

# CONVERGENCE ANALYSIS OF BROADBAND, INTERNET AND INFORMATION FLOW FOR 43 AFRICAN COUNTRIES FOR 1991-2015

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## Abstract

In the field of information technology, broadband, internet and information flow have been found to be the primary elements to indicate access to information in this current information age. We examine whether the country difference in Broadband use, Internet use and information flow existing in 1991 has been reduced and if so how fast. Convergence framework had been utilised to answer these questions for 43 African countries. The results indicated that all the three chosen information technology indicators for 43 African countries are converging toward a reduction of dispersion and a catch-up process during the period 1991-2015. However, there are marked differences exhibited in the convergence processes for the Total groups and for the subgroups of countries by income level.

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## 1. Introduction

There uptake of technology has been a process of diffusion, where we see countries who are economically stable adopting earlier whilst the less economically stable lagging behind. According to (Barro 1995), the interesting insights about growth involve the convergence behaviour along the transition path. Because of diminishing returns to capital, economies grow faster when they start further below their steady-state positions. Thus, if the determinants of the steady-state positions are held fixed, poorer places are predicted to grow faster in per capita terms. In this paper we investigate if this economic theory of convergence can also apply in mobile broadband (Broadband), Internet, and Information flow in African countries.

The purpose of this research is to is to examine whether the country differences existing in the early years such as 2000 for broadband and internet and 1991 for information flow have been reduced and if so how fast has it reduced.

This paper is organized in the following four additional sections. In the second section, the paper will provide background information on convergence methodology and explain methods that will be used. In the third section, we will present data, data sources, and our steps of convergence analysis. Results of our analysis will be discussed in the fourth section. Finally, the conclusion gives us an overview of our findings.

## 2. Method and Data

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## 2.1 Method

The traditional convergence analysis attempts to examine two basis questions. First, do countries initially lagging in such performance measures as “information flow”, “Broadband”, and “internet” tend to improve faster so that they catch up to the performance of leading countries over time? Second, does dispersion of performance measures among countries get reduced over time?  $\gamma$  convergence is used to examine the first question, while  $\sigma$  convergence is used to analyse the second question.

A simple approximation to Quah’s methodology was proposed by Boyle and McCarthy (1997) where they use Kendall’s index of rank concordance (Siegel, 1956) to measure changes in the ordinal ranking of countries over time. They label their method as  $\gamma$  convergence. By using  $\gamma$  convergence with simple measure of  $\sigma$  convergence, they suggest that one can identify the nature of  $\gamma$  convergence and a sense of the dynamics of the cross-country distribution of performance measures.

For our methodology, we use  $\gamma$  convergence (Boyle and McCarthy, 1997) and  $\sigma$  convergence (Friedman, 1992). Common measures of dispersion include the standard deviation or coefficient of variation (Heckelman, 2015). For  $\sigma$  convergence, we have selected to use the coefficient of variation. Using coefficient of variation  $\sigma$  enables us to compare the speed of changing dispersion across different dimensions of performance measures such as “information flow” versus “broadband” or “information flow” versus “internet”.

For  $\gamma$  convergence model, Boyle and McCarthy (1997) and Chang et al. (Forthcoming) suggested the use of Kendall’s index of rank concordance which measures mobility of the individual countries over time within the cross-country distribution of a particular performance measure (Liddle, 2012; Chang et al., forthcoming) In other words,  $\gamma$  convergence measures the degree of changing ranking order of countries between a given year and the initial year. The  $\gamma$  convergence we use is Kendall’s binary index version and is defined as follows:

$$\gamma = [var(AR(Y)_{i,t} + AR(Y)_{i,0}) / var(2 * AR(Y)_{i,0})] - (1)$$

Where  $AR(Y)_{i,t}$  = the actual rank of country  $i$ ’s performance measure in year  $t$

$AR(Y)_{i,0}$  = the actual rank of country  $i$ ’s performance measure in year 0

$\gamma$  = Binary Gamma Index in year  $t$ .

The  $\gamma$  index has the advantage of being of single number traced over time in two-dimension, analogous to the  $\sigma$  convergence index. The value of rank concordance ranges from zero to unity. If no change in rank order takes place, the rank concordance becomes unity. If a catch-up process is present, the index will be less than unity. The statistic is distributed as chi-square and we test the null hypothesis that  $\gamma$  convergence is identical difference between ranks of different years (Siegel, 1956).

According to Legendre (2005), the proper use of X2 test to test statistical significance of Kendall’s coefficient of concordance on yearly  $\gamma$  index requires that the number of countries should be less than 7 and the number of years being compared should be less than 20. In our case, most of our subgroups have the number of countries exceeding 20. Therefore, the use of X2 may not always be appropriate. For this reason, we also ran an alternative test of significance by using t test and Kendall’s Tau B. And t test gave us the significant results.

## 2.2 Data & Source

This paper is focused on the three performance indicators namely information flow, Broadband and Internet to ascertain the level of dispersion and catch-up for all African countries.

Information flow as the first performance indicator show an overview of how information is flowing in the countries in the form of internet use, television use, and trade in newspapers. The total is normalised as a measure of per 1000 people using the internet, television use (per 1000 people) and trade in newspapers (% of GDP), the data is collected for African countries amounting to 42.

The data was accessed from KOF index of Globalisation, database:

([http://globalization.kof.ethz.ch/media/filer\\_public/2014/04/02/globalization\\_index\\_2013.zip](http://globalization.kof.ethz.ch/media/filer_public/2014/04/02/globalization_index_2013.zip)). From a total of 47 African countries appearing in the data set, some countries were eliminated due to incompleteness of the data leading to a

total of 42 African countries being selected to represent Africa. The data set also provided the data which started from as far as the year 1970 but due to irregularities of the data availability throughout the years, the data considered was for the period starting 1991 to 2013 when the data was now consistent for all the considered countries.

Broadband usage, the second performance indicator deals with showing the level of connectedness of the people in a country through the mobile broadband internet. Mobile broadband is the marketing term for wireless Internet access delivered through cellular mobile towers to computers, mobile phones, and other digital devices using portable modems. Although broadband has a technical meaning, wireless-carrier marketing uses the phrase "mobile broadband" as a synonym for mobile Internet access. In this paper, broadband usage is used a measured in terms of mobile-cellular subscriptions per 100 inhabitants. This was done for the 44 African countries.

The data for Broadband usage was collected from ITU statistics website, database: [http://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2017/Mobile\\_cellular\\_2000-2016.xls](http://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2017/Mobile_cellular_2000-2016.xls). From a total of 46 countries which are appearing in the data set, some countries were also eliminated because they had missing data for some years. Out of 46 countries, two countries were removed to remain with 44 African countries selected to represent Africa's broadband usage. The ITU database provide the data from the year 2000 to the year 2015. The data was consistent in terms of availability, throughout the years to the year 2015 which led to the considering of the data for the period 2000 to 2015.

Internet is the last performance indicator responsible for showing the level of internet use in the country. This is looking at internet connectivity using computers. The Internet is a massive network of networks, a networking infrastructure. It connects millions of computers together globally, forming a network in which any computer can communicate with any other computer if they are both connected to the Internet. Internet usage will be measured as a % of people who are connected to the internet in a country. This was done for the 43 African countries.

The data for internet usage was collected from ITU website, database: [http://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2017/Individuals\\_Internet\\_2000-2016.xls](http://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2017/Individuals_Internet_2000-2016.xls). The data set had all world countries which also consist of 45 African countries which

are in context to this research, but some other countries were not selected because they had missing data. Two countries were removed from the data of internet usage to remain with 43 countries which had all the data available throughout the period 2000 to 2015. The ITU database provided data for internet usage for the period 2000 to 2015, and because all the data was consistent in terms of availability all the years were considered.

## 3. Results & Conclusion

### 3.1 Results

The historical pattern of  $\sigma$  and  $\gamma$  indexes for the total group of countries.

#### BROADBAND:

Both the  $\sigma$  and  $\gamma$  indexes for Broadband for the total group of countries shows a declining pattern throughout the period of 2000 to 2015. This indicates that convergence of broadband indexes has taken place.

The rate of decline for the  $\gamma$  index is moderate at a negative CAGR of -0.91%. the yearly  $\gamma$  index declined steadily from 1 in the initial year 2000 to reach 0.87 by year 2015. A comparison of the other respective years to the beginning year 2000 measured by X2 test show statistically significant results for every year at less than 0.1% level.

The rate of decline for  $\sigma$  measures during the period 2000 to 2015 shows a very rapid reduction of dispersion at a negative CAGR of -9.63% which is about 10.7 times faster than  $\gamma$  measures. The difference test of C.V. using t test between respective years in comparison to the beginning year shows statistically significant in many cases. The first five years were not statistically significant but the other years from 2006 to 2015 were statistically significant.

In contrast to  $\sigma$  index,  $\gamma$  index is not declining in a smooth and continuous pattern. Rather the  $\gamma$  index shows a slight increase which starts to appear in the middle of the total period starting from year 2009, where  $\gamma$  index in 2009 was 0.86 to a high 0.89 in 2013 and a slight drop to 0.87 in 2015, with the differences statistically significant. This showed a divergence in the period 2009 to 2013.

#### INTERNET

Both the  $\sigma$  and  $\gamma$  indexes for Internet the total group of

countries shows a declining pattern throughout the period of 2000 to 2015. This indicates that convergence of Internet indexes has taken place.

The rate of decline for the  $\gamma$  index is moderate, a sign of moderate catch-up at a negative CAGR of -1.17%. The yearly index declines from 1 in the year 2000 to 0.84 in 2015. A comparison of year 2000 to the other respective years measured by X2 test shows statistically significant results every year at less than 0.1% level.

The rate of decline for  $\sigma$  measures during the period 2000 to 2015 shows a moderately rapid reduction of dispersion at a negative CAGR of -5.49%. The difference test of C.V. using t test between respective years in comparison to the beginning year does not show statistically significant results in many cases. The only year which indicated statistical significant result is 2014.

In contrast to  $\gamma$  index,  $\sigma$  index is not declining in a continuous pattern. Rather the  $\sigma$  index shows an up and down fluctuation in 2000 to 2006, where in 2000 to 2003 in had a rapid decline where  $\sigma$  index reached 0.71 from 0.99 then a marked increase in 2004 to 0.78, a decline in 2005 to 0.73, an increase in 2006 to 0.75, and from 2007 to 2015 it followed a continuous decline from 0.72 to 0.42. The differences from 2000 to 2013 are however not statistically significant.

#### INFORMATION FLOW

Both the  $\sigma$  and  $\gamma$  indexes for information flow the total group of countries shows a declining pattern throughout the period of 1991 to 2013. This indicates that convergence of information flow indexes has taken place.

The rate of decline for the  $\gamma$  index is moderate, to show moderate catch up at a negative CAGR of -0.61%. The yearly index declines from 1 in the year 1991 to 0.87 in 2015. A comparison of year 1991 to the other respective years measured by X2 test shows statistically significant results every year at less than 0.1% level, as shown in Table3.

The rate of decline for  $\sigma$  measures during the period 1991 to 2013 shows a rapid reduction of dispersion at a negative CAGR of -5.49%. The difference test of C.V. using t test between respective years in comparison to the beginning year shows statistically significant results from the year 2000 to 2013.

The declining pattern of  $\sigma$  index in contrast to  $\gamma$  is not

continuous, but it was rather made of two phases. In the first phase 1991 to 1995,  $\sigma$  index showed no sign of convergence with 0.98, shown in Figure 3, difference of which was not statistically significant. The second phase from 1996 to 2013 shows a sudden cliff where  $\sigma$  index decrease from 0.95 in 1996 to 0.43 in 2013, with the differences showing statistically significant values from 2000 to 2013.

To gain further insights on different convergence patterns we repeated the same  $\sigma$  and  $\gamma$  convergence analysis for the subgroups of the African countries characterised by their level of income, that is Low level and Middle level income.

#### BROADBAND

The middle level countries show results similar with the total group of countries. The  $\sigma$  and  $\gamma$  convergence pattern for Broadband usage shows a very rapid reduction of dispersion. The  $\sigma$  convergence index reached 0.19 by the year 2015 at a negative CAGR of -9.20%. On the other hand, Low level income subgroup  $\sigma$  index also shows rapid reduction of dispersion like middle level income and total group, to reach 0.32 by year 2015 at a negative CAGR of -6.4%.

Both income groups display declining pattern of  $\gamma$  convergence index throughout the period, to show a moderate catch-up process which reach 0.75. The more moderate rate of decline is witnessed in low level income subgroup at a negative CAGR of -1.70% and followed by middle level income subgroup at a negative CAGR of -0.92%. All the X2 test results shows that significant statistical difference exists for each year for each subgroup as indicated in Table2.

In summary, the convergence patterns of all the two subgroups resemble that of the total group with a continuous declining pattern. Both subgroup shows a divergence, low level income subgroup shows a moderate divergence from 2008 to 2009 and a level off from 2010 to 2013. On the other hand, middle income showed the divergence from 2006 to 2015.

#### INTERNET

The middle level income subgroup of Internet showed the most rapid reduction in dispersion with the  $\sigma$  convergence index reaching 0.33 by year 2015 at a negative CAGR of -6.25%. On the other hand, internet usage had a moderate reduction of dispersion which reached 0.63 by year 2015 at a negative CAGR of -2.68. The statistically significant difference test is determined only for 2014 and 2015 in the

high-level income subgroup.

Generally, the convergence patterns of all the two subgroups resemble that of the total group with a continuous declining pattern. However, the initial years of both groups showed some up and down fluctuation where in low level income reached 0.86 in 2003 from 0.95 in 2001, then up to reach 0.99 in 2004, 0.91 by 2007 and 0.86 by 2008 when it started a continuous decline till 2015. Middle level income subgroup had its fluctuation when it reached 0.70 in 2003 from 1.0 in 2001, 0.77 in 2004 to 0.7 in 2005, then 0.73 in 2006 to 0.7 in 2007 where it starts to follow a continuous decline until 2015.

Both income groups display declining pattern of  $\gamma$  convergence index throughout the period, the rate of decline is more rapid in low income subgroup to reach 0.67 at a negative CAGR -2.17%, whilst middle level income shows a moderate catch-up where  $\gamma$  convergence index reached 0.82 at a negative CAGR of -1.17%.

Conclusively, the convergence pattern of the two subgroups also resemble that of the total group exhibiting a continuous declining pattern. The middle level income subgroup shows a moderate divergence from 2008 to 2015, whereas low income subgroup shows a continuous moderate decline from 2000 to 2015.

#### INFORMATION FLOW

The subgroups of Information flow show that the most rapid decline of  $\sigma$  index comes from Low level income at a negative CAGR of -3.78%. Information flow shows a moderately high reduction of dispersion, the  $\sigma$  convergence index reached 0.48 at a negative CAGR of -3.38%.

Both the subgroups show display declining patterns of  $\gamma$  indexes throughout the period. The catch-up process was more rapid in middle level income from 1991 to 2013 at a negative CAGR of -1.40%, whilst low level income has a moderate catch up process where  $\gamma$  convergence index reached 0.74 at a negative CAGR of -1.39%. The X2 test show that significant statistical difference exists for all the years for each subgroup.

In summary the convergence patterns of all two income subgroups resemble that of the total group with a continuous declining pattern. The low-level income subgroup shows three marked phases. The first phase shows a level-off period from 1991 to 1996. The second phase (1996-2001) is a sudden cliff where  $\sigma$  index decrease from 0.99 in 1996 to 0.87 in

2001, with statistical significant values in 2000 and 2001. The third phase (2002-2013) shows a slow continuous decline with statistically significant values. On the other hand, the middle level income shows a continuous moderately rapid decline from 1991 to 2013 with statistically significant values from 2003 to 2013.

### 3.2 Conclusion

Both the sigma and gamma indexes display the pattern of convergence for the total group of countries during the period 2000 to 2015 and 1991 to 2013. The key driving force for rapid sigma convergence is coming from middle level income group especially for Broadband and internet. The gamma convergence is similar for both the middle level and low-level income groups. Combining results total group and income level subgroups provide strong support for the existence of sigma convergence.

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Figure 1. Sigma and Gamma Convergence Index in Broadband for Total groups, 2000-2015

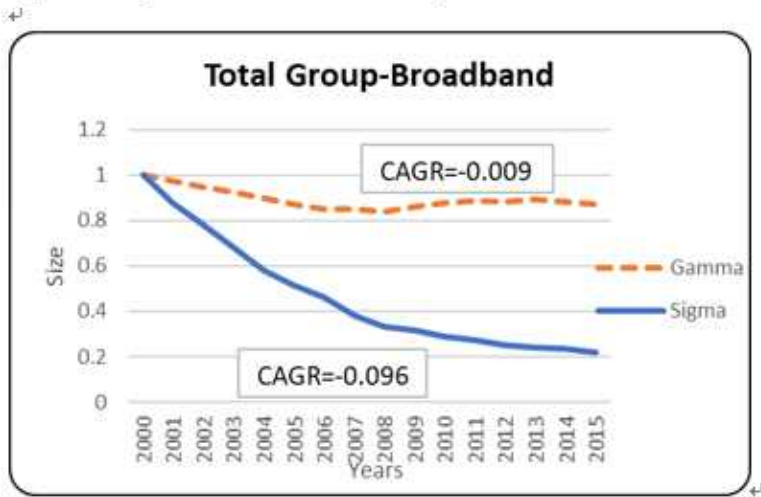


Figure 2. Sigma and Gamma Convergence Index in Internet for Total groups, 2000-2015

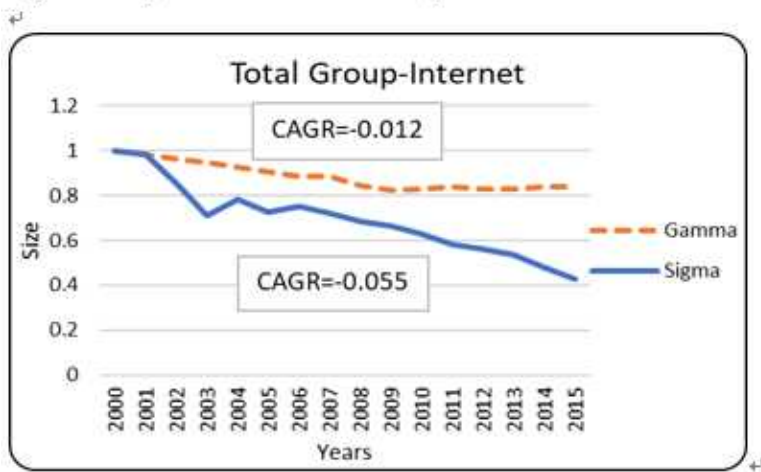


Figure 3. Sigma and Gamma Convergence Index in information flow for Total groups, 1991-2013

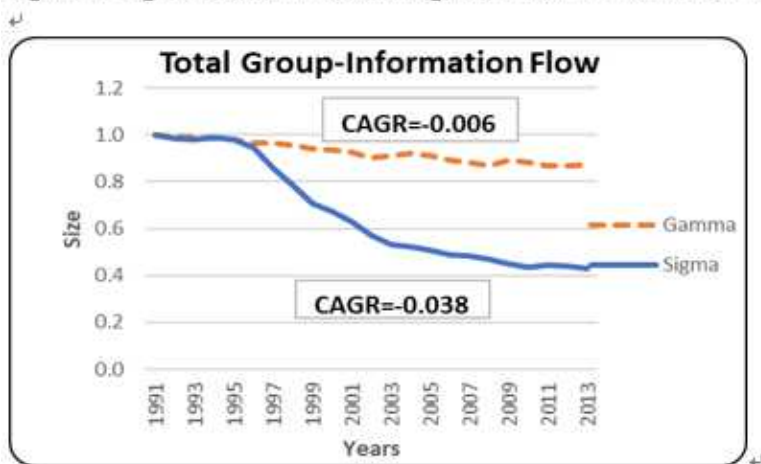


Figure 4. Sigma and Gamma Convergence Index in Broadband for Subgroups, 2000-2015

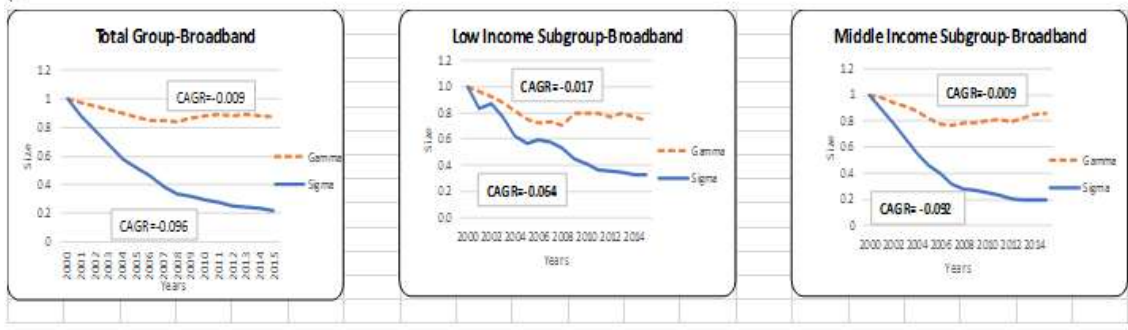


Figure 5. Sigma and Gamma Convergence Index in Internet for Subgroups, 2000-2015

