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Speed of Catch-up and Digital Divide: A Study of Three Information Communication Technologies for 44 African Countries.

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Abstract

Information system has been at center of economic development in several developed countries, and as Africa envision to improve its global economic competitiveness it is important to assess penetration rate the digital divide and catch-up effect over the years. This paper examined whether there exists digital divide and if so, is it narrowing over time and whether the ICT is converging with time in the African countries. Three technologies namely mobile-cellular, internet and fixed broadband were used to measure the digital divide and the catch-up effect. Gamma and sigma convergence methodology together with averaged penetration ratios were used to assess the cross-country performance of each technology. This study confirms both the narrowing of digital divide and convergence of ICT in all three technologies for both total group and subgroups. The digital gap was narrowing over time and the low-income countries were catching up faster to the middle-income countries in all three technologies. However, there are marked differences exhibited in the speed of narrowing digital divide and the speed of convergence between the total groups and the subgroups of countries. Some policy implications were discussed in the conclusion and they can be utilized in designing developmental ICT policies in each technology case for individual countries.

Ⅰ. Introduction

The comparative statistics for measuring Information Communication Technology (ICT) access and usage are important to countries for developing policies that promotes economic growth through implementation of the ICTs. ICT is considered a major contributor to the social and economic growth 0f countries (Park et al, 2015; Kyriakidou et al, 2011; UN, 2005; Ford 2011). As ICT use is said to be a major driver of economic development, several studies have concluded that it also works as an indicator of economic inequalities among countries (Park et al, 2015), so as it is the cause of those inequalities (James, 2017). Despite only looking at ICT as a driver of economic development, it is also important for social and human development according to United Nations Development Program (UNDP, 2001), and it is considered a basic human right in the contemporary society (United Nations, 2009).

As ICTs have proved to be at the center stage of economic development in countries and societies, there remain a challenge of inequalities both within and across countries. The disparities in ICT infrastructure, use and skills among groups of people or countries are referred to as digital divide. Digital divide can be measured at country level by assessing disparities which exists within a country, looking at urban and rural differences, and differences amongst other social

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groups in the country. It can also be expressed at a cross-country level where a set of countries or regional groups are compared amongst each other.

The use of ICTs improves productivity in economic activities and enhances social inclusion, hence the presence of digital divide works as an impediment to both economic and social development. The 21st century industries are heavily driven by technology integration, and the success of these innovation driven economic activities is based on more citizens possessing sufficient level of digital capability. A large disparity in digital divide may dampen an economy's competitiveness both regionally and globally. After acknowledging the presence of digital divide amongst the countries and its negative effects to economic development, ITU member states during ITU conference in 2014 resolved to set their efforts on bridging the digital divide and to promote access and use of ICT through a resolution named "Connect 2020"

Convergence of ICT became an interesting area of study to assess how the diffusion is taking place across countries. Previously, (Kyriakidou 2011) studied on the convergence of broadband in European countries, whilst another study comparing the convergence of ICT between the developed and developing countries was conducted by (Billon 2009) and another one focused on convergence ranks of ICT in OECD countries (Ford, 2011). However, a study for African countries as a separate group has not yet been done to assess its progress in terms of ICT development and convergence of digital divide. Hence, the motivation to conduct this study to investigate the convergence of digital divide in African countries using three key ICT indicators mobile-cellular, internet and fixed broadband. In this study we seek to examine whether there exists digital divide in African countries by looking at differences existing between middle-income countries and low-income countries in the beginning years and to test whether it has been reduced over time, and if so how fast.

The analysis of the convergence process of digital divide in this study was conducted by assessing total group of all African countries and subgroups based on income level for mobile-cellular, internet and fixed broadband. Firstly, we measured the average penetration rate of each technology, secondly, we tested the reduction of dispersion of these ICT indicators using sigma (σ) convergence and lastly, we measured for the catch-up process amongst the countries utilising gamma (γ) convergence. After assessing the total group, we categorise the countries into income subgroups using the World Bank categorization. We then similarly measure for the average penetration rate, σ convergence and γ convergence.

II. Research background

Several studies have been conducted to assess the development and drivers of information communication technology within the country and across countries. The other discipline assessed the disparities or digital divide between urban and rural areas within the country (Philip et al, 2017, Prieger, 2013), whilst other researchers focused on a cross-country analysis (Park et al, 2015; Rath 2016, Rice 2016; Kyriakidou, 2011; Ford 2011).

The previous literature implements various statistical techniques and empirical methods in answering the question of digital divide. Other studies used one variable for a specific ICT instrument for example internet, whilst others implemented a composite indicator proposed by International Telecommunication Union (ITU) which considers all the indicators of ICT development focusing on ICT access, use and skills (ITU, 2009).

The speed of convergence of digital divide was previously measured by (Park et al 2015) when they assessed 108 countries to examine the convergence process and further grouped the countries using the Philips and Sul's (2007) log t convergence test to measure the speed of convergence among the subgroups. The 1st group with the highest level of convergence was found to have the slowest speed of convergence whilst the 3rd group with the lowest level of convergence exhibited the highest speed of convergence.

In the study by (Rath, 2016), a convergence analysis of ICT on 47 developed and developing countries showed that there was divergence of ICT among all countries. the study further

grouped countries into groups of aggregate (all countries), developed countries and emerging countries for a comparison of the convergence process. The results found in both subgroups of developed countries and emerging countries were still consistent with a diverging process experienced in the aggregate group.

A study on the club convergence and factors of digital divide across countries by (Park, 2015) also provide similar conclusion to Rath (2016) of divergence. The study analysed total of 108 countries, and furthermore grouped the countries into 3 subgroups using the Phillips and Sul's log t convergence test, group 1, 2 and 3. Interestingly, the findings from the subgroups showed contrasting results which supports that digitization was converging. These finding also contradicted with findings from (Rath, 2011) which exhibited divergence in the subgroups.

In a similar study of measuring the digital divide, (Zhang, 2013) conducted a study of income disparity and digital divide. The study grouped countries into different income groups, OECD high-income, non-OECD high income, upper-middle income, lower middle income and low income to assess technology adoption rates. The study finds less support for convergence, where the catch-up process was only evident in rich countries. The digital gap was only reduced amongst the OECD high income and non-OECD high income, whilst the gap between the OECD high income and other countries was increasing. The overall finding of the study supports the divergence process like the findings from (Rath, 2011).

In the recent study by (Zhang 2017) of 150 countries focusing on patterns and determinants of global divide, the study concluded that gaps of mobile penetration among different groups of income level countries have decreased significantly during the past 23 years. Zhang also grouped countries using income level to assess the performance of the subgroups; the findings of his study shows some contradictions to his early work in 2013. The recent work shows significant reduction of the digital gap in mobile penetration between the counties supporting existence of a convergence process. Despite these contrasting findings, Zhang however confirmed that there still exists a gap between the rich countries and poor countries in-spite of the recent closing of the gap.

(James, 2009) used an interesting method of absolute magnitude to measure digital divide in developing countries using two indicators, mobile-phones and internet. The study assessed the absolute digital divide as opposite to relative divide which he claimed was losing its ground. The results of the research showed that for the total of 60 countries under study there was reduction in digital divide for both mobile phones and internet. However, as the countries were grouped into low income and low-middle income subgroups, the results contradicted the one of total countries as it showed strong increase in digital divide for low income countries in both technologies.

Another perspective in the literature was a comparison of whether the technologies are converging to each other. (Ford, 2011) conducted an analysis of whether broadband internet was converging to the adoption process which occurred in wireline telephone service. The study found out that over time, the rankings of broadband internet was becoming like the ranking of wireline telephone in the OECD countries.

Ⅲ. Research method

For our methodology, we use γ convergence proposed by (Boyle and McCarthy, 1997) and σ convergence (Friedman 1992, Chang 2017). Using coefficient of variation σ enables us to compare the speed of changing dispersion across different dimensions whilst γ convergence measure the changes in ranking order of country performances (Catch-up). The γ convergence use Kendall's binary index version and is defined as follows:

$$\gamma t = [var\ (AR\ (Y)it + AR(Y)io)\ /var\ (2*AR\ (Y)io)] \qquad (1)$$

Where $AR\ (Y)it$ = the actual rank of country i's performance measure in year t, $AR\ (Y)i0$= the actual rank of country i's performance measure in year 0, γt= Binary Gamma Index in year t.

Ⅳ. Results

This study finds the existence of digital divide in all three technologies as shown by differences of penetration ratio between middle-income and low-income groups over the years, but the magnitude of digital divide varied by technology. Firstly, at the beginning, the annual penetration ratio of mobile-cellular for middle-income subgroup of countries was 5.53% versus low-income subgroup countries penetration ratio of 0.48%, which represents a gap of 11.14 times between the two subgroups. The digital gap in 2015 had changed with the middle-income subgroup reaching an annual penetration of 114.95% against a low-income subgroup ratio of 62.99% which represents a digital gap of 1.82 times. The results confirm existence of digital divide in both periods, and that the digital divide has been narrowing over time from an initial difference of 11,14 times in 2000 to a difference of 1.82 times in 2015.

Secondly, the penetration ratio of internet shows similar trend with middle-income subgroup which initially had 1.31% of total population using internet versus low-income subgroup ratio of 0.2% of total population using internet in year 2000, showing an initial digital gap of about 6.55 times between the two subgroups. In 2015 the adoption rate had improved to reach 31.77% of individuals using internet in middle-income subgroup versus a rate of 8.47% in the low-income subgroup which exhibit a gap of 3.75 times. We may conclude that digital gap was present in both periods, and that from year 2000 the digital divide of internet has been narrowing as shown by the narrowing initial gap of 6.55 times to 3.75 times by year 2015.

Thirdly, fixed broadband also exhibits the existence and narrowing of digital divide as shown by the penetration ratio of 0.54% of total population in the middle-income subgroup countries against low-income subgroup countries ratio of 0.03% of total population in the beginning year of 2006, showing an initial gap of 15.62 times. The penetration ratio improved to reach 3.53% in middle-income subgroup against a low-income subgroup ratio of 0.33% at the end of 2015, showing a digital gap of 10.7 times. Both periods show the presence of digital divide amongst the countries but like other technologies confirms the narrowing of the digital divide as explained by an initial gap of 15.62 times which narrowed to 10.7 times between 2006-2015.

In sum, the widest digital divide in the initial period exists in fixed broadband (15.62) followed by mobile-cellular (11.04) and the least in internet (6.44). Based on the changes in penetration ratio over the years, the technology which had the fastest annual narrowing of digital divide is mobile-cellular (-11.3%) followed by fixed broadband (-5.25%) and the least was internet (-3.72%). By 2015 the widest digital divide remained fixed broadband with a digital divide (10.7), but other technologies changed positions, internet (3.76) became second widest and the least was mobile-cellular (1.83). The narrowing patterns of the technologies were distinct for each technology with mobile-cellular having a rapid continuous narrowing pattern, while internet follows a similar pattern of continuous narrowing but at a moderate speed. Fixed broad broadband however had a contrasting pattern which showed an up and down pattern with some stationery speed in some years up to 2011, and a moderate continuous narrowing pattern thereafter.

After measuring the overall digital divide using penetration ratio, we then proceed to convergence analysis for three technologies. Our results from γ convergence analysis shows that catch-up speed by the low-income subgroups was faster than middle-income subgroups in all three technologies. The catch-up speed of mobile-cellular had an annual speed of -1.93% in the low-income subgroup versus an annual speed of -1.04% in the middle-income subgroup. Similarly, internet followed the same trend with a low-income subgroup annual catch-up speed of -2.46% versus a middle-income subgroup speed of -1.33%. Fixed broadband exhibited the fastest γ convergence in the low-income subgroup with an annual speed of -3.32% versus a significantly lower catch-up speed of 0.45% in the middle-income subgroups. In summary, the low-income countries with low penetration ratio have been catching up to the middle-income countries with high penetration rate.

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