MOBILE TELEPHONY ACCESS AND USAGE IN AFRICA

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ABSTRACT: This paper uses data from nationally representative household surveys conducted in 17 African countries to analyse mobile adoption and usage. The paper shows that countries differ in their levels of ICT adoption and usage and also in factors that influence adoption and usage. Income and education vastly enhance mobile adoption but gender, age and membership of social networks have little impact. Income is the main explanatory variable for usage. In terms of mobile expenditure the study also finds linkages to fixed-line, work and public phone usages. These linkages need, however, to be explored in more detail in future. Mobile expenditure is inelastic with respect to income, ie the proportion of mobile expenditure to individual income increases less than 1% for each 1% increase in income. This indicates that people with higher income spend a smaller proportion of their income on mobile expenditure compared to those with less income.

The study provides tools to identify policy intervention to improve ICT take-up and usage and defines universal service obligations based on income and monthly usage costs. It helps to put a number to what can be expected from lower access and usage costs in terms of market volume and number of new subscribers. Linking this to other economic data such as national household income and expenditure surveys and GDP calculation would allow forecast of the economic and social impact of policy interventions.

Key policy interventions would be regulatory measures to decrease access and usage costs, rural electrification and policies to increase ICT skills of pupils and teachers.

Keywords: ICT, Mobile access, Mobile usage, Income elasticity estimation, Gender.

Introduction

The information, telecommunication and broadcasting sector is increasingly integrated into the day to day activities of businesses and lives of households and individuals worldwide. Numerous studies have shown that ICTs contribute to economic growth, employment and social inclusion. It is therefore important that policymakers monitor progress towards access and usage of ICTs. A paper by Roller and Waverman (2001) suggests that the spread of modern fixed-line networks in OECD countries was responsible for one-third of output growth between 1970 and 1990. The importance of ICTs for economic growth is further supported by studies from Jalava & Pohjola (2002), Oliner & Sichel (2000), Pohjola (2001), Niininen (2001), Sichel (1997), Jorgenson *et al* (2005), OECD (2003) and UNCTAD (2006). Waverman *et al* (2005) investigate the role of mobile phones in developing economies and find that they are playing the same crucial role that fixed telephony played in developed economies in the 1970s and 1980s. Their study covered 38 developing countries for the period 1996 to 2003 and provides evidence of the strong impact of mobile in developing countries.

1 Matthias Stork wrote his Master's thesis about the RIA household survey with the topic Estimating Demand Elasticities: Using Revealed and Stated Preferences Techniques. The Master's thesis was submitted at the University of Heidelberg, Germany in partial fulfilment for the MA Geography.

Table 1: ICT densities in 2007

	Internet users per 100 inhabitants	Main (fixed) telephone lines per 100 inhabitants	Mobile cellular telephone subscribers per 100 inhabitants
Sub-Saharan Africa	6.47	3.17	26.77
Low Income	6.04	5.87	24.06
Lower Middle Income	15.69	15.23	50.99
Upper Middle Income	31.48	21.01	86.18
High Income Countries	54.78	43.85	112.42
Benin	1.66	1.22	20.98
Botswana	4.25	7.28	75.84
Burkina Faso[2]	0.59	0.70	10.90
Cameroon[3]	2.23	0.79	24.45
Côte d'Ivoire[4]	1.63	1.41	36.60
Ethiopia	0.35	1.06	1.45
Ghana	2.77	1.60	32.39
Kenya	7.99	0.71	30.48
Mozambique[5]	0.93	0.33	15.42
Namibia	4.87	6.66	38.58
Nigeria	6.75	1.07	27.28
Rwanda[6]	1.08	0.24	6.53
Senegal	6.62	2.17	33.31
South Africa	8.16	9.56	87.08
Tanzania	0.99	0.58	20.40
Uganda	6.48	0.53	13.58
Zambia	4.19	0.77	22.14

Source: ITU database 2008

Country level data reveal a global digital divide between continents and countries but also within countries (Baliamoune-Lutz, 2003). Table 1 displays the difference between low, lower-middle, upper-middle and high-income countries for Internet, fixed-line and mobile density. It also displays the same information for countries covered by these studies and the sub-Saharan Africa (SSA) averages. The SSA average for Internet users and fixed-line users is lower than the low income average. It can also be seen from Table 1 that several countries from this 16-country sample are below the low income and SSA averages. Countries have a much lower ICT density compared to the low-income average. Table 2 and 3 document the digital divide within countries for access to fixed telephony in urban compared with rural areas and knowledge about and usage of the Internet across disposable income quartiles.

2 Internet and main fixed line data from 2006
3 Internet and main fixed line data from 2006
4 Internet and main fixed line data from 2006
5 Main fixed line data from 2006
6 Internet data from 2006

TABLE 2: URBAN VS RURAL FIXED-LINE ACCESS

Households with working fixed-line phones	National	Major Urban	Other Urban	Rural
Rwanda	0.10%	1.20%	0.00%	0.00%
Uganda	0.30%	1.60%	2.00%	0.00%
Tanzania	0.90%	2.80%	2.50%	0.20%
Mozambique	1.70%	7.30%	1.30%	0.00%
Cameroon	1.80%	3.50%	3.50%	0.00%
Kenya	2.30%	11.40%	0.90%	1.40%
Ghana	2.60%	6.30%	4.60%	0.30%
Nigeria*	2.70%	9.70%	5.70%	1.20%
Benin	4.60%	15.50%	6.80%	0.60%
Burkina Faso	4.70%	18.30%	16.70%	0.30%
Côte d'Ivoire	4.80%	10.80%	7.10%	1.30%
Ethiopia	7.60%	46.00%	22.70%	2.90%
Botswana	11.00%	7.80%	17.00%	8.70%
Senegal	11.70%	21.50%	19.20%	0.60%
Namibia	17.40%	34.10%	29.60%	7.90%
South Africa	18.20%	38.90%	18.50%	2.10%
Zambia*	2.44%	5.20%	7.55%	0.00%

Source: RIA 2007/2008 household survey

Bagchi & Udo (2007) state that African countries are not experiencing the benefits from ICT that are being experienced by OECD nations and lag severely behind even global averages in ICT adoption, in particular in investment-intensive infrastructure such as fixed-line telephony and broadband Internet access.[7]

McCormick & Onjala (2007) list the following reasons for the low level of ICT access and usage in Africa:

- weak telecommunications infrastructure;
- generally low level of economic activity;
- irregular or non-existent electricity supplies; and
- lack of human resource capacity, lack of skills and brain drain.

7 See also Sciadas (2003)

TABLE 3: ICT KNOWLEDGE AND USE, AND MOBILE ACCESS ACROSS DISPOSABLE INCOME CATEGORIES

	16+ knowing what the Internet is		16+ using the Internet		Owning a mobile phone or active SIM card	
	Lower three income quartile in ppp terms	Top disposable income quartile in ppp terms	Lower three income quartile in ppp terms	Top disposable income quartile in ppp terms	Lower three income quartile in ppp terms	Top disposable income quartile in ppp terms
Benin	17%	33%	6%	16%	17%	63%
Botswana	14%	52%	2%	19%	53%	83%
Burkina Faso	6%	17%	2%	10%	19%	50%
Cameroon	35%	54%	10%	25%	28%	74%
Côte d'Ivoire	12%	31%	4%	14%	33%	63%
Ethiopia	6%	18%	0%	3%	1%	11%
Ghana	26%	27%	5%	8%	53%	79%
Kenya	25%	52%	9%	32%	42%	79%
Mozambique	2%	10%	1%	3%	20%	49%
Namibia	16%	60%	4%	25%	37%	86%
Nigeria	35%	52%	10%	22%	74%	93%
Rwanda	4%	13%	1%	4%	4%	26%
Senegal	37%	71%	9%	14%	29%	77%
South Africa	42%	75%	7%	38%	54%	84%
Tanzania	6%	16%	1%	4%	14%	46%
Uganda	4%	15%	1%	7%	12%	46%
Zambia	39%	60%	1%	13%	36%	84%

Source: RIA 2007/2008 household survey

The results from the researchICTafrica.net (RIA) household survey, however, shows that the monthly cost of telecommunication services is the main reason behind low levels of access and usage.

The great potential of ICTs as catalysts of social and economic development is clearly recognised in continental discourses of agencies such as NEPAD, economic regional association strategies and in national policies. ICT dissemination and adoption in developing countries facilitates the achievement of major development goals in the areas of health, education, governance and others. People in developing countries need easier and cheaper access to ICTs. They need enhanced ICT skills to better employ these technologies in their homes, schools and jobs. Policies and strategies that have been adopted, however, have not been successful in addressing the question of how African countries can catch up with global levels of ICT access and usage and how the poor can join the newly developing information societies. For this it is important to understand the factors that lead to adoption of ICTs by households and individuals. It is also important to understand what factors other than income impact on usage once households or individuals have adopted ICTs.

Data and descriptive statistics

The data used for this study stem from surveys conducted by ResearchICTAfrica (RIA[8] in 17 African countries during the end of 2007 and the beginning of 2008.[9] The data is nationally[10] representative on a household level and for individuals 16 years of age or older. The survey was stratified into metropolitan, other urban and rural areas. Enumerator areas (EAs) were sampled for each stratum using probability proportional to size (pps). The individual to be selected for each household was randomly selected from all household members and visitors who stayed at the home on the night the household was visited and who were 16 years of age or older.

The RIA questionnaire was divided into three sections. The first part, the household roster, collected information about all household members. The second part collected household-related information. The head of the household, or someone who manages the household, answered parts one and two. The third part, the individual section, was answered by a randomly selected individual 16 years of age or older, who slept in the house the night of the interview, and included household members and visitors.

A household constitutes a person or group of persons, irrespective of whether related or not, who normally live together in the same housing unit or group of housing units, have common cooking arrangements and share financial resources. Maids, guards and babysitters who live with a family are part of the household. A head of a household is a person who economically supports or manages the household, or for reasons of age or respect is considered by members of the household as head, or declares himself or herself to be head of a household.

8 Research ICT Africa (RIA) is a network of universities and research institutions from 19 African countries hosted at The EDGE institute, Johannesburg, South Africa. For more information see www.researchICTafrica.net.

9 These are Benin, Botswana, Burkina Faso, Cameroun, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Uganda and Zambia. The data for Zambia are not included in this analysis since that data had not been weighted by the time of submission of this article.

10 The data for Zambia and Nigeria are national extrapolations but not nationally representative. In Zambia the selection probabilities had to be estimated since enumerator ID information was not unique. In Nigeria the sample was drawn only from 6 of 36 provinces.

Table 4: RIA 2007/2008 household survey sample

	Major Urban	Other Urban	Rural	Total
Benin	432	336	333	1.101
Botswana	348	241	229	818
Burkina Faso	416	329	332	1.077
Cameroon	490	347	398	1.235
Côte d'Ivoire	502	312	298	1.112
Ethiopia	1.173	631	551	2.355
Ghana	473	324	295	1.092
Kenya	472	557	432	1.461
Mozambique	562	312	257	1.131
Namibia	311	294	280	885
Nigeria	895	1.012	844	2.751
Rwanda	415	333	330	1.078
Senegal	432	312	337	1.081
South Africa	779	465	527	1.771
Tanzania	634	393	463	1.490
Uganda	436	347	344	1.127
Zambia	405	212	264	881
Total	9.175	6.757	6.514	22.446

Stated and Revealed preferences

The RIA household survey collected information from mobile users about their monthly expenditure, but also from non-users about their willingness and ability (WTP) to spend on mobile telephony. The first is known as revealed and the latter as stated preferences. WTP measures are widely used to provide information to policymakers regarding the economic value of non-market, non-pecuniary or environmental goods. For stated preferences, no behavioural changes can be observed; the individuals only state that they intend to behave in that particular fashion. (Adamowicz *et al*, 1994).

The payment ladder method with exponentially distributed amounts was used to infer the willingness and ability to pay for mobile services of non-users. The payment card was first used by Mitchell & Carson (1984). The payment ladder is a kind of payment card which lists WTP values from low to high. Enumerators read the values to the respondent, starting at the top of the list and moving down. They asked until three values were answered with no. If the respondents were almost certain about their willingness and ability to pay a monetary value then a tick (√) was placed in the space next to that amount. If the respondents were not sure about an amount then it was simply left blank. If the respondents were almost certain that an amount was too high then a cross (x) was placed next to the amount. Three crosses (NOs) were required to complete the question to assure that no intransitivities occurred. The highest amount the respondent was willing and able to pay and the lowest amount the respondent was neither willing nor able to pay was captured. The difference between these two values is the range of uncertainty. (Bann, 1999). Having two points increases the chance of eliciting the respondents' actual willingness to pay. The payment ladder avoids starting point bias and

reduces the number of outliners (Bateman, 2002). To avoid range and centring biases[11] the payment ladder was based on exponential value increment, as suggested by Row *et al* (1996). This approach has three major advantages.

First, the scale is consistent with the hypothesis of increasing measurement error with increasing value. For instance, a person might value a cup of coffee in a café at US$2 plus minus US$0.20, but a vacation at US$2 000 plus minus US$200. Secondly, according to Row *et al* (1996) there exists evidence that measurement errors in values obtained in contingent valuation studies have a log-normal distribution and that a logarithmic transformation of the WTP data addresses the increasing measurement error in hypothetical WTP data. Therefore the exponential payment ladder can be seen consistent with the error distribution of WTP values. The third argument Row *et al* (1996) put forward refers to the concept of "just noticeable" differences and they use the example of light sources to explain this. A source of light has a brightness B. The difference between two such sources is "just noticeable" if the difference can be detected 75% of the time. When bringing these sources into a sequence arranged in order of increasing brightness B1, B2, …, Bn, so that each source is "just noticeable" from the preceding one, then the relationship each to the other is given by Weber's law:

$$B_n - B_{n-1} = k.B_{n-1} \qquad (1)$$

where k is a positive constant. Hence the "just noticeable" differences are increasing proportionally to the sequence of sources and can also been written by exponential function:

$$B_n = B_1.(1+k)^{n-1} \qquad (2)$$

The value of k can be seen as a percentage increase between adjacent scale values. The survey used 28 values, starting with a zero (not interested at all) and ending with an empty cell for amounts higher than listed. Equation (2) was used to compute the 2nd amount to the 27th amount. K was selected so that (1 + k)n-1 equals the highest value on the list.[12]

Mobile Adoption / Access

This section analyses factors that contribute to the probability of an individual to adopting mobile telephony, ie either owning a mobile phone or active SIM card. The dependant variable is dichotomous and using linear regression models would not be appropriate.[13] Probit models are being used instead, assuming normal distributed error terms. The assumption about the error term is arbitrary and its validity cannot be tested.[14] A model can only be identified once an assumption is imposed on the mean and variance of the error term. This implies that coefficients cannot be interpreted directly since they are influenced by the necessary assumptions. Changing the assumptions about the error term changes the values of the coefficients uniformly (Long, 2006). But it does not affect the probability of an event occurring[15]. It affects the spread of the distribution but not the proportion of the distribution above or below the threshold uniformly (Long, 2006).

The decision to adopt mobile telephony is the result of several factors that cannot be observed and that will be different for each individual. What can be observed is whether an

11 See Venkatachalam (2004) and Row *et al* (1996).

12 For example, with n = 24 cells which have to be computed and $1000 the highest value, the equation would be given by 1000 = (1 + 0,35)23

13 See for example Maddala (1983) and Gourieroux (1986)

14 For a more detailed discussion on this assumption see Long (1997).

15 See Long (2007) pp 49-50 for a proof

individual has a mobile phone or active SIM card (Mobile=1) or not (Mobile=0). One individual might neither be able to afford nor be interested in a mobile phone while another might be close to acquiring one and still saving money towards it. For both individuals it can only be observed that they do not have a mobile phone, ie Mobile=0. The process leading to that decision is unobserved and referred to a latent variable. Probit or Logit models tie observable (independent variables) to the latent variable through contributions to the probability of the latent variable taking a value above or below a threshold that would lead to the observable outcome, adoption or not. Many factors are considered in the economic literature as influencing the latent variable,[16] such as socio-economic factors (social networks, income, prices, household size, education, age and gender) and environmental factors (infrastructures, enumerator area, country's characteristics).

Piccoli *et al* (2001) established that the education level of an individual influences ICT adoption and usage, through influencing an individual's capability to use technology. The theory of technology use also points to age as a factor that influences when and how an individual uses technologies. Some studies indicate that age is a key factor in the use of technology, with younger people tending to exhibit higher use levels. Consequently, these individuals tend to use ICT technologies more than older users.

Gender and technology studies have found that men and women adopt and use technology differently. (Gefen & Straub, 1997; Venkatesh & Morris, 2000). Men's decisions to use technology are more strongly influenced by their perception of usefulness, while women's decisions are based more on perceptions of the technology's ease of use. (Venkatesh & Morris, 2000). Further, men and women may view the same mode of communication differently.[17]

16 See for example: Kwapong (2007) Fabiani *et al* (2005), Bagchi & Udo (2007), Kabbar & Crump (2006)

17 See Gefen & Straub (1997); Ono (2003)

TABLE 5: PROBIT MODEL SPECIFICATION

Variable	Variable Name	Type of Variable	Expected sign	Comment
Dependent Variable	Mobile (M)	Dichotomous variable: Individual has a mobile or active SIM card = 1, 0 otherwise	NA	
Independent Variables	Income (I)	Continuous variable: Individual income in US$ based on end of year nominal exchange rates (source IMF)	Positive	Income is assumed to be the main barrier to adoption
	Gender (G)	Dichotomous variable: female = 1, male = 0	Not significant	The assumption is that there is no gender difference when it comes to mobile adoption
	Age (A)	In years	Negative	Technology being a domain for the younger generation
	Tertiary (T) Secondary (S) Primary (P) Vocational (V)	Dichotomous variable: highest education being tertiary = 1, otherwise 0 Dichotomous variable: highest education being secondary = 1, otherwise 0 Dichotomous variable: highest education being primary, remedial or traditional =1, otherwise 0 Dichotomous variable: highest education being vocational =1, otherwise 0	Positive	Education should enable individuals to use mobile phones, while also being an indicator for income, model would drop variables if multi-collinearity persists
	Rural (R)	Dichotomous variable: rural = 1, urban =0	Negative	Mobile network coverage is less in rural areas compared to urban (major urban and other urban) ones and less adoption is therefore expected
	Social Network (SN)	Dichotomous variable: social network (as church groups, sports clubs etc.) membership = 1, otherwise 0	Positive	Membership in social networks might increase communication need
	Constant (C)	Captures various factors that are either constant for a country, such as the price for mobile or fixed telephony, or that serve as reference for dichotomous variables such as the educational variables and rural-urban location.	Negative	Captures no education, but also urban

Table 5 displays the Probit model configuration and Table 6 details the results for each country. Table 6 provides summary results without reporting coefficients, showing for each of the independent variables whether their impact on the probability of mobile adoption is significant and whether it is positive or negative.[18]

18 The detailed results can be found in the appendix.

Table 6: Nationally representative Probit results for each country using sampling weights

Country	Pseudo R2	Prob > chi2	Positive Coefficients + = significant at 0.1 level, ++ = significant at 0.05 level,+++ = significant at 0.01 level Negative Coefficients - = significant at 0.1 level, — = significant at 0.05 level, —- = significant at 0.01 level									
			I	A	G	T	S	P	V	R	SN	Constant
Benin	0.396	0.00	+++	++	No	+++	+++	+++	+++	—-	No	—-
Botswana	0.16	0.00	+	No	No	++	+++	No	Skip	—	+++	No
Burkina Faso	0.253	0.00	+++	—-	—-	+++	+++	+++	Skip	—-	No	No
Cameroon	0.258	0.00	+++	++	No	+++	+++	+++	++	—-	++	—-
Côte d'Ivoire	0.292	0.00	+++	—	No	+++	+++	No	+++	—-	+++	No
Ethiopia	0.452	0.00	+++	No	No	+++	++	No	+++	—-	No	—-
Ghana	0.158	0.00	No	-	No	+++	+++	+++	++	—-	++	No
Kenya	0.258	0.00	+++	No	No	+++	+++	.++	+++	No	++	—-
Mozambique	0.214	0.00	+++	No	+++	+++	+++	+++	No	—-	No	—-
Namibia	0.224	0.00	+++	No	No	+++	+++	No	No	—-	No	No
Nigeria*	0.172	0.00	+++	—	No	+++	+++	No	+	No	++	No
Rwanda	0.244	0.00	No	No	No	Skip	+++	+++	Skip	—-	No	—-
Senegal	0.215	0.00	++	No	—-	+++	+++	++	++	—-	No	No
South Africa	0.171	0.00	+++	—-	+++	+++	+++	No	No	—-	No	No
Tanzania	0.172	0.00	+++	+	-	Skip	+++	+++	+	—-	+++	—-
Uganda	0.357	0.00	+++	+	No	+++	++	No	+++	—-	No	—-
Zambia*	0.2894	0.00	+++	No	No	Skip	+++	+++	+++	Skip	+++	—-

(source: RIA 2007/2008 household survey)

The results suggest that the variables used to analyse mobile phone adoption contribute significantly to explaining the probability of adoption. Income increases the probability of mobile phone adoption as expected. Only for Ghana and Rwanda was it not significant. Substituting individual income with disposable income increases the pseudo R2 in both cases and leads to income being significant with positive coefficient. Disposable income has the advantage over individual income in that it takes into account the buying power of dependents that do not have own income. It does not generally lead to better results, though. Income as a barrier to adoption has two consequences. First, people will increasingly adopt mobile telephony should their income increase. Secondly, they might adopt it at current income if access (handset) prices and usage cost were to come down.

Age has a positive influence for some countries and a negative for others in the probability of mobile adoption. Age is likely to have a positive impact on the probability to adopt mobile up to a certain level and then the impact decreases. Using age2 instead of age in subsequent research could solve this. [19]

The gender variable is mostly insignificant as expected (11 countries). Only in Senegal, Tanzania and Burkina Faso does being a woman decrease the probability of mobile telephony adoption. In South Africa and Mozambique it increases the probability significantly.

19 See Tegegne (1999).

The result from the Probit models confirms the assumptions about education as well as those about the rural areas. Membership of social networks contributed positively to the probability of mobile adoption in seven out of 16 countries. For the remaining countries it was insignificant.

Randomly selected individuals older than 16 years from each household without mobile phone or active SIM card were asked for their willingness and ability to pay for a handset and what they thought a handset would cost them. These average figures are shown in Table 7. The difference between average willingness to pay and average expected costs confirms income as the main adoption barrier. Table 7 also indicates the number of new mobile phone users operators could expect should they offer mobiles for US$20, US$15 and US$10 respectively. US$20 handsets would attract about three million new customers in Kenya and Ivory Coast, for example. Ethiopia could expect 2,6 million more users if the handset price dropped to US$10 and provided that SIM cards were available. Ethiopia is the country with the widest gap between willingness to pay and expected cost and the country with the lowest mobile teledensity (see Table 1). The handset price is also known to fluctuate with the availability of SIM cards.

TABLE 7: WILLINGNESS AND ABILITY TO PAY

	Average willingness and ability to pay for a mobile handset in US$	Average expected cost of a mobile handset in US$	National New users at US$20 for a handset	New users at US$15 for a handset	New users at US$10 for a handset
Benin	7.45	11.44	124 972	487 176	677 715
Botswana	19.14	27.38	119 014	196 496	228 203
Burkina Faso	8.92	12.84	427 032	1 242 397	1 451 446
Cameroon	15.11	22.16	864 053	1 728 316	1 865 876
Côte d'Ivoire	29.70	30.06	3 057 420	3 539 351	3 914 283
Ethiopia	6.06	64.19	1 436 628	1 637 668	2 644 673
Ghana	14.02	23.15	1 283 271	1 469 652	1 841 837
Kenya	16.98	26.68	2 857 406	4 160 498	5 658 430
Mozambique	4.00	23.2	56 457	79 895	287 147
Namibia	24.64	25.12	162 992	192 395	232 584
Nigeria*	5.65	12.57	356 907	1 004 573	2 527 884
Senegal	19.55	2 543.0	1 336 691	2 169 548	2 301 775
South Africa	17.44	32.41	2 549 812	3 251 782	3 991 768
Tanzania	10.89	17.3	1 422 927	2 102 510	3 272 065
Zambia*	17.42	22.43	682 864	1 061 607	1 598 555

(source: RIA 2007/2008 household survey)

INCOME ELASTICITY / E-USAGE

Perl (1983), Taylor (1994; 2002) developed telecommunication demand models that address price and income elasticities for public phones, mobile phones and local, national and international fixed-line calls as well as cross price elasticities.[20]

20 See for example Kaserman *et al* (1990) and Parsons (1998)

Universal Service Obligations (USO) in this context have been thoroughly discussed in the literature.[21] Garbacz & Thompson (1997, 2002, 2003) find that price elasticities for landline services in the USA approach zero in recent years and that subsidies therefore have little or no impact on universal service. Crandall & Waverman (2000) Eriksson *et al* (1998) and Hausman *et al* (1993) support these findings.

Wallsten (2001) finds that greatly reduced international settlement rates for telecom traffic between the United States and the rest of the world had the effect of reduced prices and increased traffic in developing countries due to relatively high price elasticities. However, Garbacz & Thompson (2005) point out that international calls are of less relevance to poor people in developing countries compared to local and national calls, where price elasticities are low. They also find that the mobile monthly price elasticity exceeds fixed-line price elasticity in developing countries by a substantial amount and suggest that wireline phones are substitutes in the mobile market while mobile phones are not substitutes in the wireline market but complements. This is to some extent contradicted by Esselaar & Stork (2005) who find through studying usage data for nine African countries that mobile telephony is a substitute for fixed-line telephony across all income groups.

Clarke & Wallsten (2002) argue that universal service for the poor in developing countries is generally ineffective. Modelling income elasticities could establish alternative approaches to current universal service definitions. Rather than specifying coverage or geographic spread, universal service obligations (USOs) could be in terms of costs for monthly usage packages that take into account existing income barriers.

Lee (1999) in estimating access demand for mobile networks, shows that per capita GDP and the size of the existing fixed-line network increase the probability of people subscribing to mobile telephone services. This implies that the mobile telephone network is interdependent with the fixed-line network.

Demand, as understood by economists, is defined as the amount of goods or services people are willing to buy at a certain price (*ceteribus paribus* – other things, including income, equal). In this sense, demand is a concept affected by buying power. A person may have needs but no demand, due to income limitations. With insufficient income, demand can be zero or low even if the need is urgent. Demand or buying power for goods or services arises from the consumers' preferences for specific goods or services. Thus defining goods or a service, and studying how the consumer orders his/her preferences for such a product or service in relation to other available goods and services are crucial.

Demand arises from a previous knowledge of the product and a subjective evaluation of its benefits and costs. Communications services differ from other goods or services since some require a subscription prior to usage, such as post paid mobile and fixed line services. Even for prepaid mobile services a distinction can be made between access (cost of a handset) and usage costs. Subscription is necessary to use the Internet as well in most cases (notable exception is the Internet café). In the case of telephony the access service provides utility to a customer in terms of granting the ability to make and receive calls, even though it is uncertain whether the ability will be exercised. This is the so-called option value (Hee Lee, 2006).

For the purpose of analysing demand income elasticity for mobile telecommunication services we assume that the potential usage basket of a consumer consists of calls (q) and

21 See Gasmi *et al* (2000), Panzar (2000), Rosston & Wimmer (2000), Valletti (2000)

a composite product (x) that represent all other goods and services. We further assume that the consumer's decision on individual demand for calls is made by maximising a utility function within a given budget constraint. In addition to the factors of calls (q) and a composite product (x) affecting his/her utility, income (y) can be considered. Moreover, if call externality is incorporated in the utility of an individual, the number of existing subscribers who are making calls to and receiving calls from the individual affects the demand for calls. Thus, after including the size of the network (N) in order to reflect call externality, the utility function of a customer (U) is represented in expression (3):

$$U = U(q,x,N) \qquad (3)$$

At the same time, the budget constraint considering access charge and call charge is given by

$$(r + \pi q) + px = y \qquad (4)$$

Where r is the price of access to the telecommunications system, π the price of a call, y is income of the consumer and p the price of the composite product x. For the utility function in (3), the number of calls represents direct benefits of using the mobile, while the number of subscribers represents indirect benefits through network size. Given the budget constraint in (4), and assuming the utility function is strictly quasi-concave and differentiable, using Lagrangian techniques the demand functions for calls and the composite product, as shown below in expressions (5) and (6), can be derived from the optimal solution of the utility function:

$$q = q(\pi,p,N,y\text{-}r) \qquad (5)$$

$$x = x(\pi,p,N,y\text{-}r) \qquad (6)$$

These functions differ from conventional demand functions in two aspects: The budget constraint is y-r, rather than y, which reflects the condition of having to purchase access to telecommunication services, and the demand functions depend upon the number of subscribers, which reflects the access and usage externalities. Perl (1983), Taylor (1994, 2002) and Taylor and Kridel (1990) developed telecommunication demand models that are now widely used in the literature. The model has the following form:

$$q = Ae^{-\alpha p} y^{\beta} e^{u} \qquad (7)$$

Where q denotes use of the telephone network, p denotes the price of access and use, y denotes income, and u denotes a random error term. Network externalities as well as current socio-demographic factors can be included in this model as well.[22] Equation (7) can be transformed by taking the natural logarithm of the left hand and right hand sides:

$$\ln(q) = a\text{-}\alpha p + \beta \ln(y) + \varphi Z + \varepsilon \qquad (8)$$

Where $a = \log A$ and Z the socio-demographic factors set. The transformed demand functions for mobile phone services are then expanded by socio-economic factors and postulated to be of following form:

$$\ln(m) = \beta_0 + \beta_1 Y + \beta_2 A + \beta_3 PP + \beta_4 WP + \beta_5 G + \beta_6 F + \beta_7 SN + \beta_8 R + \varepsilon \qquad (9)$$

22 Haque (2007) suggests ways of testing for the functional form of the demand function for telecommunication services. This would be beyond the scope of this paper and will be addressed with a separate paper.

m = monthly mobile expenditure in US$, converted using nominal end of 2007 exchange rates (source IMF)

Y= natural logarithm of individual income in US$, converted using nominal end of 2007 exchange rates (source IMF). The income is the sum of any salary or wage, self-employment income, property income, income from agricultural produce, pension, transfer income and scholarships.

A = age in years

PP = dichotomous public phone variable: used public phone in the last three months =1, otherwise 0

WP = dichotomous work phone variable: access to a phone at work =1, otherwise 0

G = dichotomous gender variable, female=1, male=0

F = dichotomous fixed-line variable: fixed-line access at home =1, otherwise 0

SN = Dichotomous variable: social network (church groups, sports clubs etc.) membership = 1, otherwise 0

R = Dichotomous variable: rural = 1, urban (other urban and major urban) =0

The price variable used in the analysis is represented by the amount that an individual paid for access and usage of mobiles. However, since country results are being computed individually, there will not be a change for any of the responses, the cost of the usage basket is the same for everyone in a country. This lets the price variable become a constant.

Table 8 presents the results from robust regressions for each country, using weighted data. Income is in each case significant and positively related to mobile expenditure.

The gender variable is insignificant for 10 countries, which is somewhat surprising given that the average income of women is lower compared with that of men for all countries but Mozambique. However income is already taken care of in the equation. This means that although at different income levels, women spend the same on mobile phones as men. For Botswana, Cameroon, Mozambique and Namibia, the gender variables were significant and negative, which means that women spend less. Nigeria had the only positive significant coefficient.[23]

23 These finding can be explored further by using mean rank comparisons for the ratio mobile expenditure / disposable income.

TABLE 8: MOBILE EXPENDITURE – ROBUST REGRESSION RESULTS FOR EACH COUNTRY USING SAMPLING WEIGHTS

Country	R2	Prob > F	Only significant coefficients are being displayed: * = significant at 0.1 level, ** = significant at 0.05 level, *** = significant at 0.01 level							
			Y	A	G	WP	PP	F	R	SN
Benin	0.399	0.000	0.35***			1.07***	-0.27***			
Botswana	0.298	0.000	0.46***		-0.26**					
Burkina Faso	0.206	0.000	0.33***				0.28*	0.35***		
Cameroon	0.22	0.000	0.27***		-0.32**		-0.22*	0.54*	-0.4*	
Côte d'Ivoire	0.196	0.000	0.36***	-0.02*		0.45**		0.37*	0.34*	
Ethiopia	0.353	0.000	0.29***	-0.01**					-0.47***	0.23*
Ghana	0.145	0.000	0.47***	-0.01**						
Kenya	0.251	0.000	0.33***	-0.02***		0.44***		0.47***		
Mozambique	0.189	0.000	0.11**	-0.03***	-0.72***			1.04***		
Namibia	0.449	0.000	0.43***		-0.23*	0.37**				
Nigeria	0.458	0.000	0.71***		0.24***			-0.41*	0.24***	
Rwanda	0.339	0.000	0.55***				0.66***			
Senegal	0.266	0.000	0.43***				0.247*			
South Africa	0.477	0.000	0.47***	-0.02***		0.2**	-0.2***	0.3***		
Tanzania	0.127	0.000	0.33***					0.84**		
Uganda	0.292	0.000	0.39 ***					0.48**	-0.24*	0.43**
Zambia	0.378	0.000	0.52***	-0.01**				0.69***		

Source: RIA 2007/2008 household survey

Having a working fixed-line phone at home is linked to higher mobile expenditure in eight out of 16 countries. This can be explained by two factors. First, households with fixed-line phones are generally wealthier, which might not directly be reflected in the individual income of the respondent (dependents). Second, having a fixed-line phone at home provides more opportunity to talk, such as calling home. These results confirm the existence of a relationship between mobile and fixed-line networks. To contribute to the complementarity and substitutability discussion further, the fixed-line expenditure would need to be investigated for any effect through the number of mobile phone users in the household as well. The survey data also can be used to explain usage pattern in more detail.

Public phone usage has only been significant for six out of 16 countries. For Benin, Cameroon and South Africa it has a negative effect on mobile phone expenditure and for Burkina Faso, Rwanda and Senegal a positive one. This too needs to be analysed in more detail. Public phones might be used by predominantly lower income groups or might actually substitute mobile phone expenditure. More country-specific research is required to arrive at definite conclusions.

This applies equally, for the impact of access to a work phone or private use. In five countries the work phone variable shows as positive and significant. While having access to a work phone is a good indicator of income, one might also have suspected a negative impact on mobile usage expenditure since the work phone could be used to substitute for mobile calls.

Age has a significant and negative impact in six countries where that variable is significant. For those countries a youth user's effect can be established.

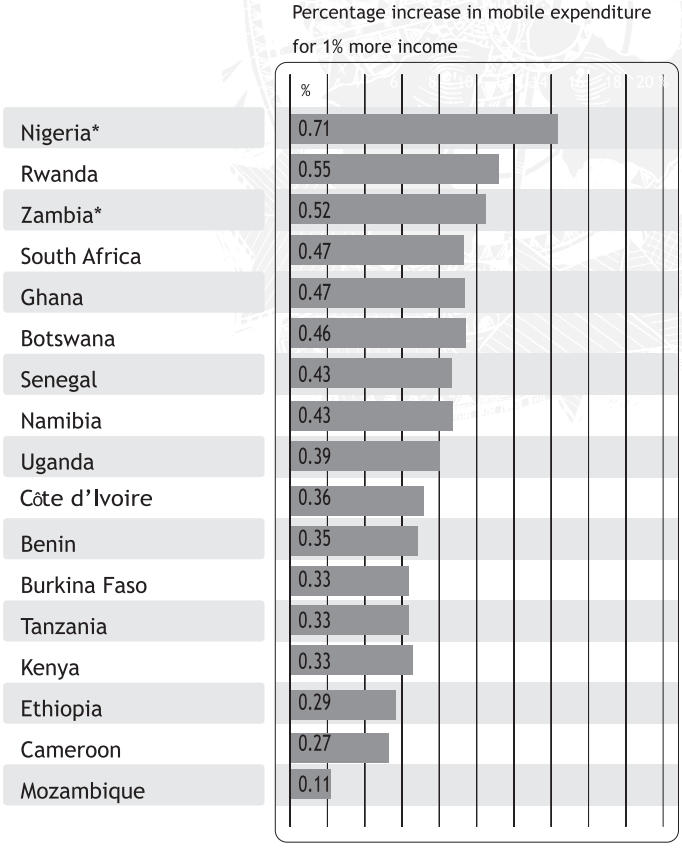
The main objective is to estimate demand elasticities. A distinction is made between income and price elasticities. Income elasticity describes the magnitude and also therefore the responsiveness of a demand change for a product in respect of an income change. Graphically expressed, the income elasticity is – *ceteris paribus* – the slope of the demand curve, dependent on the income.

$$e_y = \frac{\triangle Q/Q}{\triangle Y/Y}$$

Where: Q = quantity demanded; Y = income and, e_y = income elasticity.

The first derivative of the regression equation for income yields the coefficient for Y, which is the income elasticity, that is, the percentage change in mobile expenditure at a 1% change in income.[24] The estimation results show that income variable is statically significant and positive for all 17 countries.

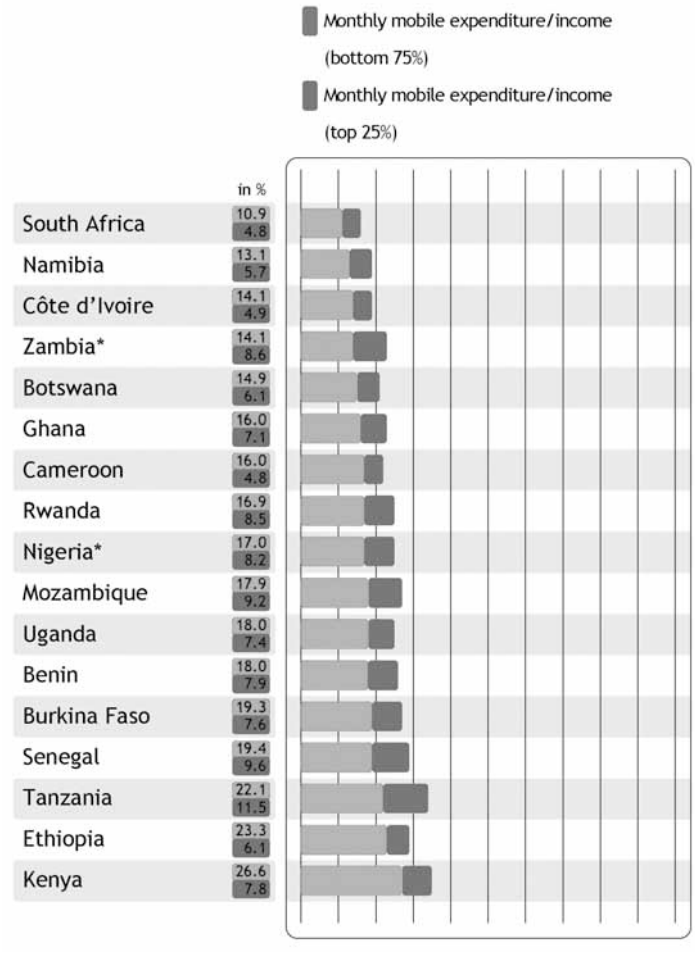
FIGURE 1: INCOME ELASTICITY: PERCENTAGE CHANGE IN MOBILE EXPENDITURE FOR 1% CHANGE IN INCOME.



24 See Wooldrige (2006: 46 and 705) and Hej *et al* (2004: 296).

Figure 1 shows the percentage change in mobile expenditure for a 1% income change. For all countries the mobile expenditure is inelastic with regard to income. Nigeria has the highest income elasticity and Mozambique the lowest. Since these are national figures based on cross-section data it implies that people with higher incomes spend a smaller proportion of their income on mobile telephony compared to low income households. Figure 2 confirms this. Income elasticity seems to be linked to relative cost of mobile usage, penetration and coverage. Those factors need to be explored in more detail in subsequent studies utilising supply side data and qualitative research.

FIGURE 2: SHARE OF MOBILE EXPENDITURE PER MONTH IN TERMS OF INDIVIDUAL INCOME.



PRICE ELASTICITY / E-USAGE

Price elasticity describes the magnitude and also therefore the responsiveness of a demand change for a product in respect of a price change. Graphically expressed, the price elasticity is – *ceteris paribus* – the slope of the demand curve, dependent on the price.

$$e_p = \frac{\triangle Q/Q}{\triangle P/P}$$

Where: Q= quantity demanded; P = price of the good and e_p = price elasticity.

The price elasticity of demand is in almost all cases, except for inferior goods, negative; if the price increases the demand decreases. To simplify the notation, demand elasticities are in general expressed in absolute value and therefore expressed as positive (Frank & Bernanke, 2003).

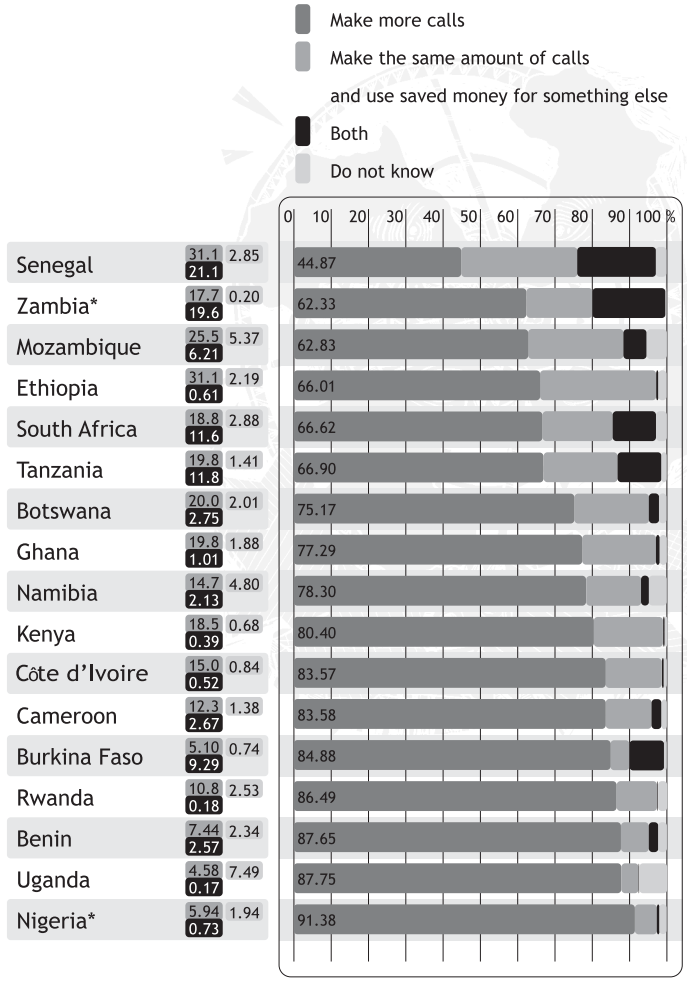
Milne (2006) provides a very intuitive argument for the changing structure of price elasticity in a hypothetical case. She argues that when phones become available for the first time in a low-income community and usage charges or tariffs are relatively high (in terms of income) people will make a limited number of essential calls. In such a scenario, even if the price falls by a small amount the number of such calls, for instance in an emergency or substituting a telephone call for a bus ride to a city, will not increase by much. In other words price elasticity will be relatively low (much less than -1). But, as prices fall, in a much cheaper service environment she argues that people will start using the phone for many non-essential purposes, ranging from relationship maintenance to simple conveniences. Add to this pricing innovations that enable poorer people to purchase small denomination pre-paid calling cards to make phone calls and it becomes intuitive that the number of calls made will increase significantly. Milne (2006) argues that when this happens, the price elasticity will rapidly rise towards -1 or even more than -1.

Table 9: Mobile penetration (source: RIA 2007/2008 household survey)

	Monthly average mobile expenditure in US$	Current market in US$ million	16+ with mobile phone or active SIM		16+ with more than one SIM card	number of duplicated SIM cards	Total number of active SIM cards	Share of Prepaid users
Benin	8.33	11.38	1 365 851	30.2%	496 917	1 173 454	2 047 486	95.96%
Botswana	10.18	6.67	654 737	59.5%	61 670	129 323	722 390	99.28%
Burkina Faso	5.84	10.77	1 844 701	27.2%	380 945	943 819	2 408 616	96.69%
Cameroon	7.14	21.29	2 979 597	36.5%	240 473	600 756	3 440 472	88.04%
Côte d'Ivoire	12.52	63.13	5 042 524	41.8%	762 295	1 741 585	6 037 870	91.77%
Ethiopia	3.81	5.29	1 387 910	3.2%	8 379	17 282	1 410 159	88.31%
Ghana	10.44	78.23	7 491 378	59.8%	832 341	1 969 676	8 691 409	99.83%
Kenya	10.41	112.11	10 772 696	52.0%	2 796 971	5 932 015	13 984 190	98.89%
Mozambique	6.26	30.47	4 865 758	25.7%	143 404	286 808	5 012 287	98.89%
Namibia	11.41	7.14	625 707	49.3%	39 090	83 807	670 424	89.95%
Nigeria*	10.88	686.54	63 101 014	77.3%	12 265 752	26 381 512	77 954 949	99.33%
Rwanda	6.02	3.13	520 259	9.9%	16 170	32 340	536 429	94.77%
Senegal	11.00	27.54	2 502 300	39.8%	125 251	291 243	2 705 744	99.70%
South Africa	15.88	320.49	20 185 135	62.1%	2 200 647	4 845 907	22 938 052	78.64%
Tanzania	7.44	30.79	4 138 338	21.5%	602 730	1 301 997	5 070 790	96.95%
Uganda	5.75	16.81	2 924 095	20.7%	526 378	1 097 654	3 505 813	97.84%
Zambia*	10.55	25.96	2 459 961	45.5%	110 683	253 279	2 605 368	99.7%

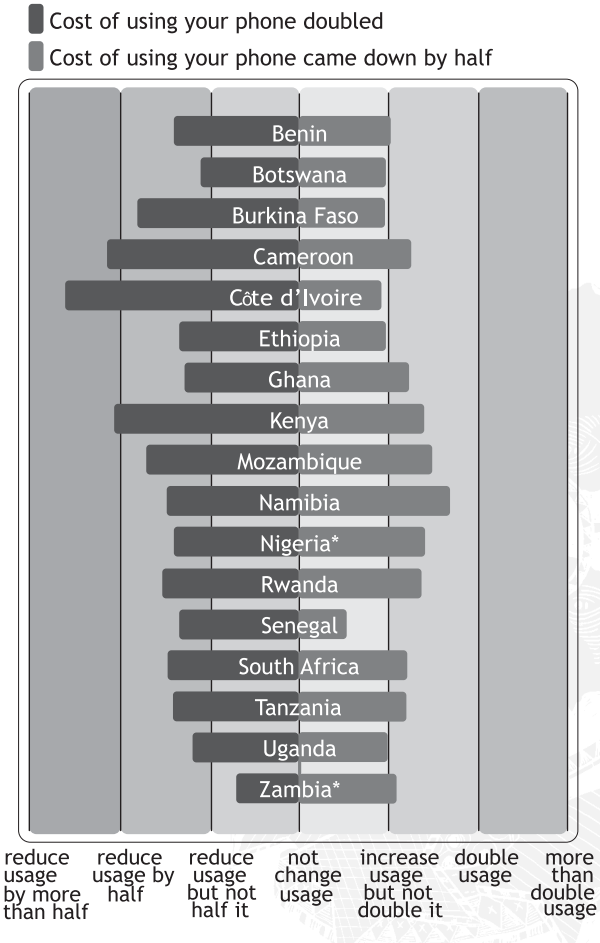
One of the biggest problems in estimating price elasticity of demand (PED) for telecom services in developing country situations is the lack of accurate usage data. Unlike in developed countries where usage is easily obtainable from monthly bills for post-paid connections, the vast majority in developing countries, in the case of the current study between 78% and 99%, have no billing records (for prepaid shares see Table 9). Many use public phones, phones at work or other people's phones which also does not generate records.

FIGURE 3: IF CALLS WERE CHEAPER WHAT WOULD YOU DO?



Source: RIA 2007/2008 household survey.

FIGURE 4: AVERAGE REACTION TO COST OF USING YOUR PHONE GOING DOWN BY HALF OR DOUBLING



Source: RIA 2007/2008 household survey

Another difficulty is that cross-section data, like those being analysed here, are not suitable to calculate price elasticities since data are only captured for one snapshot at a time. Changes in consumer behaviour due to price changes can only be analysed using time-series data. Cross section data only allow a rough glimpse at price elasticities by using contingent valuation methods. Respondents with mobile phone or active SIM card were asked how they would react to price decreases and increases. The answers to these questions are displayed in Figure 3 and Figure 4. Figure 3 shows that the vast majority of respondents would make more calls if prices were to come down. Senegal and Ethiopia are the two countries with the highest share of respondents that would use the saved money for something else.

Figure 4 shows how respondents state that they would react to a doubling or halving of call charges. What can be seen in the response is asymmetrical, ie respondents would react to price increases more strongly than they would do to price decreases. However, approximating price elasticity from these two contingent valuation results is, strictly

speaking, not possible. Respondents state their preferences and do not reveal observed behaviour reacting to price changes.

Table 10: Mobile willingness and ability to pay

	16+ without a mobile phone or active SIM card		Willing and able to spend more than:			Average monthly WTP in US$ of potential users	Monthly untapped market in US$ million
			US$1	US$2	US$5		
Benin	69.8%	3 162 099	2 797 101	1 402 507	161 217	2.94	8.26
Botswana	40.5%	446 140	311 446	199 511	66 192	4.28	1.47
Burkina Faso	72.8%	4 929 897	4 371 694	1 875 892	430 952	3.13	13.71
Cameroon	63.5%	5 177 393	3 452 460	1 855 275	550 724	3.75	13.14
Côte d'Ivoire	58.2%	7 033 592	4 485 498	3 645 855	1 677 528	6.86	31.44
Ethiopia	96.8%	42 497 353	10 231 145	3 104 395	74 428	1.53	25.68
Ghana	40.2%	5 036 815	2 849 435	1 953 135	984 279	9.34	38.40
Kenya	48.0%	9 941 748	5 866 299	5 235 785	1 245 083	3.30	25.69
Mozambique	74.3%	14 078 222	1 407 840	1 199 765	376 037	2.96	6.70
Namibia	50.7%	644 056	275 364	247 254	71 171	4.88	1.35
Nigeria	22.7%	18 541 687	7 989 151	6 234 941	5 128 000	6.09	65.25
Rwanda	90.1%	4 735 492					
Senegal	60.2%	3 779 221	3 428 481	1 294 681	502 730	3.28	11.33
South Africa	37.9%	12 331 758	7 604 512	5 551 777	2 209 625	4.34	36.27
Tanzania	78.5%	15 066 652	5 560 959	4 750 935	1 064 087	2.61	21.42
Uganda	79.3%	11 174 801					
Zambia*	54%	2 944 732	1 933 833	1 310 576	329 922	3.45	8.20

Source: RIA 2007/2008 household survey

Table 10 presents data on the untapped market, those 16 years or older that do not have a mobile or active SIM card at present. It shows the results for the number of people that could be reached with US$1, US$2 and US$5 Average Revenue per Users (ARPU) business models.

Conclusion

This paper shows that countries differ in their levels of ICT adoption and usage and also in the factors that influence adoption and usage. Income and education vastly enhances mobile adoption but gender, age and membership of social networks have little impact. Income is the main explanatory variable for usage. In terms of mobile expenditure the study also finds linkages to fixed-line, work and public phone usages. These linkages need, however, to be explored in more detail in future. Mobile expenditure proves to be inelastic with regard to income, ie as income increases mobile expenditure increases to a lesser extent indicating its importance in individual budgets.

Key policy interventions would be regulatory measures to increase access and usage of mobile services by promoting network investment. The current super profits being enjoyed by

operators across the continent as a result of prices that are among the highest in the world need to be moderated. In most markets there is no effective competition requiring regulatory interventions to ensure cost-based wholesale and retail pricing.

Increasing Coverage: Licence fees for infrastructure investment should cover the administrative and usage costs of national resources only. The current high cost of licences in most countries used to generate funds for state coffers translate to high prices for consumers as operators recover their licence costs. Countries need to look at incentives, not disincentives, to encourage network rollouts.

Wider Access: Access prices can be reduced by exempting telecommunication equipment, in particular mobile handsets and services from import duties and additional taxes.

Allow more Usage: Policy measures to increase the competition within the industry are the best mechanisms to reduce usage costs. In a competitive environment the operator can choose to compete on price or on service quality. Regulatory measures can improve competition on price by creating price transparency.

Price Transparency: Contract and prepaid tariffs vary across operators to an extent that a product to product comparison is impossible for consumers. Non-transparent pricing, including rapidly changing promotions and misleading media campaigns, make it difficult for end users to make informed decisions. This prevents operators from having to compete on prices and leads to higher average prices. Establishing price transparency on the basis of published monthly usage baskets will make the cost to the end user transparent and force operators to compete on price or service quality.

Cost-based Interconnection Rates: Above cost interconnection charges are often used by dominant operators to restrict small operators from gaining market share. High interconnection charges make off-net calls expensive and punish consumers or small operators. Cost-based interconnection rates (or benchmarked on cost base) increase the competition between operators and hence lead to lower usage cost.

Licences for Low ARPU business models: Regulators should award additional licences to applicants that are able to offer low ARPU business models, preferably below US$2.

The correct policy and regulatory measures can boost mobile access and usage. Avoiding sector and service-specific levies and additional taxes will result in lower recovery costs and therefore lower prices. Lower prices would allow millions of people currently unable to afford access to mobile services to do so and allow those currently restricting their usage as a result of the high cost of services to use services more extensively and effectively. This is likely to produce greater profits for companies overall and governments will as a consequence have even more money in their coffers due to taxes on greater operator revenues. ❑

References

Adamowicz, W., Louviere, J. and Williams (1994). Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities. *Journal of Environmental Economics and Management*, Vol. 26, pp.271-292.

Bagchi, K. and Udo, G. (2007). Empirically testing factors that drive ICT adoption in Africa and OECD set of Nations, *Issues in Information Systems*, Vol. 8, No.2, pp. 45-52.

Baliamoune-Lutz, M. (2003). An analysis of the determinants and effects of ICT diffusion in developing countries, *Information Technology for Development*, Vol.10, pp.151-169.

Bann, C. (1999). A Contingent Valuation of the Mangroves of Benut. Forestry, Department, Peninsular Malaysia, Danish Cooperation for Environment and Development and the Johor State. www.soc.uoc.gr/calendar/2000EAERE/papers/PDF/A6-Bann.pdf Last Appeal: 10.07.07

Bateman, I., Carson, R., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D., Sugden, R., Swanson, J. (2002). *Economic Valuation with Stated Preference Techniques - A Manua*l. Edward Elgar, Cheltenham, UK, ISBN: 1-84064-919-4.

Clarke, G. and Wallsten, S. (2002). Universal(ly bad) service: Providing infrastructure services to rural and poor urban consumers. World Bank Policy Research Working Paper, 2868, 1–54.

Crandall, R. and Waverman, L. (2000). *Who pays for universal service? When telephone subsidies become transparen*t. Washington, DC: Brookings Institution Press.

Eriksson, R., Kaserman, D. and Mayo, J. (1998). Targeted and untargeted subsidy schemes: Evidence from postdivestiture efforts to promote universal telephone service. *Journal of Law and Economics*, 41, 477–502.

Esselaar, S. and Stork, C. (2005). Mobile Cellular Telephone: Fixed-line Substitution in Sub-Saharan Africa, *The Southern African Journal of Information and Communication*, Issue 6, pages 64-73, ISSN 1607-2235.

Fabiani, S., Schivardi, F. and Trento, S. (2005), ICT adoption in Italian manufacturing: firm-level evidence, *Industrial and Cooperate Change*, pp.1-25.

Frank, R. and Bernanke, B. (2003). *Principles of Economics*. McGraw-Hill, Boston

Garbacz, C. and Thompson, H. G., Jr. (1997). Assessing the impact of FCC lifeline and link-up programs on telephone penetration. *Journal of Regulatory Economics*, 11, 67–78.

Garbacz, C. and Thompson, H. G., Jr. (2002). Estimating telephone demand with state decennial census data from 1970–1990. *Journal of Regulatory Economics*, 21, 317–329.

Garbacz, C. and Thompson, H. G., Jr. (2003). Estimating telephone demand with state decennial census data from 1970–1990: Update with 2000 data. *Journal of Regulatory Economics*, 24, 373–378.

Garbacz, C. and Thompson, H. G., Jr. (2005). Universal telecommunications service: A world perspective. *Information Economics and Policy*, 17, 495–512.

Garbacz, C. and Thompson, H. G., Jr. (2007). Demand for telecommunication services in developing countries. *Telecommunications Policy* 31 (2007) 276–289.

Gasmi, F., Laffont, J. J. and Sharkey, W. (2000). Competition, universal service and telecommunications policy in developing countries. *Information Economics and Policy*, 12, 221–248.

Gefen, D. and Straub, D. (1997). Gender difference in the perception and use of e-mail: an extension to the technology acceptance model. *MIS Quarterly*, 21, 389– 400.

Gourieroux, C. (1986). Econométrie des variables qualitatives, *Economica*.

Haque, O. M. (2007). Income Elasticity and Economic Development, Springer, ISBN 0-387-24292-9.

Hausman, J., Tardiff, T. and Belinfante, A. (1993). The effects of the breakup of AT&T on telephone penetration in the United States. *American Economic Review* (American Economic Association Papers and Proceedings), 83, 178–184.

Heij, C., de Boer, P., Franses, P., Kloek, T. and van Dijk, H. (2004). *Econometric Methods with Applications in Business and Economics*, Oxford University Press, ISBN 0-19-926801-0.

Jalava, J. and Pohjola, M. (2002). Economic growth in New Economy: Evidence from advanced economies, *Information Economics and Policy*, Vol.14, pp. 189-210

Jorgenson D., Ho, M.S. and Stiroh, K. (2005). *Productivity: Information Technology and the American Growth Ressurgence*. London; Cambridge: The MIT Press.

Kabbar, E.F. and Crump, B.J. (2006). The factors that influence Adoption of ICT by recent refugee immigrants to New Zealand, *Informing Science Journal*, Vol.9, pp.111-120.

Kaserman, D. L., Mayo, J. W. and Flynn, J. E. (1990). Cross subsidization in telecommunications: Beyond the universal service fairy tale. *Journal of Regulatory Economics*, 2, 231–249.

Kelly, T. (2004). Changing ICT ranking of African Nations. *The Southern African Journal of Information and Communication*, Issue No. 5, 2004.

Kwapong, O.A.T.F (2007). Problems of policy formulation and implementation: The case of ICT use in rural women's empowerment in Ghana, *International Journal of Education and Development using Information and Communication Technology*, Vol.3, No. 2, pp. 68-88.

Long, S. (1997). *Regression Models for Categorical and Limited Dependent Variables, Advanced Quantitative Techniques in the Social Sience Series*, Sage Publications, ISBN 0-8039-7374-8.

Long, S. and Freese, J. (2006). *Regression Models for Categorical Dependent Variables Using Stata*, Stata Press, ISBN1-59718-011-4.

Maddala, G. S. (1983). *Limited-dependent and Qualitative Variables in Econometrics*, Cambridge University Press.

McCormick, D. and Onjala, J. (2007). *Methodology for Value Chain Analysis in ICT Industry Frameworks for the Study of Africa*, Institute for Development Studies University of Nairobi

Milne, C. (2006). "Telecoms demand: measures for improving demand in developing countries – a toolkit for action". Discussion Paper WDR 0603, Main Report (World Dialogue on Regulation).

Mitchell, R. and Carson, R. (1984). A Contingent Valuation Estimate of National Freshwater Benefits – Technical Report to the US Environmental Protection Agency. Resources for Future, Washington D.C.

Niininen, P. (2001). Computers and economic growth in Finland, in *Information Technology, Productivity, and Economic Growth: International Evidence and implications for economic Development*, Matti Pohjola, ed., Oxford University Press.

OECD (2003). ICT and Economic growth. Evidence from OECD countries, industries and firms. Paris (France).

Oliner, S.D. and Sichel, D.E. (2000). The resurgence of growth in the late 1990s: Is Information Technology the Story?, *Journal of Economic Perspectives*, Vol.14, pp. 3-22.

Ono, H. (2003). Gender and the Internet. *Social Sciences Quarterly*, 84, 111–121.

Orbicom (2003). L'observatoire de la fracture numérique ... et au-delà. Conseil national de la recherche du Canada, Québec (Canada).

Panzar, J. C. (2000). A methodology for measuring the costs of universal service obligations. *Information Economics and Policy*, 12, 211–220.

Parsons, S. G. (1998). Cross-subsidization in telecommunications. *Journal of Regulatory Economics*, 13, 157–182.

Perl, L. J. (1983). Residential demand for telephone service. White Plains, NY: National Economic Research Associates.

Piccoli, G., Ahmed, R. and Ives, B. (2001). Web based virtual learning environments: a research framework and a preliminary assessment of effectiveness in basic IT skills training. *MIS Quarterly*, 25, 401–426.

Pohjola, M. (2001). Information technology and economic growth: A cross-country Analysis, in: *Information Technology, Productivity, and Economic Growth: International Evidence and implications for economic Development*, Matti Pohjola, ed., oxford University Press.

Roller, L. H. and Waverman, L. (2001). Telecommunications Infrastructure and Economic Development: A simultaneous approach. *The American Economic Review*, Vol. 91, No 4, 909-923.

Rosston, G. L. and Wimmer, B. R. (2000). The state of universal service. *Information Economics and Policy*, 12, 261–283.

Row R., Schulze W. and Breffle W. (1996). A Test for Payment Card Biases. *Journal of Environmental Economics and Management*, Vol. 31, pp. 178-185.

Sichel, D. (1997). The Computer revolution- An Economic Perspective, Washington D.C.: Brookings Institutions Press.

Taylor, L. D. (1994). *Telecommunications demand in theory and practice*. Dordrecht: Kluwer Academic Press.

Taylor, L. D. (2002). Customer demand analysis. In M. Cave, S. Majumdar, and I. Vogelsang (Eds.), *Handbook of telecommunications economics* (pp. 97–142). Amsterdam: Elsevier Science.

Taylor, L.D. and Kridel, D.J. (1990). "Residential Demand for Access to the Telephone Network," in *Telecommunications Demand Modeling*, ed. by de Fontenay, A., Shugard, M.H. and Sibley, D.S. North Holland Publishing Co., Amsterdam.

Tegegne, G.E. (1999). "Willingness to pay for environmental protection: an application of Contingent Valuation Method (CMV) in Sekota District, Northern Ethiopia". *Ethiopian Journal of Agricultural Economics* Vol 3: 123-130

UNCTAD (2006). "Rapport 2006 sur l'Economie de l'information", UNCTAD/SDTE/ECB/2006.

Valletti, T. M. (2000). Introduction: Symposium on universal service obligation and competition. *Information Economics and Policy*, 12, 205–210.

Venkatachalam, L. (2004). The Contingent Valuation Method – A Review. Environmental Impact Assessment Review, Vol. 24, pp. 89–124.

Venkatesh, V. and Morris, M.G. (2000). Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior. *MIS Quarterly*, 24, 115–139.

Wallsten, S. (2001). Telecommunications investment and traffic in developing countries: The effects of international settlement rate reforms. *Journal of Regulatory Economic*s, 20, 307–323.

Waverman, L., Meschi, M. and Fuss, M. (2005). The impact of telecoms on economic growth in developing countries. In Africa: The Impact of Mobile Phones: Moving the Debate Forward, The Vodafone Policy paper series, No.2.

Wooldrige, J. (2006). *Introductory Econometrics A modern Approach*, 4th edition, South-Western Cengage Leraning, Canada, ISBN 13 : 978-0-324-58548-3.