, the drop amounted to a 10.26% burst in the economy in 2015.

Figure 6 shows that most African countries experience a sharp drop in economic worth in 2015. This shrink in African economies may be as a result of high volatility in the price of major natural resources like crude oil, gold, copper, coal, uranium, etc.

in the international market and since most of African countries economic activities are dependent on sales of natural resources, their revenues have dropped drastically.

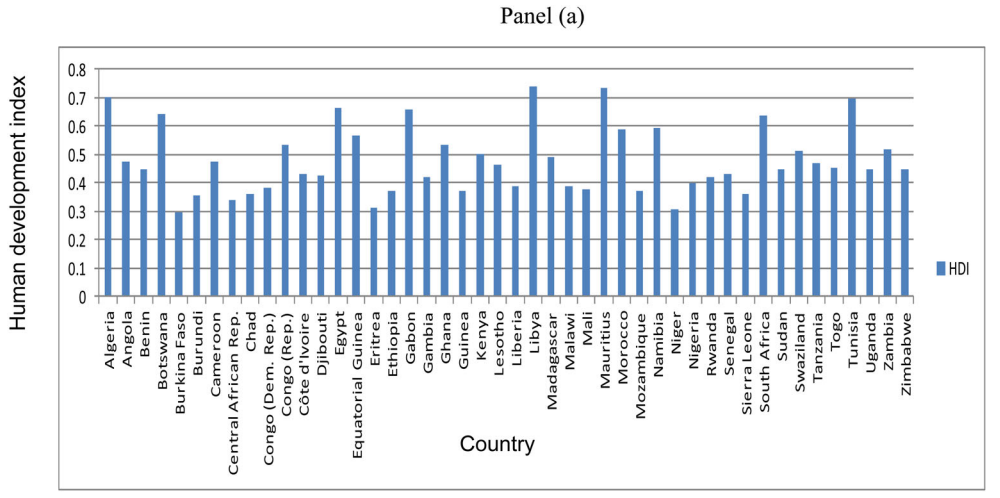
4.3. Economic development in Africa

The socioeconomic progress of African countries is measured through the H.D.I. as suggested by Hub (1996) in the United Nation Development Program (U.N.D.P.) report in this study. This study considers the trend of the H.D.I. of the selected African countries to evaluate economic development in Africa. The U.N.D.P.'s (2015) H.D.I. is the composite index measuring average achievement in three basic dimensions of human development – a long and healthy life, knowledge and a decent standard of living. The categorisation of the index are: HDI value is more than 0.80 – very high human development; HDI value is between 0.70 and 0.80 – high human development; HDI value is between 0.55 and 0.69 – medium human development; HDI value is less than 0.55 – low human development. The H.D.I. is a measure for economic development of a nation. Thus, the trend of H.D.I. in Africa is presented in Figure 7.

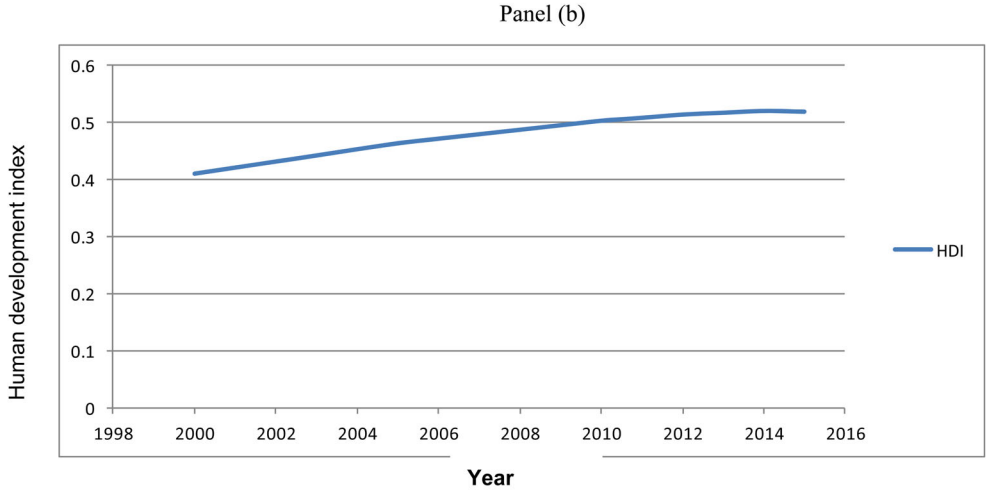
The average H.D.I. for African countries presented in panel (a) of Figure 7 shows that Libya had the highest average H.D.I. with 0.74, followed by Mauritius with 0.73, Algeria with 0.70 and Tunisia with 0.70. Libya, Mauritius, Algeria and Tunisia are the countries with average H.D.I. in the high H.D.I. range of 0.70–0.80. The result further shows that Egypt had an average H.D.I. of 0.66, Gabon had 0.66, Botswana had 0.64, South Africa had 0.64, Namibia had 0.60, Morocco had 0.59 and Equatorial Guinea had 0.57. Egypt, Gabon, Botswana, South Africa, Namibia, Morocco and Equatorial Guinea were able to attained an average H.D.I. within 0.55–0.69 – medium human development. Thus, Libya, Mauritius, Algeria, Tunisia, Egypt, Gabon, Botswana, South Africa, Namibia, Morocco and Equatorial Guinea were able to achieve at least medium H.D.I.

Panel (b) of Figure 7 shows the average H.D.I. of African countries for 2000–2016. The average H.D.I. stood at 0.41 in 2000, rose to 0.45 in 2004 and increased further to 0.50 in 2010. The rise in average H.D.I. continues in 2015 with 0.52 H.D.I. The H.D.I. rise in African countries is slow due to the undeveloped nature of infrastructures like education and health facilities in the majority of African countries. This result shows that an average H.D.I. in Africa is less than 0.55, low H.D.I. Though, at individual countries level, come countries show some level of development at some point.

The ratio of change in the H.D.I. is between 0.14% and 3.66% for African countries. The results show that Algeria, Libya, Mauritius and Tunisia are high human developed countries. Algeria achieved this height with 0.702 in 2007 and 0.738 in 2015, while Libya reached the high human developed status in 2000 with 0.731 and 0.738 in 2013. Mauritius reached the high human developed county in 2003 with an H.D.I. of 0.703 and 0.776 in 2015 while Tunisia transformed to a high human developed country in 2008 with an H.D.I. of 0.704 and peaked at 0.721 H.D.I. in 2015. These four countries have achieved the high H.D.I. within the time frame of this study, 2000–2015. Among these countries, Mauritius is the only S.S.A. country while the remaining three countries, Algeria, Libya and Tunisia are North African Arab countries.



Source: Author's calculations and analysis of data, 2018

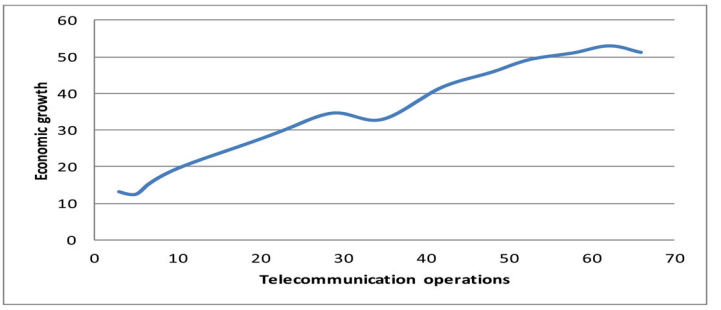


Source: Author's calculations and analysis of data, 2018

Figure 7. Trend of human development index in Africa.
Panel (a): Source: Author's calculations and analysis of data, 2018.
Panel (b): Source: Author's calculations and analysis of data, 2018.

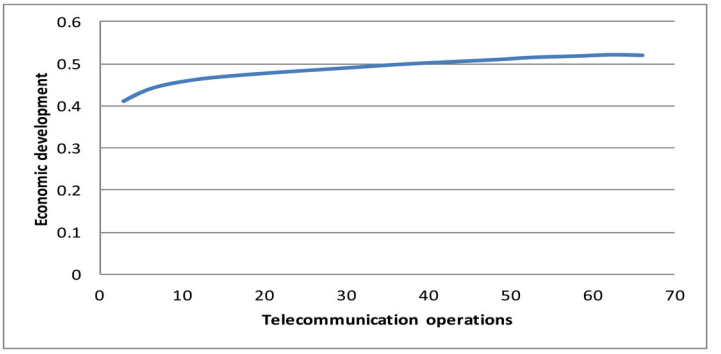
The African countries that have reached the medium H.D.I. are Botswana, Congo (Rep.), Egypt, Equatorial Guinea, Gabon, Ghana, Morocco, Namibia, South Africa, Tunisia and Zambia. Their human development indices are within 0.55–0.69 for the period under study, 2000–2016. The rest of the countries in Africa fall within low H.D.I. range (i.e., less than 0.55) for 2000–2016.

The average H.D.I. for S.S.A. countries was 0.518 in 2014, which was below the average of the 0.66 H.D.I. for the world's developing countries in 2014. From these results, we can conclude that most African countries are under-developed since the majority of the countries' H.D.I.s are less than 0.55.



Source: Author's calculations and analysis of data, 2018

Figure 8. Telecommunication operations and economic growth in Africa.
Source: Author's calculations and analysis of data, 2018.



Source: Author's calculations and analysis of data, 2018

Figure 9. Telecommunication operations and economic development in Africa.
Source: Author's calculations and analysis of data, 2018.

4.4. Impact of telecommunication on economic growth and development in Africa

Figure 8 depicts a relationship that exists between telecommunication operations and economic growth in Africa from 2000 to 2016. The line graph shows that there is direct relationship between telecommunication operations and economic growth. This implied that as telecommunication operations increases, there is high tendency of economic growth to increase. However, there is an inverse relationship between telecommunication operation and economic growth in Africa in 2008–2009 due to the world economic crisis, and in 2014–2016 due to a drop in revenue of many African countries as a result of a decline in the prices of major commodities exported by African countries.

Figure 9 shows the direct relationship between telecommunication operations and economic development in Africa. The positive impact of telecommunication operations is greater at the beginning of the trend but started increasing decreasing rate in 2009 when telecommunication operations reached 34.75 index. This is as a result of a decline in major economic activities due to the economic shrink of the world, which had an effect on infrastructures of telecommunication in Africa.

Table 3. Summary statistics for the variables used in the study.

Variable	HDI	GDPPC	CIT
Mean	0.477008	31.97868	29.48705
Median	0.456000	9.143192	18.40307
Maximum	0.777000	568.0000	132.3922
Minimum	0.000000	0.416000	0.034248
Std. Dev.	0.126658	68.91970	30.77947
Skewness	0.187479	4.184373	1.212426
Kurtosis	3.483292	23.14429	3.757503
Jarque-Bera	11.47438	14592.07	197.9140
Probability	0.003224	0.000000	0.000000
Sum	351.0780	23536.31	21702.47
Sum Sq. Dev.	11.79110	3491195.	696321.4
Observations	736	736	736

Source: Authors' computations, 2018.

The slope of line trend in Figure 8 shows the speed of reactions of economic growth to telecommunication development higher than that of economic development to telecommunication development in Figure 9. From the results, economic growth responds faster than economic development to telecommunication development in Africa.

4.5. Descriptive statistics

Table 3 describes the summary statistics of the panel series for this study in which the average values of H.D.I. – proxy for economic development; real G.D.P. – proxy for economic growth and C.I.T.; standard deviation attached to them and distribution of disparity (skewness, kurtosis and Jarque-Bera normality test) were measured in 46 African countries.

The results revealed that the H.D.I. average in Africa from 2000 to 2016 is 0.477008 index with a median of 0.456000 index, though the maximum value is 0.777000. The average value is within the low income category and this result shows that the majority of African countries are still low-income countries. The standard deviation of the average H.D.I. in Africa is 0.126658 with Jarque-Bera statistic of 11.47438, which suggested that the residuals of human development in Africa are not normally distributed. The average real G.D.P. in Africa is U.S.$31.97868 billion, with a median of U.S.$9.143192 billion and a maximum value of U.S.$568.0000 billion with standard deviation U.S.$68.91970 billion. The results show wide disparity in the value of real G.D.P. in Africa, which implies that economic growth in Africa varies country by country. The Jarque-Bera normality test for economic growth revealed that the residuals of real G.D.P. are not normally distributed in Africa.

The C.I.T. shows the level of telecommunication penetration and development in Africa in which the average telecommunication index is 29.48705 and the maximum is 132.3922 with standard deviation of 30.77947. The disparity is wide in Africa due to the concentration of telecommunication services in urban centres and cities, but rural areas are still struggling to get access to telecommunication services. The normality test of the residuals for C.I.T. is 197.9140, which suggested that residuals are not normally distributed.

Table 4. Degree of association among research variables.

	HDI	GDPPC	CIT
HDI	1.0000		
GDPPC	0.3684	1.0000	
CIT	0.6699	0.4227	1.0000

Source: Authors' computations, 2018.

4.6. Partial correlation analysis

The partial correlation among the research variables (economic development, economic growth, C.I.T.) are presented in Table 4.

The results show that economic growth has 36.84% positive association with economic development, while C.I.T. has 66.99% association with economic development in Africa. The results show that C.I.T. has a 42.27% degree of association with economic growth. It is evidenced from these results that stronger relationship exist between I.C.T. penetration (C.I.T.) and economic development in Africa while a weak relationship exists between I.C.T. penetration (C.I.T.) and economic growth in Africa.

4.7. Ranking of telecommunication development index in Africa

This section evaluates the level of C.I.T. in individual African countries in which average value of the telecommunication index from 2000 to 2015 is used. The index of telecommunication is derived from three telecommunication indicators (penetration of connected mobile lines, penetration of connected fixed and C.D.M.A. lines and percentage of population with access to the Internet) in Africa for 2000–2016.

Table 5 shows the average index of telecommunication ranking for selected African countries, from 2000 to 2016 and the rank positions. The results revealed that Libya had the highest average mobile telecommunication index of 91.61 over time, standing at first place in the ranking, followed by Gabon with an average mobile telecommunication index of 87.30, taking second place in the ranking, and South Africa with an average mobile telecommunication index of 85.94, taking third place in the ranking in Africa between 2000–2016.

The fixed line telephone penetration shows that Mauritius had the highest average fixed line telecommunication index of 28.88, ranked at first place, followed by Libya with 14.47, taking second place, and Egypt's fixed line telecommunication index stood at 11.65, taking third place in Africa for the period under study. The average Internet penetration index in Africa between 2000 and 2016, shows that Algeria had average Internet access index of 29.60 and it is the highest in Africa, which made Algeria to stand at the first position in the ranking, while Botswana stood the second position with 24.03 average Internet access index. South Africa stood at third position of average Internet access index with 23.90.

5. Conclusion

The study captured an overview of telecommunication, economic growth and development performance in Africa using a stylised facts analysis. The study covers

Table 5. Telecommunication development index and rank for African countries.

	Mobile telephone subscription		Fixed telephone subscription		Internet access subscription	
Country	Index	Rank	Index	Rank	Index	Rank
Algeria	60.54	8	7.48	7	29.60	1
Angola	31.22	27	0.84	26	7.38	17
Benin	40.67	17	1.23	23	6.12	20
Botswana	82.83	4	7.60	6	24.03	2
Burkina Faso	27.62	32	0.72	30	1.63	37
Burundi	11.87	44	0.30	40	1.17	40
Cameroon	32.27	24	1.92	16	7.62	14
Central African Rep.	12.21	43	0.14	45	1.93	36
Chad	16.13	40	0.23	42	4.15	24
Congo (Dem. Rep.)	17.95	38	0.03	46	0.52	46
Congo (Rep.)	52.24	12	0.40	36	4.89	23
Côte d'Ivoire	51.31	13	1.52	19	10.57	10
Djibouti	13.88	42	1.84	17	2.60	32
Egypt	56.58	9	11.65	3	20.12	4
Equatorial Guinea	33.50	23	1.67	18	4.14	25
Eritrea	2.50	46	0.86	25	10.67	9
Ethiopia	9.90	45	0.81	27	3.36	28
Gabon	87.30	2	2.15	14	6.52	19
Gambia	55.77	10	3.01	11	7.91	13
Ghana	50.73	14	1.23	22	6.03	21
Guinea	28.07	29	0.18	43	1.48	38
Kenya	37.30	20	0.88	24	5.23	22
Lesotho	39.17	18	2.04	15	2.16	35
Liberia	27.84	30	0.18	44	0.96	42
Libya	91.61	1	14.47	2	7.24	18
Madagascar	20.04	37	0.71	31	2.76	29
Malawi	14.03	41	0.75	29	1.08	41
Mali	46.78	15	0.68	32	2.76	30
Mauritius	77.19	5	28.88	1	8.21	11
Morocco	71.11	7	7.17	8	10.94	8
Mozambique	23.37	34	0.37	39	0.78	44
Namibia	54.82	11	6.89	9	17.09	5
Niger	16.14	39	0.37	38	0.93	43
Nigeria	36.01	21	0.60	33	0.70	45
Rwanda	22.92	36	0.28	41	2.18	34
Senegal	44.30	16	2.28	13	4.10	26
Sierra Leone	26.47	33	0.44	35	7.56	15
South Africa	85.94	3	9.53	5	23.90	3
Sudan	31.72	25	1.32	20	15.47	7
Swaziland	38.66	19	3.89	10	7.48	16
Tanzania	29.83	28	0.38	37	1.47	39
Togo	27.75	31	1.25	21	16.71	6
Tunisia	72.57	6	11.12	4	8.01	12
Uganda	23.24	35	0.57	34	2.63	31
Zambia	31.62	26	0.77	28	2.19	33
Zimbabwe	35.03	22	2.45	12	3.43	27

Source: Authors' computations, 2018.

analysis of performance of telecommunication services in Africa, 2000–2016, ranking of telecommunication development index, economic growth performance, economic development, impact of telecommunication on economic growth and development, trends of other macroeconomic indicators, descriptive statistics and partial correlation to substantiate the theoretical and empirical claims of the study.

The C.I.T. penetration (mobile telephone subscriptions, fixed telephone subscriptions and Internet access subscriptions) form the rationale for measuring I.C.T. penetration in this study by using averaging techniques to ascertain the country-specific growth for the period of 2000–2016. The P.C.A. is further explored to derive a single

index for ranking of telecommunication development experience in African countries. The results confirm that Libya, Gabon and South Africa are the most sophisticated in terms of mobile telecommunication development in Africa, but the mobile telecommunication penetration has had more impact on economic growth in South Africa, more than any other African country since it has the highest average real G.D.P. within the period under study. Libya witnessed the highest H.D.I. which translates to a high standard of living within the period in Africa, while Gabon and South Africa also experienced medium H.D.I. which indicate that they also experienced moderate economic development in Africa when compared with other countries in the region.

The penetration of fixed line and Internet access telecommunications are low in most African countries. The fixed line telecommunication penetration is higher in Mauritius, Libya and Egypt respectively, while Internet penetration is higher in Algeria, Botswana and South Africa respectively, within the duration under study in Africa. In totality, the C.I.T.; a measure for I.C.T. penetration has a positive impact on economic growth and development in Africa, though the positive impact is higher in economic growth than economic development as shown by the slope of the curves depicting the relationship existing with I.C.T. penetration, economic growth and development in Africa.

Since the penetration of fixed line and Internet access telecommunication are low in most of the African countries, more investment is needed in fixed line and Internet access telecommunication. This will boost subscription of fixed line and Internet access telecommunication in order to reduce cost of electronic communication and promote the digital economy in Africa.

Notes

1. Please note that this study did not use both 4th industrial revolution and industry 4.0 as equivalents, but rather interchangeably. This is because some call it the 4th industrial revolution, or industry 4.0, but whatever it is called, it represents the combination of cyber-physical systems, the Internet of Things, and the Internet of Systems. In essence, industry 4.0 is the trend towards automation and data exchange in manufacturing technologies and processes which include cyber-physical systems (CPS), the Internet of things (IoT), industrial Internet of things (IIOT), cloud computing, cognitive computing and artificial intelligence (Marr, 2016; Wikipedia, 2020).
2. https://www.britannica.com/event/Industrial-Revolution

Disclosure statement

No potential conflict of interest was reported by the authors.

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