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The patterns of mobile telephony development in Sub Sahara Africa: A cluster analysis

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THE PATTERNS OF MOBILE TELEPHONY DEVELOPMENT IN SUB SAHARA AFRICA: A CLUSTER ANALYSIS

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Submitted for presentation to **International Telecommunication Society: Bi annual,
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1. Introduction

The wide spread of the ICT's especially mobile phones to different societies over time has proved to be the fastest growing technology ever in human history. The adaptation to the ICT's in societies has proved to create significant economic and social opportunities; though challenges persist as well (Kozma, 2008). For example, mobile networks have succeeded to reduce voice communication gap between developed and developing world; with signals covering 90 percent of the world population and 80 percent of the world rural population (ITU, 2009).

In Africa, mobile telecommunication has played significant role as the only channel that offers telecommunication services, especially voice communication, to the masses. Mobile networks compared to fixed networks; they are characterized with relatively scalable and low investment cost, cheap customer-end devices, and adaptable payment methods. For these reasons, mobile network services are widely accessible, affordable and easily adaptable to the low income populations in developing countries. Though momentous growth has been realized in mobile voice communication; there is evidence of significant developments in advanced telecommunication services such as internet and broadband accessed through mobile phones.

In previous research works on telecommunication development, majority of investigators have directly or indirectly used income criterion; hence aggregating the whole of Africa, or developing world as a unit of study; and sometimes country case studies. General intuition suggests presence of differences in the process and level of the sector development; however, less attention has been paid to understanding the mobile telecommunication development patterns and characteristics that might exist between different countries within the continent, in this case Africa. The continent is made up of 54 countries, with diverse economic and social political situation. Due to the small size of their individual country markets, if some states harness ICTs, and other states do not, then the resulting merits of ICTs for the whole region and individual countries suffers.(US National Telecommunication and Information Administration, 1999)

The main purpose of this study is to compliment previous studies in telecommunication development in Sub Sahara Africa by highlighting specific categories of countries that significantly share similar characteristics in the

development of mobile voice communication. The study intends to answer two questions; first, what are clusters that exist in the mobile communication market in Sub Saharan Africa; and second, how has each cluster behaved during the development of mobile communication in the past decade.

The results will provide the knowledge on existing categories; thus anchor further studies that concentrate on country specific as representative of large area with similar characteristics as well as establishing a benchmark on different aspects according to the variables used in the study. These benchmarks could be used to develop best practices of optimal policy mix for further development of mobile telecommunications. Further, the results are intended to be a foundation for further studies on advanced mobile telecommunication services i.e. internet, broadband and applications in the region.

2. Review of previous studies

An extensive body of empirical studies exists on different facets of telecommunication developments and its impact on economic development, social welfare and other aspects such as environmental issues. This part highlights on main empirical studies that have focused on mobile telephony development in the developing countries, and Africa in particular. The literature review begins with a block of studies that investigate the impact of telecommunication development on economic growth, and vice versa. However, most of these early studies have not included institutional and market reforms; hence, the following sub section of literature review deals with this issue. Further, studies that combined both income and economic status; and institutional arrangement in their assessment are reported. The last part of this literature focuses on studies that have attempted cluster analysis methodology to analyze telecommunication development.

Waverman, Meschi and Fuss (2005), investigated the impact of telecoms in economic growth in developing countries. Using data from African economies, their study indicated strong contribution of telecoms investment in boosting economic growth, especially in developing economies. More specifically, their results showed telecommunications penetration is likely to boost economic growth in developing countries in relatively higher rates than in developed economies; and developing countries are expected to benefit more from mobile telephony than fixed telephony. Though their primary focus was to investigate impact of telecoms economic

development, they also noticed reverse causality effect between economic development and telecoms development since economic growth or high economic status is likely to provide disposable income which can stimulate demand for telecommunication services. According to Michael (2008), who investigated on the role of telecommunication in regional economic development in Africa, the role of telecommunication investment is significant in economic development, however, at a diminishing rate. Compared with the previous noted studies which concentrated on basic modes of telecommunication networks i.e. fixed telephony and mobile telephony; World Bank (2009) extended their definition on telecommunication to include internet and broadband. Their study suggests that penetration of advanced telecommunication services especially internet and broadband, is likely to stimulate economic growth more than basic telecom services (fixed and mobile telephony).

The above studies made considerable contribution to our understanding about the general trend on effect of telecoms development on economic growth, and vice versa; however, they did not capture other factors such as policy choices, and institutional reform that mostly took place in the same duration covered of their analysis. Further, all of these studies attempted to establish general characteristics and trends' covering large number of countries; detailed categorization and differences between these categories were not their focus. The instruments used in these studies especially GDP per capita, mobile phone penetration provide part of tools that will measure telecoms development between countries in this study.

On the other hand, country's institutional arrangements and telecommunication policy determine the expansion, efficiency and penetration of telecom services. Poor institutional organization tends to have detrimental effects in network rollout, adaptation of new technologies, service prices, quality of service and telecommunication penetration in the population (Xi and Lu, 2004). The presence of independent regulator, competition and privatization of the incumbent operators have propensity to support supply of telecom services. For example, UNCTAD (2009) reports that only five countries in Africa which have mobile penetration of less than ten at the end of 2008 were characterized by monopoly service provision or absence of established strategic mobile operator. According to Ros(1999), countries that privatized or allowed major private ownership in their incumbent telecom operator have higher penetration of telecom services. This result was only significant to countries with per-capital GDP below \$10,000; hence significant for

developing economies. These studies used presence of competition, independent regulator and/or privatization as variable to measure institutional and policy effects in the development of telecommunication. Since most of these studies included different data set of countries and their concentration was not exclusively for mobile telecommunication development, it will be interesting to include these variables in this analysis to understand their contribution in mobile telecommunication development patterns in Sub Saharan Africa.

Banerjee and Ros (2004) investigated patterns in global fixed and mobile telecommunication development. They used penetration rates and cumulative annual growth rates (CAGR) for fixed line and mobile penetration; and country's economic level as variable for the analysis. Using data from 61 economies, the results of their study suggest that patterns of development are mainly due to technological substations in developed countries and economic substitution in developing world where mobile telecommunication took a leapfrog advantage due to lack or poorly developed fixed line infrastructure. Further, from their dataset, they were able to produce four cluster presented different categories of economies at deferent levels of mobile and fixed phone penetration; together with policy outlook. Along the same lines, Wang Chonglu (2009) studied fixed-mobile substitution using cluster analysis. He developed the fixed-mobile substitution degree index comprising income (GDP per capita) and voice telecommunication growth rates: cumulative annual growth rate and penetration rate for fixed and mobile; and the ratio of mobile cellular subscription to the fixed lines. The study applied cluster analysis on data from 151 economies. The study was able to categorize their data in five different clusters, each at a certain level of fixed-mobile substitution. The results coincide with our intuition; most developing and under-developed economies have large masses that are still at the middle stage of the fixed-mobile substitution – telecommunication development; which indicates that developing economies have a room to grow in mobile telecommunication.

Both studies provided insight on using cluster analysis method in analyzing trend and patterns in development of telecommunication services, especially fixed and mobile substitution phenomenon. Nevertheless, it is important to note that the issue in developing countries is not merely fixed-mobile substations since fixed-line telecommunication was neither accessible nor usable to the majority who access and use mobile phones. For example, just six countries out of 54 countries in Africa –

Algeria, Egypt, Morocco, Nigeria, South Africa and Tunisia accounts for almost 80 percent of all fixed lines in the continent; most of them in urban area for businesses (Michael, 2008). Most customers experience mobile telephony as their first experience of voice telecommunication service, and this phenomenon is likely to continue to an extended period. Further, institutional arrangement variables that capture the effect of liberalization and privatization policies were not included in both studies.

In this study, focus will be paid to the mobile voice communication development in African economies. Variables that showed significant contribution in previous studies in the relationship between telecommunications development, economic growth and institutional arrangement will be included in cluster analysis. These variables consist of GDP per capita, penetration rate and cumulative growth annual rate for mobile network and country risk rating to account for economical and political situations.. Privatization of incumbent operators will not be included in the study, since most of incumbent operators in Africa tend to be in fixed line which is not the focus of this study. On the other hand, Africa is a continent with over fifty countries, some countries with less than one million populations while others has massive populations; concentration of development in few countries can distort the result of aggregated results. Thus population size of each individual country will be an added variable in the study to capture effect of population size in development of telecommunication among countries.

3. Methodology and Data Analysis

3.1 Data

Data used in this study cover Sub Sahara Region which consists of 46 member countries. The list of countries in Sub Saharan Africa has been adopted according to World Bank categorization. Somalia and South Sudan have been omitted from the analysis due to unavailability of economic data in the former, and inexistence South Sudan as a country during the duration of analyzed data.

Data has been sourced from various international databases such as World Bank for GNI (Gross National Income) per capita; mobile penetration rate and Cumulative Annual Growth rate has been taken and computed from ITU World Telecommunication/ ICT Indicators Database; and Country Risk rating have been adopted from Coface's Country Risk and Economic Research database. Each

variable is explained below:

- ***GNI per capita***: As proved in previous studies (see Waverman et al. (2005), Banerjee, A. et al. (2004)), the level of economic development especially individuals and businesses' income affect the demand for telecommunication services, hence plays an important variable in development of telecommunication service. In this study, Gross National Income (GNI) per capita, Atlas method (current US Dollars) is used. The Atlas method used by World Bank applies a special deflector that accounts for inflation and exchange rates, making it robust for international comparison.
- ***Penetration of mobile telecommunication*** provides the level at which the economy has attained in terms of adopting mobile telecommunication voice services. Those countries with higher penetration rate are considered while some countries have attained saturation, hence they portray a developed market (Banarjee, A et al. (2004), Wang chonglu (2010)). The mobile penetration rate for 2011 has been used in this study.
- ***Cumulative Annual Growth Rate (CAGR) 2003 -2011***: It measures the pace at which a particular country was adding new subscribers between 2003 and 2011. Usually countries with low penetration of mobile services have more room to grow, hence they tend to experience high growth rate which diminishes as the market nears saturation.
- ***Country Risk rating***: acts as a proxy for the institutional performance that determines qualities of institutional performance include rule of law, stable judicial systems, democracy, stable central banks, corruption, and regulatory and policy environment. In this study a COFACE's Country Risk rating has been used. It is a seven level risk assessment tool that ranks countries very low risks as A1 to very high risk as D. To suit the analysis the indicator is given by COFACE which ranges from A1 to C, were changed into number intervals ranging from 1 to 7 as depicted in the table below:

Coface level	Converted level	Description
A1	1	Very Low
A2	2	Low
A3	3	Acceptable
A4	4	Quite Acceptable
B	5	Significant
C	6	High
D	7	Very High

Africa has the large number of fragile states such as Somalia, Sudan and Eritrea (OECD, 2011). These countries are affected conflict hence portraying unstable political and economic conditionings that discourages business environment. Under these conditions two things are possible; first, the governments are weak, hence cannot invest in telecommunications facilities able to cater the demands of the markets at affordable prices; and secondly, the government cannot create sound policies and effectively implement its policies and regulation. Since mobile telecommunication in the continent has been heavily dependent on private sector investments (World Bank, 2012); the role of institutional performance is very important.

A different argument would be to use efficiency of independent regulator as a measure for institutional contribution to telecommunications development. While that option is more desirable, there are difficulties in implementing it for the following reasons. First, by 2011 more than 90 percent of all countries in Africa had established an ‘independent’ regulator. Hence, using a dummy variable indicating presence or absence of an regulatory authority, the most common way used in research, would not explain variation in country’s’ mobile development pattern among countries. Second, there is no a standardized way that measures performance of telecommunications regulators across countries in year to year basis. And third, in this paper is assumed that country’s risk status is more likely to also encompass the regulator performance characterizes, including other features that affect suppliers such as exchange rates, stability of tax regimes and corruption, issues which are usually not measured when assessing regulators performance.

3.2 Primary observation on the data

To gain initial understanding of the data, a primary investigation was conducted to depict any prevailing behaviors that might be portrayed by the data prior to deploying more intensive statistical analysis. At this stage, one variable is chosen then put into researches subjective ranges that differentiate various level of development. At each level basic descriptive statistics are analyzed, followed by changes in the remaining variables at each particular category.

3.2.1 Level of Mobile Penetration

First, mobile penetration rate is investigated in three subjective ranges that portrays low, medium and high levels of mobile development. As the table below

depicts, Sub Sahara Africa region has a wide variation of mobile penetration ranging from 4.5% penetration in Eritrea to 145.7% in Botswana. The same can be seen in the mean of each group, as the mean for countries with high mobile penetration is four times that of the lowest group. Also, as much as there are countries that have forged ahead and achieve high levels of mobile penetration, a considerable number of countries have been left behind, since thirteen countries are still in the lowest group with a mean of 25.1 % mobile penetration.

Other variables have demonstrated interesting features in each category of mobile penetration rate. The mobile penetration level seem to be inversely related to cumulative annual growth rate. Even when Eritrea is omitted from the data, which seems as an outlier as the only country with CAGR above 1 in the period under investigation, still lowest group depicts fastest acceleration growth. This agrees with previous studies (see Banerjee, A. et al. (2004) and Wang Chonglu, X. (2010)). Further, this observation portrays important information; the countries in this group have the lowest subscription base at the beginning of period under investigation, which is 2003. Although their penetration level might still be low, most of the mobile penetration experienced was achieved during the years under analysis.

On the other hand, income seems to vary directly proportional to the level of mobile penetration since wealthy country can easily afford telecommunication services compared to less wealthy countries (see Ros, 1999).

Lastly, the country risk depicts poor institutional performance in the group of countries with low penetration rate. The lowest mobile penetrated group is characterized by highly risk countries, which might be in conflicts or dictatorship states. The level of country risk is very risk, risk and significant for lowest, middle and high mobile penetration groups respectively. Cote d'Ivoire is an exception as the only country with this category with the worst country risk measure, i.e. very risk. However, the telecommunication sector in the country is very competitive with five mobile operators and 2856 HHI¹ value. Looking to the data closely, all countries with penetration beyond saturation, with exception of Gabon, have their rating between quite acceptable and acceptable risk rating, which ensures sound institutional performance including policy and regulation environment.

¹ Herfindahl-Hirschman Index

		Mobile penetration		
		0% - 40%	41% - 80%	81% - 150%
	<i>Actual range</i>	4.5% - 38.3%	40.7 - 79.2	84.8 - 145.7
	<i>No of countries</i>	13	21	12
	<i>Mean</i>	25.1	57.4	105.7
	<i>Median</i>	25.1	56.3	96.4
CAGR (2003 - 2011)	<i>Range</i>	0.32 - 2.96	0.24 - 0.53	0.11 - 0.47
	<i>Mean</i>	0.72	0.4	0.29
GNIpc (2011)	<i>Range</i>	231 - 823	281 - 14540	624 - 11711
	<i>Mean</i>	478.7	2005	5214
Country risk	<i>Range</i>	6 - 7	5 - 7	3 - 7
	<i>Mean</i>	6.7	6.2	4.7

3.2.2 Level of economic development

An attempt to further study the data was conducted by categorizing the countries according to World Bank classification which classifies countries according to their income. The classification ranges from Low Income, Lower-Middle income, Lower-Upper incomes and High income economies. Although it does not differ significantly from one year to another, the actual range of income for each group is calculated and decides each year. For this study, GNI per capita, Atlas Method 2011 was used throughout this analysis. All four categories had countries belong to them with most countries lie in low income economies, although few countries were in high income countries, especially small income island countries and resource-rich economies. The table below shows countries belong to each category.

Low income < \$1025	Low-Middle income \$1025 - \$4035	Low-Upper income \$4036 - \$12475	High Income \$12476>
Benin Burkina Faso Burundi Central Africa Rep. Chad Comoros Congo (Democratic Republic) Eritrea Ethiopia Gambia Guinea Guinea-Bissau Kenya Liberia Madagascar Malawi Mali Mozambique Niger Rwanda Sierra Leone Tanzania Togo Uganda Zimbabwe	Cameroon Cape Verde Congo Cote d'Ivoire Ghana Mauritania Nigeria Sao Tome and Principle Senegal Sudan Swaziland Zambia	Angola Botswana Gabon Mauritius Seychelles South Africa	Equatorial Guinea

Looking to the characteristics of other variables in each income-based category, similar trends can be observed similar to those observed in the previous subsection. Consider the table below that depicts attributes of these income based categories in respect to other variables.

	GNI per capita (2011)			
	Low income < \$1025	Low Middle Income \$1026 - \$4035	Upper Middle Income \$4036 - \$12475	High Income \$12476>
Actual range	\$230 - \$1119	\$1151 - \$3797	\$5148 - \$11711	\$14,540
No	27	11	7	1
Mean	581.2	\$1,987	\$8,401	\$14,540
Mean Penetration	43	72.4	112	59.2
Mean CAGR	0.55	0.37	0.22	0.3
Mean Country Risk	6.3	6	4	7

Since the trends shown by the above table are similar to those depicted from the above section, some rows have been omitted except means of other variables. The low income countries are characterized by 43% as mean mobile penetration, and 72.4% and 112 % for lower-middle income and upper income countries. Similarly, Countries in low income category experienced highest CAGR in the period, and they have less stable institutional environment compared to other categories that incrementally portray lower CAGR and more stable institutional environment.

Equatorial Guinea provides a special case as the only country in Sub Saharan Africa with GNI per capita in high income category; however is it has achieved a modest penetration rate of 59.6% by 2011, with CAGR of 0.3 in the period of eight years from 2003. This discrepancy between economic level and penetration level is likely to be attributed by low level of institutional performance in the country. Although the country has a regulating body, there is only one operator offering all forms of voice communication, restricting competition in the market hence halting penetration of mobile services despite of high demand.

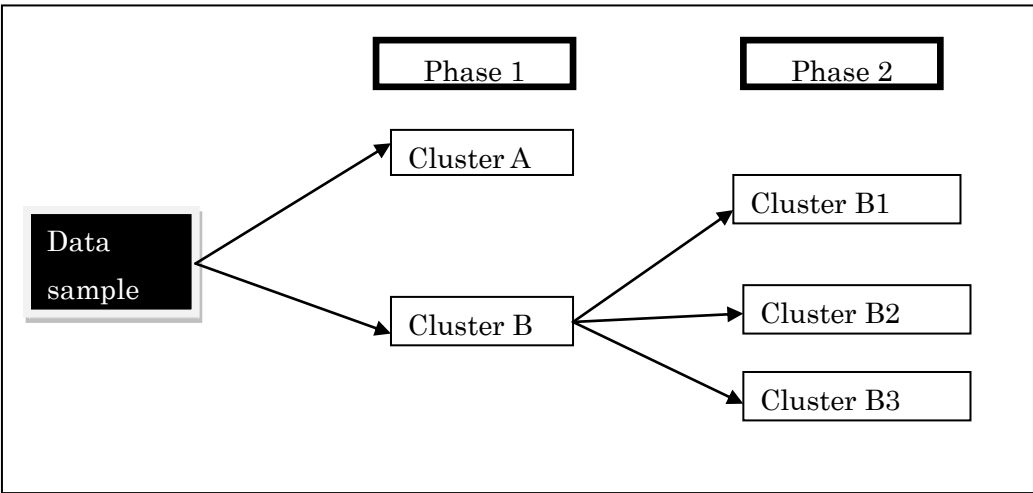
3.3 Cluster Analysis

Cluster analysis method was used to develop group of countries that significantly share similar characteristics based on the four variables described in the previous chapter. As the distinction of Cluster analysis, there is neither dependent nor independent variables; so all variables are equally put in the cluster matrix to

determine meaningful groups of entities, based on the combination of variables, which share similarities among its entities but exhibit high level of differences between various groups.

Hierarchical technique of cluster analysis was adopted as an algorithm for forming clusters among the data. This technique starts by considering each entity as an individual cluster, then move upwards by forming cluster at each step creating group of entities by analyzing combination of their attributes, until one cluster is formed at the end. The procedure followed Ward method applying squared Euclidean Distance as a measure of similarity. Ward’s method calculates the total sum of squared deviations from the mean of a cluster and seeks to reduce the error sum of squares hence achieving very efficient outcomes. Hence this method is considered as one of the most efficient method for cluster formation, especially when the number of cluster has not been decided prior to the analysis, which is the case in this study.

The analysis procedure was taken in two phases. The first phase, cluster analysis was applied in the data sample with all entities used in the study. Two clusters major clusters were formed; cluster A with 11 countries and cluster B with 35 countries. In the second phase, the countries in cluster B were further analyzed for clusters available in the group, the level at which three distinct clusters namely B1, B2, B3 were formed. Note that the level at which to terminate the clustering process depends on the researcher’s subjective understanding on the attributes of particular clusters. In the second phase, three clusters were seen as appropriately explain groups existing in the countries included in second phase. Consider the figure below



Finally, at each phase a secondary investigation was conducted; first, by using Analysis of Variation method the variables were studied to understand which one largely contributed in the resulting categories. At each phase, the variables are analyzed; the ones have lowest mean square errors and consequently high F statistics are considered to have highly contributed to the formation of clusters. Second, each cluster is analyzed to depict characteristics of each cluster, and contribution of variables that affect the resulting clusters.

Results of Cluster Analysis

Phase one and formation of Cluster A and B

The ANOVA table shown in the table below, depict that Mobile penetration, GNI per capita and Country Risk level were the attributes that influenced categorization of the data. Although all have lower values of mean square within groups than between groups, which allow clustering, the role played by CAGR is insignificant.

		Mean Square	F	Sig.
Mobile penetration 2011	Between Groups	12034.911	20.121	.000
	Within Groups	598.129		
CAGR (2003 - 2011)	Between Groups	.241	1.441	.248
	Within Groups	.167		
GNI per capita 2011	Between Groups	4.736E8	276.577	.000
	Within Groups	1712324.425		
Country Risk	Between Groups	12.876	15.423	.000
	Within Groups	.835		

Phase one of clusters analysis results in one big cluster of 26 countries referred to as Cluster B, and the remaining 11 countries, labeled as Cluster A appearing in the lower side of the dendrogram.

Cluster A has different characteristics from majority of most countries in Sub Saharan Africa exhibiting wealthier, most stable and highly penetrated mobile markets. All countries but Cape Verde and Congo, are in Upper Middle income countries or high income countries. The group has average mobile penetration rates of and 98 percent in 2011 as most countries in cluster have attained or are approaching saturation point in mobile penetration. Angola and Equatorial Guinea portray an exception in terms of penetration since as both are have above USD 5000

but are the worst rated economies in terms of institutional performance as high risky economies.

Second phase of cluster analysis and formation of Clusters B1, B2 and B3

Second phase, where cluster analysis was applied in the cluster B countries, three distinct groups emerged. According to ANOVA table, the contribution of Country Risk to categorize data in phase two diminishes, and together with CAGR, they do not contribute to formation of groups in cluster B. As shown in the table below, the level of Mobile penetration rate achieved and economic status remain significant attributes in the clustering process.

		Mean Square	F	Sig.
Mobile penetration 2011	Between Groups	5033.197	12.297	.001
	Within Groups	409.288		
CAGR (2003 - 2011)	Between Groups	.243	1.190	.283
	Within Groups	.204		
GNI per capita 2011	Between Groups	4136778.404	136.423	.000
	Within Groups	30323.171		
Country Risk	Between Groups	.643	1.122	.297
	Within Groups	.573		

Cluster B1: This group consists of countries in lower middle income category with average GNI per capita of USD 1268 and an average penetration of 66.8%. Some countries in this group, in particular Ghana, Cote d'Ivoire and Mauritania have achieved mobile penetration beyond 80 % hence approaching to saturation. In terms of institutional environment, this group has weak condition with an average risk level is 6 interpreted as high risk; however, it has enjoyed considerable CAGR of 0.365

Cluster B2: All countries in this cluster are in low income category with a average GNI per capita of USD 621, making a cluster with the largest number of countries. The penetration of mobile telecommunication is just approaching half of the inhabitants with an average of 47%. This group has showed the highest CARG in the period under investigation, posting 0.59; however its institutional risks is not highly different from the previous cluster, they both exhibit high risk, with an average of 6.3 risk level. In this group, Benin, Gambia and Zimbabwe have demonstrated highest levels of mobile penetration beyond 70 %; on the other hand

Eritrea has the lowest country with mobile penetration in the whole sample data.

Cluster B3: This cluster has seven countries which are characterized with the lowest GNI per capita below USD 375, as well as the lowest average mobile penetration rate of 27.3 %. Despite low penetration rates, the cluster has depicted high CAGR of 0.5 on average, although it has not grown as fast as cluster B2. The institutional performance is these countries are the poorest, with average of 6.6, which is close to very risk situation. These results portray that, although there is a plenty of room for growth of mobile telecommunications, demand might be too weak for mobile services.

4.0 Discussions

From this study, some lessons can be drawn in regard to development of telecommunication markets in developing countries, particularly Sub Saharan Africa in particular digital divide, strengthening of institutional environment and opportunity for African regulators to learn from each others.

Digital divide is very apparent in the Sub Saharan Region. Although broad observation would show that in aggregate terms Sub Saharan Africa is catching up in terms of mobile telecommunication; there exists wide variation among countries in the region. As shown in the analysis, countries in Cluster A which consist about quarter of all countries in the region have achieved telecommunication mobile penetration levels closer to saturation, while countries in cluster B3 and some in cluster B2 have very low penetration rate below 30%. By aggregating the whole region, researchers might overlook some countries such as Burundi in which despite of establishment of telecom regulator and allowing competition in her mobile market which has four operators, mobile penetration was still below 20 percent by 2011.

On the other hand, the study have also exposed countries which have out perform their peers in with similar institutional risks or economic level, hence sets as a benchmark and offer learning opportunities from best practices from within the region. For example, Despite of Liberia being one of the poorest country with one but lowest GNI per capita of 281.2 and been rated as a very high risk country for investors, the country has achieved 49.2 percent of mobile penetration which is almost similar with the region penetration rate. Intuitively, there are policy lessons

that can be drawn on how to promote development of mobile telephony in the least developing countries. Similar situations have been demonstrated by Ghana, Cote d'Ivoire, Benin and Gambia. Hence, African regulators can learn from regulator from Africa, sharing almost similar economic and institutional conditions.

5.0 Conclusions

The results from this analysis have agreed to other previous researches on the significance of country's wealth of its citizen as an important attribute to the development of telecommunication services, and mobile telecommunication in particular. In terms of commutative annual growth rate, although some trends were seen in the primary analysis, its contribution in formation of clusters were rather weak, suggesting that the countries in this analysis grew significantly during the nine years under study, and its variation is either inconsistent among clusters, or it grew almost the same across countries in the analysis period. Lastly, the measure of country risk seems to play an important role in defining mobile telecommunications development, at least in the first phase. The drop of its significance in the second phase cluster analysis might be attributed to invariability among countries since almost all countries were rated at high risk and very high risk across countries cluster B1, B2 and B3

APPENDIX I: Cluster Results Table

	Country Name	Mobile penetration 2011	CAGR (2003 - 2011)	GNI per capita 2011	Country Risk Level
Cluster A	Angola	48.38	0.442943	5147.711	6
	Botswana	142.82	0.231561	8680.313	4
	Cape Verde	79.19	0.24965	3797.829	5
	Congo	93.84	0.315176	3562.542	6
	Equatorial Guinea	59.15	0.295309	14540	7
	Gabon	117.32	0.220285	11113.89	5
	Mauritius	99.04	0.121142	8797.05	3
	Namibia	104.96	0.304052	5292.891	3
	Seychelles	145.71	0.113543	11711.47	4
	South Africa	126.83	0.159763	8070.032	3
	Swaziland	63.7	0.276803	3725.281	5
	MEAN	98.26727	0.2482	7676.27	4.63636
Cluster B1	Nigeria	58.58	0.460401	1452.095	7
	Sao Tome and Principe	68.26	0.422651	1473.285	6
	Zambia	60.59	0.479077	1425.311	6
	Ghana	84.78	0.439895	1570.133	5
	Cameroon	52.35	0.287729	1271.313	6
	Sudan	56.25	0.536109	1234.471	7
	Lesotho	47.91	0.265838	1105.913	6
	Senegal	73.25	0.317415	1119.357	5
	Lesotho	47.91	0.265838	1105.913	6
	Senegal	73.25	0.317415	1119.357	5
	Cote d'Ivoire	86.42	0.336429	1194.599	7
	Mauritania	92.71	0.282027	1150.82	6
	MEAN	66.855	0.36757	1268.55	6
Cluster B2	Chad	31.8	0.565246	823.0224	7
	Comoros	28.71	0.682797	809.2311	7
	Benin	85.33	0.474166	801.6405	4
	Kenya	64.84	0.369635	808.0006	6

	Zimbabwe	72.13	0.431859	776.2041	7
	Mozambique	32.83	0.378944	534.8061	6
	Tanzania	55.53	0.332197	528.555	5
	Guinea	44.02	0.508126	501.9877	7
	Uganda	48.38	0.088842	487.1055	6
	Central African Rep.	25.04	0.448606	482.7161	7
	Eritrea	4.47	2.96451	481.7323	7
	Madagascar	38.28	0.452432	466.6635	6
	Gambia	89.02	0.299794	624.5733	6
	Mali	68.32	0.521799	668.5754	7
	Rwanda	40.68	0.479732	582.787	7
	Togo	50.45	0.326829	584.0168	6
	Burkina Faso	45.27	0.471082	600.3834	6
	Guinea-Bissau	22.88	0.89505	629.2108	7
	MEAN	47.11	0.59398	621.734	6.33333
Cluster B3	Malawi	25.07	0.451151	370.6147	7
	Niger	27.01	0.553474	374.4454	6
	Ethiopia	16.67	0.866724	374.2152	6
	Sierra Leone	35.63	0.386013	373.9835	6
	Burundi	14.46	0.390039	271.245	7
	Liberia	49.17	0.518632	281.211	7
	Congo (Democratic Republic of the)	23.13	0.32487	230.8559	7
	MEAN	27.30571	0.4987	325.224	6.57143

REFERENCES

- Benerjee, Anuruddha and Agustin J. Ros, "Pattern in global and mobile telecommunications development: a cluster analysis", Telecommunication Policy (2004)
- Carsten Fink, Aaditya Mattoo, and Randeep Rathindran, "An Assessment of Telecommunication Reforms in Developing Countries", World Bank Policy Research Working Paper 2909 (2002)
- Enowbi Butuo Michael, "The Role of Telecommunication Infrastructure in the Regional Economic Growth of Africa" MPRA Paper, 2008
- H. Charles Romesburg, Cluster Analysis for Researchers, North Carolina: Lulu Press, 2004
- Koutroumpis, P. (2009), "Broadband Infrastructure and Economic Growth: A Simultaneous Approach" Telecommunications Policy, 33(9)
- Kozma Robert, (2008) 'ICT, Education Reform, and Economic Growth: A Conceptual Framework'
- Ros, Augustin J. "Does Ownership or Competition Matter? The Effects of Telecommunication Reforms on Network Expansion and Efficiency", Journal of Regulatory Economics.(1999)
- UNCTAD, 2008, Information Economy report 2007 – 2008; Science and technology for development: the new paradigm of ICT
- Wang chonglu; Xin Zhan Hong; , "Study on Fixed-Mobile Substitution of Global Voice Market," *Management and Service Science (MASS)*, 2010 *International Conference on* , vol., no., pp.1-11, 24-26 Aug. 2010
doi: 10.1109/ICMSS.2010.5577487
URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5577487&isnumber=5575325>
- Waverman, Leonard; Meschi, Meloria and Fuss, Melvyn, "The Impact of Telecoms of

Economics Growth in Developing Countries” Vodafone Policy Paper Series, No. 2, 2005, pp. 10 – 24