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# COMPARING THE DETERMINANTS OF INTERNET AND CELL PHONE USE IN AFRICA: EVIDENCE FROM GABON

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**ABSTRACT:**

Within developed countries, the market penetration of cell phones and the Internet has progressed in tandem and the point of market saturation is nearly to be reached in both markets. In contrast, the African continent has been characterized by a more uneven level of progress, with the penetration of cell phones (41% in 2010) considerably outpacing the penetration of the Internet (9.6% in 2010). The question is then raised as to whether cell phone and Internet services in Africa are following the same path towards widespread diffusion, yet with a several-year time delay, or alternatively has the expansion of Internet use been constrained by the presence of specific obstacles? The objective of this article is to compare the determinants and hindrances of both Internet and cell phone use in Gabon, based on individual survey data. Our econometric results show that the primary factors stimulating Internet use consist of a high level of education and computer skill. Social neighborhood also plays a major role in the Internet adoption process. As regards cell-phone use, the main obstacles would be economic in nature. Finally, an individual's age has a positive impact on cell phone use and negative impact on Internet use. The differences identified in both penetration and user profiles between Internet and cell phone service should motivate African governments to develop digital policies more heavily focused on a wider dissemination of cell phones in order to make innovative services and applications (e.g. in the field of health or education) available to as broad a population as possible.

KEYWORDS: Internet Use, Cell-phone Use, IT Diffusion, Digital Divide, Africa.

JEL code: L5, L9, O14, O33, O57

## 1. Introduction

In Europe, the penetration of cell phones and the Internet occurred coincidentally and is now nearing the saturation point. The majority of Europeans are cell phone users and over 65% access the Internet[1]. This situation presents a sharp contrast with observations from Africa, where these two communication technologies have experienced uneven penetration patterns from one country to the next. As of the end of 2010, the Internet use rate throughout Africa stood at 9.6%, while the cell phone penetration rate had reached 41% (source: ITU). These differences in service access become even more pronounced when considering the fact that cell phones in Africa may be shared with family members, friends or neighbors (James, 2011). In the case of Kenya, Aker and Mbiti (2010) noted that as of 2009, 47% of the country's population owned a cell phone. However, since a third of survey respondents admitted to sharing their device with others, a full 80% of Kenyans were enjoying access in 2009 to cell phone services (either directly or via shared use). Over time, the discrepancies in cell phone penetration rates between the developed world and African nations have been narrowing, a trend accelerated by the fact that African cell phone operators have during the past few years made considerable investments to extend the geographic coverage of their networks[2].

On the other hand, the gap in Internet use rates between industrialized countries and the African continent have tended to widen in recent years. This "digital divide" has become exacerbated as regards the quality of Internet access, as most users in developed nations have a broadband connection in their homes (and some benefiting from very high-speed service), whereas online speeds experienced in Africa are still very slow and impede access to certain uses requiring large bandwidth, e.g. video streaming.

The question is then raised as to whether cell phone and Internet services in Africa are following the same path towards widespread diffusion, yet with a several-year time delay, or alternatively has the expansion of Internet use been constrained by the presence of specific

[1] Source: Internet World Stats.
[2] In 2010, 60% of Africa's population had access to coverage (source: ITU).

obstacles? To answer this question, the determinants surrounding Internet and cell phone adoption at the individual level must first be identified and compared. Are the factors involved in stimulating or hindering the use of these two technologies identical or different? Are the cell phone and Internet perceived as complementary or substitutable?

The originality of this article lies in its application of data generated from individual survey responses. The survey was conducted in 2008 among a sample of 1,352 residents of the country's two major cities, which account for 80% of the Gabonese population. Gabon offers several features justifying its interest for a study devoted to the issue of Information Technology (IT) use. The nation's population is very small (1.5 million inhabitants), which enhances the level of representativeness for a given survey sample size. The country possesses major deposits of natural resources and has shown interest in speeding development of its digital economy in preparation for the post-oil era. Moreover, Gabon's GDP per capita leads all of Africa. This country however has also endured several hurdles in developing its IT resources, especially in terms of infrastructure. According to the ITU organization, in 2010, only 30,000 Gabonese residents were receiving landline phone service, equivalent to 2 landlines per every 100 inhabitants; moreover, just 7.3% of the population were benefiting from Internet access. On the cell phone side, 2011 statistics indicate that the country contains 1.6 million service subscribers (the vast majority in prepaid accounts), which yields a penetration rate of 106%. This high rate can be explained by the fact that cell phone users typically hold several subscriptions. Gabon thus offers a highly attractive context for analyzing the disparate rates of cell phone and Internet penetration and then for comparing factors that stimulate adoption for each technology.

Our results illustrate that the hindrances to using Internet and cell phones are actually quite different. The probability of cell phone use increases substantially among those 30 and older, while age constitutes an obstacle to Internet access. Internet users are young, well educated and skilled in the use of computers. The probability of Internet use is higher among males, English speakers and those holding executive or white collar jobs. Moreover, Internet users tend more often to be involved in associations and have many friends connected to the Internet.

These results do not differ markedly from observations derived in studies on developed nations. Nonetheless, the uneven level of penetration between cell phone and Internet in Africa, as well as the magnitude of the digital divide in Internet use, require special attention. Policies favoring digital innovation must concentrate more specifically on offering cell phone services and applications (e.g. in the health or education fields) accessible to as many population segments as possible.

The next section of this paper will review the empirical studies performed on the determinants of Internet and cell phone penetration in African countries. Section 3 will present the survey completed in Gabon in 2008, along with the variables introduced into our econometric models. Section 4 will then provide commentary on econometric results relative to the probability of Internet vs. cell phone use. The final section will discuss the implications of these findings in terms of implementing a digital innovation policy.

## 2. Literature review

The majority of studies carried out to define the determinants behind adopting and using cell phone and Internet technologies have focused on the industrialized world. A handful of studies however have been aimed at explaining the discrepancies in penetration rates between developed and emerging countries (Andres, Cuberes, Diouf and Serebriski, 2008; Beilock and Dimitrova, 2003; Chinn and Fairlie, 2010; Kiiski and Pohjola, 2002; Liu and San, 2006; Madden, Coble-Neal and Dalzell, 2004; Mocnik and Sirec, 2010; Quibria *et al.*, 2003; Wuvanna and Leiter, 2008). The primary explanatory factors resulting from these investigations were: per capita income, average level of education (i.e. human capital), degree of competition, and the density and quality of telecommunication infrastructure. For example, based on data input from over 100 countries, Beilock and Dimitrova (2003) obtained a positive correlation between the rate of Internet penetration on the one hand and per capita income, rate of computer ownership and density of landlines on the other. These authors also found that Internet use was more widespread in countries that respected civil rights and liberties. On the basis of more recent data, Chinn and Fairlie (2010) derived similar results; in particular, they demonstrated that deviations in Internet penetration between developed and emerging countries could be explained by the quality of the legal and institutional environment. Wide income disparities within a country also

impedes Internet penetration (Mocnik and Sirec, 2010). Furthermore, Wuvanna and Leiter (2008) reported that the command of English in a country exerts a positive influence on Internet diffusion; this finding is justified by the relative abundance of English language content on the Web, thus enhancing its appeal to English-speaking populations[3].

As regards cell phone use, Rouvinen (2006), Gruber (2001) and Gruber and Verboven (2001) all pointed out that the number of phone operators in competition by far offered the best explanation of the observed penetration rates. Madden, Coble-Neal and Dalzell (2004) demonstrated that increases in the nationwide number of cell phone service subscribers are more substantial as: per capita income level rises, prices remain low, and the country's subscriber base broadens. Nonetheless, income and network effects (as measured by the subscriber base) are more powerful than price effects.[4]

The body of studies focusing on African countries is less extensive, yet the articles by Roycroft and Anantho (2003) and Oyelaran-Oyeyinka and Lal (2005) need to be cited. Roycroft and Anantho (2003) found that regarding the expansion of Internet accessibility on the African continent, the most significant factors were: the level of economic development, the country's Anglophone heritage, the capacity of available Internet bandwidth, the density of Internet servers (an indirect measurement of both content quantity and locally-offered services), and the intensity of competition among network access providers. In their research, Oyelaran-Oyeyinka and Lal (2005) indicated that the rate of Internet use in Sub-Saharan countries increased with: the country's rate of computer ownership, density of landline connections, and the number of Internet hosts. In addition, per capita income has a positive influence on Internet implementation, by means of stimulating telecommunications infrastructure investment.

Another stream of literature assesses determinants of both Internet and cell phone adoption at the individual level. Along these lines, Katz and Rice (2003) concluded that in the United States, non-cell phone users did not display the same profile as non-Internet users. The divide between cell phone users and non-users lies mainly in socioeconomic factors, as the probability of owning a cell phone increases with both age and income. As for the discrepancy between Internet users and non-users, the probability of adoption decreases with both age and level of

[3] More broadly, Viard and Economides (2011) revealed that the use of Internet in a country increased with the amount of content present on the Internet in the primary language spoken within the given country. This finding showcases one of the potential obstacles to spreading Internet access into African countries characterized by multiple local languages.
[4] Andres *et al.* (2008) also observed strong network effects at play as part of the Internet penetration process.

education. Other research has focused on the decision to have an Internet connection at home. Household income, level of education attained by the head of household and the presence of children were all positively correlated (Chaudhuri, Flamm and Horrigan, 2005; Drouard, 2011; Ghazzi and Vergara, 2010). Lastly, other research efforts have examined the determinants associated with various types of Internet use (Goldfarb and Prince, 2008; Drouard, 2010; Coneus and Schleife, 2010), in demonstrating that socioeconomic factors (age, income) exerted a strong influence on the Internet use decision, but are no longer relevant when choosing online applications and services (e-mail, games, social media, e-banking, etc.). Internet usage patterns depend to a much greater extent on: time available, computer skills, and cumulative browsing experience.

To the best of our knowledge, no empirical studies have been conducted on individual data regarding joint use of the Internet and cell phone services in Africa. Oyelaran-Oyeyinka and Adeya (2004) polled a sample of 200 individuals working in Kenyan and Nigerian universities, drawing the conclusion that Web users were younger than non-users without any significant differences existing between male and female use patterns. This sample however was very limited in scope and did not allow drawing conclusions on the entire population. Aker and Mbiti (2010) referenced a survey conducted in Kenya (called FinAccess) devoted to generating a cell phone user profile. This survey indicated that in 2006, users tended to be young, urban, educated and high income earners. The 2009 survey update highlighted the strength of cell phone penetration in rural zones as well as among the poorer and less well-educated population segments, providing a sign that access inequalities to cell phone service have narrowed. Aker and Mbiti (2010) did not however perform similar analyses on Internet use based on the same survey.

Our study is therefore one of the first to closely identify and compare the determinants of both Internet and cell phone use at the individual level in an African country.

## 3. Data and methodology

### 3.1 Description of the data

The data were derived from a Gabonese survey relative to individual use of Information and Communication Technology (ICT) services[5]. Responses were recorded face-to-face in the cities of Libreville and Port-Gentil, over the period July 1st through November 30th, 2008. To generate a sample representative of the population at large, we employed the multi-stage sampling method. More specifically, these two Gabonese cities were subdivided into districts, and an initial random sort allowed selecting a predefined number of districts to be assigned to surveyors. The types of dwellings included in the study were once again chosen in a random manner[6]. Moreover, in each dwelling, surveyors interviewed the first person encountered 15 or older[7]. In all, 1,352 individual responses were collected.

The data compiled pertain to the respondent's socioeconomic characteristics (gender, age, languages spoken and read, level of education, marital status, income bracket), social capital (membership in associations and tontine[8]), ownership of computing and electronic devices (TV, personal computer, MP3 player), computing skills, and use patterns specific to cell phones, computers and the Internet.

Table 1 lists descriptive statistics regarding the set of variables introduced into our econometric analyses. In our sample, 60% of respondents were men. One-third of all respondents were between 22 and 29 years old, with 46% younger than 30. With respect to level of education attained, 30% received no more than the first round of secondary school training, 26% held a "high school" diploma, and 44% had earned at least one university degree.

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[5] This survey was conducted within the scope of a project backed by the *Agence Universitaire de la Francophonie* (French language University Association), which associated the University of Douala (Cameroun), University Omar Bongo (Gabon), University of Rennes 1 (France) and the CEPS/INSTEAD Institute (Luxembourg).

[6] To begin the interview sequence, the surveyor would visit the dwelling nearest the first electric pole found upon arriving in the district. Following this interview, the surveyor would visit the dwelling located a distance of two electric poles from the first one and then the pattern would be repeated. This protocol guaranteed a random and uniform sampling.

[7] This interviewee selection method, within each household, did however introduce a certain bias since it led to an overrepresentation of men and young people (high school or university students) in our sample. On the other hand, the sample offers a very high level of representativeness among Libreville and Port-Gentil households and thus makes it possible to analyze in detail the impact of income conditions and electronic device ownership rates within households on individual Internet and cell phone use trends.

[8] Tontine plans are associations of individuals who pool sums of money in the aim of generating savings or credit. These arrangements are very popular in West Africa. Affiliation with tontines provides a measure of share capital.

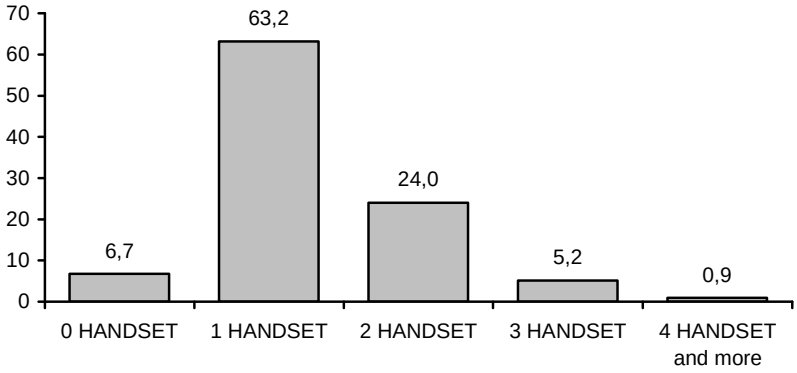
Secondary school and university students accounted for approx. 33% of our sample population. Another 22% were public sector employees, while 8% were private sector blue collar workers or employees; 11% held private sector managerial posts and 12% claimed an independent employment status (trader, craftsman, professional services). 15% of the population could be characterized as unemployed. For 65% of the sample, day-to-day life presented economic challenges.

[INSERT TABLE 1]

The share of respondents equipped with an Internet connection in their place of residence was relatively small (15%). But a total of 61% acknowledged familiarity with the Internet, and 44% had been online in one capacity or another during the previous three months regardless of their point of Internet access.

The rate of cell phone usage was substantially higher than the corresponding Internet rate. 93% of those surveyed admitted to owning and using at least one cell phone, with nearly a third of the sample owning more than one (see Fig. 1).

Figure 1: Distribution of respondents by number of cell phones owned (%)




In order to explain and compare the determinants of Internet and cell phone penetration within our Gabonese survey population, we introduced the two following binary variables: "Internet use during the previous 3 months" (INTERNET), and "ownership of at least one cell phone" (MOBILE).

The explanatory variables may be combined into three categories: the individual's socioeconomic characteristics, his/her technological skills and resources (Information Technology), and his/her social environment.

The socioeconomic characteristics taken into account herein include: gender, age, level of professional training, marital status, occupation, and lifestyle.

Regarding the impact of gender, a number of studies (e.g. Bimber (2000), Schumacher and Morahan-Martin (2001)) have demonstrated that during the initial phases of introducing new technology, the first movers tend most often to be men. Over time however as the technology is disseminated, the gap between men and women narrows. We expect that gender differences therefore should only be apparent relative to Internet use, but not cell phones, which had already reached a stage of widespread availability.

Several studies have shown that the influence of age on technological adoption rates differed between the Internet (negative correlation) and cell phone service (positive correlation) (Katz and Rice, 2003; Oyelaran-Oyeyinka and Adeay, 2004). To test the effect of age in the case of Gabon, we created a series of four binary age group variables: 15 to 21-year-olds (AGE15-21), 22 to 29-year-olds (AGE22-29), 30 to 44-year-olds (AGE30-44), and over 44 (AGE45).

Another important factor concerns the level of education, which is expected to be more heavily correlated with Internet use than cell phone use given that the benefits of Internet require at the very least being able to read and write (i.e. literacy). Yet an even higher level of education serves to take greater advantage of Internet resources and reduce training costs. Several studies have underscored the positive impact of higher education on Internet adoption rates (Goldfarb and Prince, 2008; Coneus and Schleife, 2010; Drouard, 2010). For our particular model, the level of education has been measured by means of four binary variables, i.e.: completion of primary education or the first cycle of the secondary curriculum (PRIMARY), completion of the second cycle of secondary studies (SECONDARY), a first-level post-secondary degree (TERTIARY1), and training beyond the first post-secondary degree (TERTIARY2).

Due to the quantity of English language content found on the Internet, those individuals able to read English should be more attracted to the Internet (Viard and Economides, 2011; Wuvanna and Leite, 2008). Command of the English language is measured by introducing a binary variable (ENGLISH), which equals 1 if the respondent has a good reading knowledge of English.

Income is another key factor in explaining Internet and cell phone adoption rates and should be correlated positively with both technologies. Nonetheless, Katz and Rice (2003) revealed that income had a more pronounced effect on cell phone use than on Internet trends. Without any reliable data on individual incomes, we decided to use a subjective interview question relative to each respondent's financial situation: the variable (DIFFICULTY) is assigned a value of 1 whenever the respondent considers his/her income level makes day-to-day life challenging or very challenging.

We also controlled the sample for marital status using a binary variable (PARTNER), which assumes a value of 1 if the respondent is married or living with a partner. Similarly, each individual's employment status was taken into account via the following variables: employed in the public sector (PUBLICJOB), business owners, contractors, merchants or freelance professionals (SELF-EMPLOYED), managers (middle or senior level) working in the private sector (HIGH WORKER), private sector employees or workers (LOW WORKER), high school or university students (STUDENT), and unemployed (NO JOB).

The level of computer skills is expected to yield a positive impact on Internet use, but not necessarily affect cell phone trends, except in instances where the two technologies prove to be complementary. This skill level is measured by the capacity to operate a word processing or spreadsheet software (USE SOFTWARE) and install a piece of software on a computer (INSTALL SOFTWARE). Over half of respondents knew how to use a spreadsheet or word processor, while one in five was capable of installing software.

We also introduced a measure of the computing and electronic devices available to respondents into our estimation models. 27% of interviewees had access to a computer, 63% to a CD player and 34% to an MP3 player. The presence of these devices turns out to be complementary to Internet use or an indicator of a liking for digital technologies and, in either case, should increase the probability of Internet use.

A considerable body of work has revealed the influence of social neighborhood in the decision to adopt a new technology, especially when network effects play a substantial role (Goolsbee and Zittrain, 1999; Coneus and Schleife, 2010, Liu and San, 2006; Ward, 2010). The social network, through providing advice, is capable of reducing costs or increasing the benefits derived from the use of technologies like Internet or cell phones. Social interactions and social learning become determinant factors, especially during the technological startup phase. Along

these lines, Goldfarb (2006) showed that the use of e-mail services in the United States began in universities and spread via students who went on to become influencers within their own households. Social influences have been incorporated into our models through the variable FAMILYINTERNET (respectively FRIENDINTERNET), which equals 1 if the respondent indicates that the majority of his/her family members (respectively the majority of his/her friends) use the Internet. 21% of the survey sample noted that at least one family member had already used the Internet, while 51% reported heavy Internet use among their social relations.

Moreover, the density of an individual's social network (or his/her amount of social capital) can also promote Internet or cell phone adoption, by means of strengthening network externalities and thus raising the gains expected from these technologies (Franzen 2003; Pénard and Poussing, 2010). In order to measure this effect of social capital, we created two variables: MEMBERSHIP, which equals 1 if the respondent belongs to at least one formal association (regardless of type); and TONTINE, assigned a value of 1 when the respondent is affiliated with at least one tontine association.

### 3.2 Econometric specification

The dependent variables of our econometric models are binary, with the value 1 when individual use the internet or a cell phone and 0 otherwise. For this reason, we use a logit model in which the decision to use an information technology (either Internet ou mobile phone) is defined by $y_i$ where $y_i$=1 when the individual uses this technology and $y_i$=0 otherwise[9]. The probability of adoption is conditional upon several exogenous variables.

$$Prob(y_i = 1) = F(\beta' x_i) \qquad (1)$$

where $F(.)$ is the logistic distribution function of the error term, $x_i$ refers to the explanatory variables and $\beta$ the vector of the parameters to estimate.

However, we can presume that the choice to use a mobile phone is correlated to the choice to use the Internet. For this reason, we also use a bivariate probit model. This model jointly estimates the decisions to adopt the two information technologies. Under this specification, the covariance between the two terms of errors ($\rho$) can be different from zero. If

[9] We could have alternatively chosen a probit model. In our case, the logit and probit models give similar results (Morimune, 1979; Davidson and MacKinnon, 1984).

we find a positive and significant coefficient on $\rho$, we can conclude that the use of the Internet is positively correlated with the use of the cell phone (i.e. the two technologies are complementary). Inversely, a negative coefficient on $\rho$ would suggest that Internet and mobile phone are substitutes.

## 4. Results

The estimates of the determinants behind both Internet (Table 2) and cell phone use (Table 3) suggests that these two technologies are not affected by the same set of factors, except for a shared positive impact of the variable TERTIARY2 (completion of advanced studies, Masters degree or higher). A higher level of education facilitates the adoption of those technologies (by reducing learning costs and enhancing the potential personal and professional advantages to be gained). In contrast, an education limited to the primary level constrains Internet use, whereas no significant differences are found in cell phone use patterns among individuals, regardless of their level of education attained.

[INSERT TABLE 2 AND TABLE 3]

As regards socioeconomic characteristics, we observed that age affects use rates for both cell phones and the Internet, albeit rather differently. The probability of adopting Internet drops with age, while cell phone ownership rates increase among the older generation. Young people are more attracted by new technologies, notably for the purpose of communicating with friends. Nonetheless, the youth still appear to favor the Internet, which offers a wider (and more affordable) array of applications and services than cell devices. For older respondents, cell phone technology is certainly easier to master and its benefits more readily perceptible, as opposed to the Internet.

Marital status bears no impact whatsoever on the adoption rates of these two technologies, though a respondent's employment status plays a very influential role on the propensity to use the Internet and cell phones. Relative to an unemployed person, the probability of Internet use among students or higher-skilled private sector employees is significantly higher. Students can take advantage of Internet accessibility at their academic institution and are undoubtedly

encouraged by their teachers to search for information online. Likewise, higher-skilled members of the workforce would be granted Internet access at their workplace and moreover hold jobs that require Internet connections. On the other hand, the probability of using a cell phone would be higher among non-skilled employees and the self-employed. These results might imply that the cell phone serves as an Internet substitute from a professional perspective (given that the types of professions with a preference for the Internet are not the same as those making greater use of cell phones).

The probability of Internet use increases with the level of computing skill and knowledge acquired (as measured by the ability to use a word processor or spreadsheet or to install a piece of software). Moreover, command of the English language is positively correlated with Internet use. This finding was also observed by Wuvanna and Leifer (2008) and Roycroft and Anantho (2003), and can most certainly be explained by the greater availability of English language content online.

Ownership of a CD player is positively correlated with use of a mobile device, whereas owning a PC understandably appears as being complementary to Internet use. The impact of MP3 player ownership on adoption rates for both cell phones and the Internet was found to be nonexistent.

Income conditions do not influence the rate of cell phone penetration while negatively affect Internet adoption when the data are not adjusted to account for the individual's social environment. Social neighborhood contributes substantially to the decision whether or not to use the Internet. The probability of being a user significantly rises once the respondent admits to having lots of friends using the Internet and belonging to associations. This finding suggests the presence of network externalities among friends (Goolsbee and Zittrain, 1999; Coneus and Schleife, 2010). On the other hand, affiliation with a tontine association or the tendency for other family members to use the Internet has no impact on the decision to opt for the Internet.

The set of factors either stimulating or impeding the adoption of Internet and cell phone technology are summarized in Table 4 below.

Table 4: Summary of the determinants of cell phone and Internet adoption

| | Adoption of cell phone technology | Adoption of the Internet |
|---|---|---|
| Stimulating factors | Older than 30<br>Tertiary degree holder ("License" or "Masters")<br>Self-employed<br>Low-skilled worker | Male<br>15 to 29-year-olds<br>Masters degree holder<br>University student or attending high school<br>Highly-skilled worker<br>English reading fluency<br>Computer training/skills<br>Internet use widespread among friends<br>Membership in associations |
| Hindrances | N/A | Over 30 years old |

We have also introduced cell phone use as an explanatory variable into the Internet adoption models and *vice versa* Internet use as an explanatory variable into the cell phone adoption models. When incorporating respondents' social environment, neither technology exerts an impact on use of the competing technology. The decision to use these two technologies thus seems totally independent; this conclusion has been confirmed by results obtained from the Bivariate Probit model (Table 5). The estimated coefficient $\rho$ is insignificant, thereby suggesting that the penetration of cell phone and Internet services is not correlated.

[INSERT TABLE 5]

## 5. Discussion and conclusion

Our article has demonstrated that the decision to use the Internet and cell phones is influenced by different sets of factors. As regards cell phone technology, the main determinants consist of level of education and age (being older than 30). As for Internet penetration, these determinants are also age (in this case, younger than 30), level of education, computing skills and social neighborhood (as measured by the proportion of Web users within one's social network).

Moreover, our results highlight the sharper divergences regarding Internet use compared to cell phone use. Such divergences relate once again to this issue of the digital divide.

The literature has revealed the existence of two levels of digital divide: a first-level divide between those who have already adopted information technologies and those who (still) have not (i.e. an accessibility divide); and a second-level divide within the adopters, between those able to master use of these technologies and those with a skills deficit in operating these technologies (i.e. a use divide) (Hargittai, 2002). According to DiMaggio, Hargittai, Celeste and Shafer (2004), this second-level divide would be explained by inequalities in the individual equipments in computing and electronic, as well as in the skill levels of adopters and their social entourage.

As observed above, the first-level divide remains considerable on the African continent, especially relative to Internet access. Some rural zones are still barely covered by the cell phone network and poorly connected to the landline network. Yet the second-level divide gives rise to an equally important challenge, whenever a portion of the population is illiterate with no exposure or skills in the area of ICT.

Bridging these divides entails not only improving Internet access conditions (better infrastructure, high-speed service, etc.) and cell phone network coverage, through cutting the price paid for network access (achieved by authorizing the market entry of new telecom operators and service providers), but also upgrading technological training (with as prerequisites raising the average level of education and lowering the illiteracy rate). Such training would allow showcasing the advantages and amenities derived from Internet and cell phone usage.

Promoting digital innovation policies should be a leading priority among Africa's national governments, given the broad scope of ICT within overall economic development. According to Waverman, Meschi and Fuss (2006), a 10% increase in the cell phone penetration rate for an emerging country would correspond to a 0.6% rise in its GDP growth rate. Thanks to more widespread cell phone use, African firms have become more efficient in organizing their production and coordinating relations with both suppliers and clients. Let's take the example of farmers: the cell phone provides them with up-to-date commodity prices and guides them in determining when and where they should market their output (Muto and Yamano, 2009). Along the same lines, for buyers or brokers operating in these same agricultural markets, the cell phone facilitates trades and therefore limits price dispersion or volatility (Aker, 2008, 2010). Information and communication technologies (ICT) have already reshaped daily life for many

Africans. For example, cell phone operators are now proposing mobile payment solutions, like OrangeMoney or M-Pesa, which have been highly successful throughout the continent. Solutions of this kind enable depositing, transferring and withdrawing money or paying bills. For the time being, such services are especially popular among the younger, more highly educated and urban segments of the population (Aker and Mbiti, 2010), thus illustrating the second-level divide relative to ICT use.

Despite the important benefits of information technology, digital policies are actually nonexistent or limited in many African countries. Probably because these technologies can serve as a force of opposition in non-democratic countries by providing access to information outside the country and helping disseminate news without having to rely on official communication channels (which are often subject to censorship). Not only have they allowed hosting discussion forums and played a vital role in the Arab spring uprisings (Tunisia, Egypt, Libya), but these technologies also came to the fore during elections held in several African countries (to ensure more transparency on voting processes). Rhuea and Sundarajan (2011) concluded that cell phone penetration in a country leads to a positive and significant impact on the state of civil liberties and raises the probability of instigating political change within non-democratic regimes.

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## Table 1: Description and summary statistics of the variables

| Variable | Label (binary, Yes = 1; No = 0) | Mean | Std Dev |
|---|---|---|---|
| GENDER | Male | 0.6094675 | 0.4880503 |
| AGE15-21 | Age of the respondent from 15 to 21 | 0.1235207 | 0.3291557 |
| AGE22-29 | Age of the respondent from 22 to 29 | 0.3365385 | 0.4727003 |
| AGE30-44 | Age of the respondent from 30 to 44 | 0.3254438 | 0.4687138 |
| AGE45 | Age of the respondent more than 44 | 0.2144970 | 0.4106249 |
| PRIMARY | Primary or first stage of secondary education | 0.2958580 | 0.4373614 |
| SECONDARY | Upper secondary education (High school level) | 0.2958580 | 0.4565964 |
| TERTIARY1 | The first stage of Tertiary education (University License or Bachelor) | 0.2196746 | 0.4141793 |
| TERTIARY2 | The second stage of Tertiary education (Master, Doctorate) | 0.2226331 | 0.4161679 |
| DIFFICULTY | Living conditions are difficult with my income | 0.6531065 | 0.4761576 |
| PARTNER | Married or with a partner | 0.4193787 | 0.49364 |
| PUBLIC JOB | Worker in the public sector | 0.2181953 | 0.4131735 |
| STUDENT | Student or at school | 0.3276627 | 0.4695348 |
| NO JOB | Retired/pensioned, Housewife, Unemployed | 0.1501479 | 0.3573485 |
| HIGH WORKER | High skill job in the private sector | 0.1087278 | 0.3114126 |
| LOW WORKER | Low skill job in the private sector | 0.0821006 | 0.2746195 |
| SELF-EMPLOYED | Working for one's self : professional services, craftsman, trader) | 0.1161243 | 0.3204924 |
| ENGLISH | English reading skills | 0.4267751 | 0.4947921 |
| USESOFTWARE | Being able to use an office software suite | 0.5443787 | 0.4982109 |
| INSTALLSOFTWARE | Being able to install software | 0.2019231 | 0.4015837 |
| PC | Having a personnal computer | 0.2751479 | 0.446754 |
| CD | Having a CD reader | 0.6331361 | 0.4821273 |
| MP3 | Having a MP3 player | 0.3402367 | 0.473964 |
| FAMILYINTERNET | At least one member of the family use the Internet | 0.2152367 | 0.4111385 |
| FRIENDINTERNET | Many friends use the Internet | 0.512574 | 0.5000268 |
| MEMBERSHIP | Membership in at least one voluntary organisation | 0.2951183 | 0.4562647 |
| TONTINE | Membership in at least one 'tontine' | 0.2418639 | 0.4283707 |
| INTERNETCONNEXION | Having an internet connection at home | 0.147929 | 0.355161 |
| INTERNETFIRST | Have yet used the internet | 0.6109467 | 0.4877159 |
| INTERNET | Using the internet in the last 3 months | 0.4386095 | 0.4964005 |
| MOBILE | Having a mobile phone | 0.9326923 | 0.2506468 |

## Table 2: The determinants of Internet use (logit model)

| **Dependant variable: INTERNET** | | | |
|---|---|---|---|
| **Variable** | **M1** | **M2** | **M3** |
| MOBILE | **0.526499738*** **(0.2822719394)** | 0.3508180256 (0.3151807708) | 0.3048053936 (0.3209087738) |
| GENDER | **0.4659883004*** **(0.1438441582)** | **0.4590737093*** **(0.1620517391)** | **0.3838918245** **(0.1679006548)** |
| AGE15-21 | **0.8361840389*** **(0.2317950163)** | **0.5517443402** **(0.2594375062)** | **0.525912047** **(0.2628631561)** |
| AGE22-29 | Ref. | Ref. | Ref. |
| AGE30-44 | **-0.667172236*** **(0.1974522102)** | **-0.652720776*** **(0.2246744706)** | **-0.685058315*** **(0.2272443412)** |
| AGE45 | **-1.899363224*** **(0.2655772768)** | **-1.712139278*** **(0.3112440966)** | **-1.714069573*** **(0.3125975403)** |
| PRIMARY | **-1.180221646*** **( 0.209330691)** | **-0.712227719*** **(0.2385848244)** | **-0.700539413*** **(0.2406163069)** |
| SECONDARY | Ref. | Ref. | Ref. |
| TERTIARY1 | **0.8003278134*** **(0.1799812137)** | 0.2562328974 (0.2064752024) | 0.2778655371 (0.2083979796) |
| TERTIARY2 | **2.077718925*** **(0.2077036279)** | **0.9752742266*** **(0.2415337316)** | **0.9565425296*** **(0.2421692182)** |
| DIFFICULTY | **-0.434588122*** **(0.1427658312)** | -0.108866892 (0.1639055552) | -0.112224703 (0.1650687206) |
| PARTNER | 0.0471482394 (0.1684661452) | -0.150241532 (0.1941610303) | -0.182614628 (0.1962457561) |
| PUBLIC JOB | **0.432937108** **(0.1869706824)** | 0.27590445 (0.2182373045) | 0.2988299271 (0.2193592843) |
| STUDENT | **0.6873742558*** **(0.2136685348)** | **0.5924681133** **(0.2438011378)** | **0.6175129239** **(0.2463594906)** |
| NO JOB | Ref. | Ref. | Ref. |
| HIGH WORKER | **1.0706279195*** **(0.2553878569)** | **0.5938960141** **(0.2873683739)** | **0.6495739627** **(0.2898034733)** |
| LOW WORKER | 0.0756651987 (0.3023537346) | -0.332118012 (0.3465806291) | -0.415018765 (0.3490591426) |
| SELF-EMPLOYED | 0.1086794054 (0.2793061765) | 0.0231646262 (0.3381637839) | 0.0008647043 (0.3416924125) |
| ENGLISH | / | **0.4683594229*** **(0.1573862245)** | **0.4413884984*** **(0.1584838115)** |
| USE SOFTWARE | / | **1.4025261074*** **(0.1799227456)** | **1.3917206167*** **(0.1826228757)** |
| INSTALL SOFTWARE | / | **0.9633526042*** **(0.2219891694)** | **0.9298347387*** **(0.2234467841)** |
| PC | **/** | **0.5818231671*** **(0.1875788961)** | **0.5989390223*** **(0.1890484269)** |
| CD | **/** | -0.245526986 (0.1802822968) | -0.212159798 (0.1821223475) |
| MP3 | **/** | 0.1932998296 (0.1790409917) | 0.1738369876 (0.1805516861) |
| FAMILYINTERNET | / | 0.1899634861 (0.186813987) | 0.176618702 (0.1881541804) |
| FRIENDINTERNET | / | **0.7830192412*** **(0.1567020011)** | **0.7691744391*** **(0.1576836859)** |
| MEMBERSHIP | / | / | **0.5966132193*** **(0.1753217331)** |
| TONTINE | / | / | -0.072190935 (0.1971947423) |
| Intercept | -1.251829128*** (0.3517830299) | -2.583868609*** (0.4207668546) | -2.62586421*** (0.4268115071) |
| Number of Observations | 1352 | 1352 | 1352 |
| -2 Log L | 1347.040 | 1104.241 | 1092.472 |
| Percent Concordant | 83.1 | 89.2 | 89.5 |

## Table 3: The determinants of mobile phone adoption (logit model)

| **Dependant variable : MOBILE** | | | |
|---|---|---|---|
| **Variable** | **M4** | **M5** | **M6** |
| INTERNET | **0.4887599809*** **(0.2783764332)** | 0.3496587002 (0.3094375386) | 0.3037524195 (0.3103704596) |
| GENDER | -0.249772172 (0.2340014921) | -0.261773506 (0.2361214159) | -0.265694254 (0.2420526934) |
| AGE15-21 | -0.029664546 (0.3268994217) | 0.0080322261 (0.3308434315) | 0.0211756947 (0.3318353784) |
| AGE22-29 | | | |
| AGE30-44 | **0.8698048325** (0.3480341056)** | **0.8997336277** ( 0.351004994)** | **0.8819829472** (0.3511578675)** |
| AGE45 | **0.8740051809** (0.3974012056)** | **0.9831133605** (0.4038119674)** | **0.9537496433** (0.406554299)** |
| PRIMARY | 0.001469415 (0.270248852) | 0.0580488301 (0.2760812757) | 0.0470758933 (0.2773155701) |
| SECONDARY | Ref. | Ref. | Ref. |
| TERTIARY1 | **0.8799194636** (0.3533995877)** | **0.8460994306** (0.3594365949)** | **0.8575418496** (0.3608014809)** |
| TERTIARY2 | **1.3648506806*** (0.4793963136)** | **1.2131056261** (0.5007414869)** | **1.2232109111** (0.4997685272)** |
| DIFFICULTY | -0.284115658 (0.2550269791) | -0.28153104 (0.2611237302) | -0.286941236 (0.2616565511) |
| PARTNER | 0.5463599497* (0.3001534718) | 0.4991447046* (0.3031844453) | 0.466767994 (0.3052861605) |
| PUBLIC JOB | 0.5111690938 (0.3520991505) | 0.4069209284 (0.3659267227) | 0.4118752808 (0.3665382331) |
| STUDENT | 0.4824104749 (0.3170507533) | 0.4950532076 (0.3267230557) | 0.535028848 (0.326632412) |
| NO JOB | Ref. | Ref. | Ref. |
| HIGH WORKER | 0.8456659206 (0.63584861) | 0.6759149997 (0.6440606231) | 0.71024388 (0.6443627502) |
| LOW WORKER | **2.8988359526*** (1.0279665673)** | **2.7713022588*** (1.0301427035)** | **2.7160921779*** (1.0306954934)** |
| SELF-EMPLOYED | **0.9124943538** (0.4151259629)** | **0.8782190869** (0.4213660051)** | **0.8347306307** (0.4226181998)** |
| ENGLISH | / | 0.001315174 (0.2685995135) | -0.020818993 (0.2708295232) |
| USE SOFTWARE | / | 0.0512676276 (0.2914110239) | 0.0288670055 (0.2933349197) |
| INSTALL SOFTWARE | / | 0.7236040949 (0.4820095803) | 0.7264643136 (0.4836566848) |
| PC | / | -0.302516662 (0.3300587409) | -0.281463775 (0.3314609047) |
| CD | / | **0.5434549276** (0.2541992263)** | **0.5518358286** (0.2554476288)** |
| MP3 | / | 0.1036960078 (0.2979297894) | 0.0736242987 (0.2996394898) |
| FAMILYINTERNET | / | 0.1571681523 (0.3141591816) | 0.1440904831 (0.3161544367) |
| FRIENDINTERNET | / | 0.1664470501 (0.2617569929) | 0.1437192163 (0.2617545227) |
| MEMBERSHIP | / | / | 0.4389692116 (0.2991589446) |
| TONTINE | / | / | 0.2457942759 (0.3251739052) |
| Intercept | **1.3558323103*** (0.3784765879)** | **0.9592545266** (0.4162981216)** | **0.8688338792** (0.4243060766)** |
| Number of Observations | 1352 | 1352 | 1352 |
| -2 Log L | 591.452 | 581.022 | 577.905 |
| Percent Concordant | 75.1 | 77.1 | 77.1 |

**Table 5: The determinants of cell phone and internet adoption (bivariate probit model)**

| | MOBILE | INTERNET |
|---|---|---|
| **Variable** | **M7** | **M8** |
| GENDER | -0.0641117<br>(0.1130956) | **0.2031324****<br>**(0.0959426)** |
| AGE15-21 | 0.0346729<br>(0.1761226) | **0.3011462****<br>**(0.1510853)** |
| AGE22-29 | Ref. | Ref. |
| AGE30-44 | **0.4550326*****<br>**(0.1739286)** | **-0.3566676*****<br>**(0.1272764)** |
| AGE45 | **0.4771934****<br>**(0.202065)** | **-0.9435831*****<br>**(0.1729926)** |
| PRIMARY | 0.0041774<br>(0.1444399) | **-0.3910243*****<br>**(0.1346068**) |
| SECONDARY | Ref. | Ref. |
| TERTIARY1 | **0.4573689****<br>**(0.1787473)** | 0.1643974<br>(0.1211547) |
| TERTIARY2 | **0.6110072*****<br>**(0.226117)** | **0.5349025*****<br>**(0.1381469)** |
| DIFFICULTY | -0.1516864<br>(0.1322923) | -0.0825923<br>(0.0939827) |
| PARTNER | 0.2097131<br>(0.1488127) | -0.0934304<br>(0.1104589) |
| PUBLIC JOB | 0.1908688<br>(0.1727135) | 0.1686763<br>(0.1227261) |
| STUDENT | 0.275126<br>(0.1680664) | **0.3579218****<br>**(0.1402684)** |
| NO JOB | Ref. | Ref. |
| HIGH WORKER | 0.3493852<br>(0.2845328) | **0.3609701****<br>**(0.1644131)** |
| LOW WORKER | 1.266198***<br>(0.4170694) | -0.2540263<br>(0.2008825) |
| SELF-EMPLOYED | **0.4382243****<br>**(0.2103494)** | -0.0104994<br>(0.1895964) |
| ENGLISH | 0.0072098<br>(0.1351533) | **0.2528244*****<br>**(0.0915409)** |
| USE SOFTWARE | 0.0265989<br>(0.1474978) | **0.8372935*****<br>**(0.1056296)** |
| INSTALL SOFTWARE | 0.3274679<br>(0.2171387) | **0.5418171*****<br>**(0.1240075)** |
| PC | -0.1061452<br>(0.1640507) | **0.3226352*****<br>**(0.1069331)** |
| CD | **0.2914753****<br>**(0.1290833)** | -0.1037753<br>(0.1043743) |
| MP3 | 0.0369458<br>(0.147105) | 0.1006967<br>(0.1029497) |
| FAMILYINTERNET | 0.0618427<br>(0.1528193) | 0.0808928<br>(0.1061736) |
| FRIENDINTERNET | 0.1051232<br>(0.1308871) | **0.4518417*****<br>**(0.091355)** |
| MEMBERSHIP | 0.1966846<br>(0.1435696) | **0.3515417*****<br>**(0.0996442)** |
| TONTINE | 0.1168461<br>(0.1580424) | -0.0387173<br>(0.1124082) |
| Intercept | **0.6206639*****<br>**(0.2195659)** | **-1.38546*****<br>**(0.1849485)** |
| Number of Observations | 1352 | |
| Log L | -834.56841 | |
| Rho | 0.0823129<br>(0.09112410) | |