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Mobile Phones, Financial Inclusion, and Growth

Mihasonirina Andrianaivo
France Telecom-Orange Group

Kangni Kpodar ✉
International Monetary Fund, Centre for Studies and Research on International Development

Abstract: This paper assesses the impact of mobile phone rollout on economic growth in a sample of African countries from 1988 to 2007. Further, in light of the large financial infrastructure gap in African countries, we investigate whether mobile phone development fosters economic growth through better financial inclusion. In estimating the impact of mobile phone development on growth, we use mobile penetration rate as well as the cost of mobile local calls to capture mobile phone diffusion, while financial inclusion is measured by the number of deposits or loans per head. Using the System Generalized Method of Moments (GMM) estimator to address endogeneity issues, the results confirm that mobile phone development contributes significantly to economic growth in African countries. Part of the positive effect of mobile phone penetration on growth comes from greater financial inclusion.

JEL classification: O30; O40; G20
Keywords: ICT, mobile financial services, economic growth, Africa

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✉ Corresponding author. International Monetary Fund, 1900 Pennsylvania Ave NW - Washington, DC, 20431. (Phone +1 202 623-6062, Fax +1 202 589-6062. Email: kkpodar@imf.org).

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1 Introduction

In recent years, mobile phone diffusion has increased rapidly in African countries in line with similar patterns in other regions of the developing world. It is estimated that 28.5 percent of the population owns a mobile phone in African countries in 2007, compared to 46 percent in East Asia and 66 percent in Latin America.[1] However, the number of mobile telephone subscribers in percent of total population has increased much faster in African countries, at a rate of 45 percent a year on average during 2002-2007, compared to around 30 percent a year in East Asia and Latin American countries.

Meanwhile, Africa remains challenged by a financial infrastructure gap. Financial exclusion is widespread, and the coverage of bank branches and automated teller machines (ATMs) is low.[2] According to FinMark (2009), most of the population in African countries is using informal finance or is financially excluded (for instance, 88 percent of the population in Mozambique and 41 percent in Botswana in 2009). However, the Global System for Mobile Communications Association (GSMA)[3] estimates that there will be 1.7 billion unbanked customers with mobile phones by 2012. As a result, mobile phone diffusion has been seen as a powerful tool to overcome the financial infrastructure gap. Branchless banking services, such as mobile financial services, are becoming increasingly popular in a number of African countries. In this regard, it is worth investigating the benefits mobile phone development can bring to economic growth, in particular through promoting financial inclusion.

This paper specifically analyzes the impact of mobile phone penetration on economic growth rates in Africa, and adds to the model an indicator of financial inclusion to assess whether mobile phone penetration influences growth by improving financial inclusion. The paper also assesses the link between mobile phone development and financial inclusion. Finally, the paper investigates how the interaction among mobile phone penetration, financial inclusion, and growth is at play in countries where mobile financial services take hold.

Recent literature on mobile phones in developing countries has been reviewed by Donner (2008). Jensen (2007) finds microeconomic evidence of positive economic impacts of mobile telephony. By providing information, mobile phones reduce price volatility and increase responsiveness of fishing businesses. Other studies focus on the microeconomic impacts of mobile phones on small and medium-size enterprises (SMEs) (Chowdhury,

[1] The figures are population-weighted averages.

[2] In African countries, there were on average 6 bank branches and 11 ATMs per thousand km2 in 2007.

[3] GSMA is the association representing the interests of the worldwide mobile communications industry.

2006, and Donner, 2006), and some look at the impact of mobile phones on institutions and social domains (such as civil society organizations and libraries). Among the very few macroeconomic studies, Sridhar and Sridhar (2004) and Waverman, Meschi, and Fuss (2005) find that mobile phone development spurs growth. But, studies on Africa are lacking and to our knowledge, the channel of financial inclusion is yet to be analyzed.

This paper contributes to the existing literature in several ways. First, it lays down clearly the channels through which mobile phone diffusion spurs growth, with an emphasis on the financial inclusion channel. Second, it focuses on 44 African countries during 1988-2007 and includes in a standard growth model variables pertaining to mobile phone development such as penetration rates and the price of a three-minute mobile telephone local call. Third, we also use specific indicators of financial inclusion, including the number of deposits or loans per head taking into account various types of financial intermediaries, ranging from formal commercial banks to microfinance institutions, cooperatives and specialized state institutions. Fourth, with regard to the methodology, we undertake robust estimations to address reverse causality from growth to mobile phone diffusion, and any endogeneity issues between the control variables and economic growth by using the System Generalized Method of Moment (GMM) estimator. Finally, we present a financial inclusion model to assess the impact of mobile phone diffusion.

In line with the findings in the literature, we find that mobile phone penetration contributes to economic growth in Africa. In addition, as in Roller and Waverman (2001) and Waverman et al. (2005), our results suggest that mobile phones and fixed lines are substitutes and that the effect of mobile phone development on growth is higher in lower-income countries. A part of the growth effect of mobile phone penetration comes from improved financial inclusion. Moreover, the correlation between financial inclusion and growth becomes stronger as mobile phone technology spreads, especially in countries where mobile financial services are available.

The rest of the paper is organized as follows. Section II reviews the arguments supporting an economic impact of mobile phone development on economic growth, and how the former could also stimulate financial inclusion. It also summarizes the findings of empirical studies on mobile phone development and economic growth. Section III presents the data, the model and the methodology. Section IV follows with a discussion of the results, and the last section concludes with some policy recommendations.

2 Literature Review

2.1 Mobile Phone Development and Growth

Early studies looked at the impact of Information and Communication Technologies (ICT) on economic growth, with a focus on ICT equipment such as the radio, television, and fixed telephone.[4] The role of mobile phone was overlooked as mobile phone development was still in its infancy. Studying the economic impact of mobile phone development has only gained interest since the dramatic surge in mobile phone adoption from the end of 1990s. Nevertheless, the arguments developed earlier to support a positive impact of ICT development on economic growth remain relevant for a more recent technology like mobile telephony. Therefore, this section will discuss in a broader context the implications of ICT development for economic growth, while focusing on the aspects that touch upon the mobile technology.

As pointed out by Tcheng, Huet, Viennois, and Romdhane (2007), ICT development is increasingly considered as an engine for growth, rather than a consequence of it. Three characteristics of ICT explain this view: (i) ICT are omnipresent in most business sectors, (ii) ICT improve continuously and therefore reduce costs for the users, and (iii) ICT contribute to innovation and to the development of new products and processes. Building on the literature, we identify the main channels through which ICT, including mobile phones, can contribute to economic growth. Indeed, ICT spurs economic growth because they contribute directly and indirectly to output growth and employment creation, stimulate capital accumulation, improve firm productivity, generate network and economic externalities, favor better market functioning, reduce transaction costs, and more importantly encourage deeper financial inclusion. Also, ICT development can trigger social and economic development, even though some opportunity costs should be acknowledged. We discuss these channels separately in the following paragraphs, although some of them are closely interlinked.

2.1.1 Contribution to Output and Employment Growth

By supplying telecommunication services, mobile phone companies contribute directly to output growth and employment creation (Lewin and Sweet, 2005). Growth in the mobile telephony sector also has, without doubt, a positive ripple effect in the output growth and employment in the supporting sectors, notably manufacturers, administrators, network builders, sys-

[4] Grace, Kenny, and Qiang (2003) define ICT as tools that facilitate the production, transmission, and processing of information. ICT consist of traditional technologies such as radios modern communication tools and data delivery systems, and new technologies like telephones, computers, and the Internet.

tem managers, providers for mobile content and service applications, and retailing networks.

The impact of mobile phone development on employment creation in African countries has been highlighted by Tcheng et al. (2007). The authors note that because prepaid services dominate in African countries, selling the prepaid cards requires an effective retailing network of wholesalers, individual agents, and even informal sellers, thereby creating business opportunities for people who would have been unemployed otherwise.

2.1.2 Capital Accumulation

ICT development spurs capital accumulation as the ICT sector itself is capital intensive, and the diffusion of ICT in other sectors goes along with investment in ICT equipments. For instance, deploying a mobile telephone network requires sizeable investment in IT hardware, communications equipment and software. Nevertheless, the impact of ICT investment on growth is not straightforward, as it entails two opposite effects. While ICT investment raises capital accumulation, and hence growth, it also accelerates capital depreciation because of the shift of investment composition towards short-lived and high depreciation assets -due to falling prices and ageing- such as ICT equipment (Colecchia and Schreyer, 2001). The net impact is likely to be positive. Using a growth accounting framework, Jorgenson and Vu (2005) find that the contribution of productivity to world growth lagged behind that of capital and labor during 1989-2003. The bulk of the increase in capital input after 1995 resulted from the spike in information and technology (IT) investment, propelled by declining prices of IT equipments, especially in advanced economies. Similarly, Venturini (2009) finds that ICT capital stimulates GDP growth with a magnitude greater than its income share. Haacker (2010) note that even though low- and middle-income countries do not benefit directly from the production of ICT equipment as they are often imported, the benefit of capital deepening arising from falling prices of ICT equipment can be large in those countries, even though it remains lower than that in high-income countries.

ICT development can also contribute to capital accumulation through promoting foreign direct investments (FDI) and by easing financing of public infrastructure projects. Besides new FDI in telecommunication services, ICT development can help other sectors attract FDI as foreign companies, which invest mostly in export-oriented sectors, are more likely to set up in countries where telecommunication infrastructure is well developed. On the other hand, in many African countries, mobile phone operators contribute significantly to government revenue through profit and income taxes, value added tax (VAT) and social security contributions. The sale of licenses can also bring sizeable resources to governments, which can be used to finance critical infrastructure projects that would be beneficial to economic growth.

2.1.3 Productivity Gains

ICT improve firms' productivity by allowing firms to adopt flexible structures and locations. The increased geographic dispersion is a source of productivity gains as it also allows firms to exploit comparative advantages and save on production costs. Further productivity gains also come from better management, through enhanced intrafirm communication, and increased flexibility, owing to the removal of physical constraints on organizational communication (Grace et al., 2003). Small businesses can also increase their productivity with ICT. Voice applications reduce unproductive traveling time and improve logistics, leading to faster and more efficient decision making. They also empower small and medium-size enterprises, painters and plumbers for example, through increased flexibility (Lewin and Sweet, 2005). Donner and Escobari (2010) analyze the findings of 14 studies of the use of mobile telephony by micro and small enterprises (MSEs), and concludes that mobile use encourages MSEs' productivity by streamlining sales, marketing and procurement processes, although the benefits accrued mostly to existing MSEs rather than to new businesses.

2.1.4 Network and Economic Externalities

Early studies show evidence of growth effects of ICT, especially for telephone services and the Internet, through network externalities. As underlined by Grace, Kenny, and Qiang (2003), the value of a telephone line increases exponentially with the number of users connected to the system due to network effects. Once a threshold of users is reached, an explosive growth is recorded. Roller and Waverman (2001) estimate that ICT affect economic growth only when the penetration rate reaches 40 lines per 100 inhabitants. This explains why only developed economies were believed to benefit from ICT development because they were able to mobilize the resources required to reach a "critical mass of telecommunication infrastructure" that can fully exploit network externalities.

Nevertheless, subsequent studies show that, in fact, the positive impact of ICT can be large in developing countries because ICT compare to utilities such as water, electricity, and transportation. Waverman et al. (2005) explain that telecommunication networks are part of social overhead capital (SOC), as are expenditure on education, health services, and roads.[5] As a result, the economic and social return of ICT development is larger than the private return of the network provider.

[5] SOC are capital goods available to anyone (social), not linked to any particular part of production (overhead), and broadly available, implying that they are usually provided by governments.

2.1.5 Market Efficiency and Transaction Costs

An important benefit mobile phone development can bring to developing countries is a reduction in transaction costs. Norton (1992) highlights that the lack of readily available information in developing countries is costly, thereby making information markets relatively inefficient compared to those in developed countries. By reducing the cost of retrieving information, mobile phones improve information flows, increase arbitrage abilities, and facilitate price discovery. They allow better functioning markets and regulation of supply and demand. Moreover, good telecommunication networks substitute for costly physical transport and therefore widen networks of buyers and suppliers, and markets. Aker and Mbiti (2010) notes that while mobile phones require an initial fixed cost, the variable costs associated with their use are significantly lower than equivalent travel and other opportunity costs.[6]

2.1.6 Financial Inclusion

Mobile phone adoption has experienced a strong growth in African countries, reaching 28.5 mobile phones per 100 inhabitants in 2007, from a low level of 4.5 mobiles phones per 100 inhabitants in 2002. In contrast, financial exclusion still remains high in Africa. With the formal financial systems dominated by banks, a large share of the population lacks access to formal savings and credit opportunities as they do not have adequate collateral against which they can borrow.

Information asymmetry is severe, thereby increasing the cost to screen borrowers before making a loan and then to monitor them once they obtain it. The high unit cost of loans makes unprofitable for conventional banks to extend loans to small borrowers. This is worsened by the coverage of bank branches and ATMs in Africa, which is the lowest in the world.[7] Nonetheless, data show that despite a low number of deposits per head in African countries, the average size of deposits relative to GDP per capita is high; this suggests that the propensity to save is actually high, but probably constrained by lack of access to financial services or suitable financial instruments.[8]

African countries are facing a situation whereby the coverage of mobile cellular is getting closer to that of high-income countries, but bank penetration and financial inclusion are lagging behind that of the same group

[6] For instance in Niger, mobile phones reduce search costs by 50 percent as compared with personal travel (Aker and Mbiti, 2010).

[7] African countries have on average 6 bank branches and 11 ATMs per thousand km2 in 2007, about 3 times lower than countries in East Asia and Latin America.

[8] For instance in Africa, the number of deposit account per adult was 0.2 with an average deposit account value of 4 percent of income per capita in 2007, compared to 0.5 deposit account per adult and an average deposit account value of 0.4 percent of income per capita in East Asia.

of countries.[9] The use of this fast growing technology as an opportunity to make up for the large financial infrastructure gap has led to the deployment of several mobile financial service schemes in Africa since the success of M-PESA services in Kenya. It is expected that these innovations in financial services and mobile phone services can potentially drive financial inclusion and growth, notably because mobile phones improve information flows and help provide cost-effective financial services for previously unbanked customers.

Mobile phone diffusion reduces transaction costs, especially the costs of running physical bank branches, thereby encouraging the emergence of branchless banking services.[10] The resulting increased access to financial services for underserved people helps narrow the financial infrastructure gap in developing economies, where the costs of distance and time are very high for formal banking services. Moreover, mobile phone diffusion eases information flows, and the data collected on depositors can be used to analyze credit worthiness more efficiently, improve credit monitoring and facilitate deposit taking. Also, by reducing communication costs, mobile phone development increases arbitrage opportunities and make financial markets more efficient, which in turn lower capital costs (Leff, 1984). Therefore mobile phone diffusion improves access to credit and deposit facilities, allow more efficient allocation of credit, facilitate financial transfers, and boost financial inclusion. Levine (2003) points out that access to external capital is one channel through which financial development matters for growth because it allows financially constrained firms to expand.

According to the GSMA and Mobile Money for the Unbanked (MMU) deployment tracker, three African countries were operating mobile financial services as of end-2007-M-PESA in Kenya, WIZZIT and MTN Mobile Money in South Africa, and CELPAY in Zambia. This number has increased to 30 in 2011.[11] Currently, the most common mobile financial services include domestic money transfers, air time top ups, and bill payments; but there is also a strong desire for savings (Rasmussen, 2010). In addition, international money transfer and loan repayments via mobile phones are becoming widely used. Although prospects for further development of mobile financial services remain strong, they rely on the long-term strategies

[9] About 80 percent of the population in African countries is covered by mobile cellular networks compared to 99 percent in the OECD countries.

[10] Rasmussen (2010) suggests that branchless banking is about 26 percent cheaper than conventional banking.

[11] 27 African countries launched financial services via mobile phones between 2008 and 2011-Benin, Botswana, Burkina Faso, Burundi, Cameroon, Democratic Republic of Congo, Cote d'Ivoire, Djibouti, Egypt, Ghana, Guinea Bissau, Liberia, Madagascar, Malawi, Mali, Morocco, Mozambique, Namibia, Niger, Rwanda, Swaziland, Senegal, Sierra Leone, Somalia, Tanzania, Uganda, and Zimbabwe. Competitive schemes have also started in Kenya with ZAP and YUCASH; in South Africa with Community Banking, Mopay, and Send Money from FNB; and in Zambia with Mobile Transactions.

of stakeholders and on appropriate design of services that respond to customers' needs. The other important factor is the ability of governments to foster innovation and channel payments (Rasmussen, 2010). These schemes are becoming more sophisticated as promising partnerships between mobile telephone companies and microfinance institutions, as well as adequate regulation strengthen mobile financial services. This would widen the range of financial services available via mobile phones, which could include microsavings, micro-loans as well as micro insurance services.

2.1.7 Beyond Growth: Impact on Economic and Social Development

Mobile phone diffusion facilitates rural development. Voice applications allow dispersed families to stay in touch, reducing vulnerability and isolation; improve the bargaining power of farmers; eliminate the middleman; and enable the development of nonagricultural economic activities like ecolodges or women-owned microbusinesses. Mobile phones can also improve households' risk-sharing and allow them to respond better to shocks as information flows within networks is facilitated (Jack and Suri, 2011; Aker and Mbiti, 2010). An increasing number of development projects in the health, education and agricultural sectors are taking advantage of the large diffusion of mobile phones. Aker and Mbiti (2010) underline that in some African countries mobile phones are used to expand the reach of health services, monitor disease outbreaks, facilitate access to agricultural market information, and promote literacy for adults.

2.1.8 Opportunity Costs

Despite its several benefits, mobile phone diffusion involves some opportunity costs. Heeks (1999) points out the negative effects which might arise because of the opportunity costs of investments and expenses in ICT rather than in education and health. Studies show that the share of household income devoted to mobiles services in developing countries is rising, even though it is already higher than that of developed countries.[12] This could reduce households' budgets for food, health, and education. Furthermore, as noted by Grace et al. (2003), some developing countries might fall into a poverty trap if ICT threshold effects are at play. As a result, investment in ICT might not yield tangible economic benefits, when these scarce resources could be used for alternative investment opportunities with higher growth returns.

[12] Tcheng et al. (2007) mention that in some African countries such as Namibia, Ethiopia, and Zambia, households spend up to 10 percent of their monthly income on telephone expenses, whereas the average is 3 percent in developed countries.

2.2 *Empirical Studies*

Two main findings emerge from macroeconomic studies on mobile phone development and economic growth: (i) mobile phone diffusion contributes significantly to economic growth, notably through network effects; (ii) mobile phones and fixed lines appear substitutes rather than complements in developing countries. Sridhar and Sridhar (2004) use Roller and Waverman's (2001) framework by estimating a system of equations that endogenizes economic growth and telecom penetration, while extending the analysis to mobile phones. Using a sample of 63 developing countries with data during 1990-2001, the authors find that the elasticity of aggregate national output with respect to main telephone lines is smaller than that of mobiles, and that cellular services contribute significantly to national output. Waverman et al. (2005) reach similar conclusions on a sample of 92 countries with data between 1980 and 2003. Moreover, the authors find that mobile phones and fixed lines are substitutes in developing countries, but in developed countries they are complements. Kathuria, Uppal, and Mamta (2009) show that Indian states with higher mobile penetration rates can be expected to growth faster, and that there is a critical mass, at a penetration rate of 25 percent, beyond which the impact of mobile phones on growth is amplified by network effects.

Lee, Levendis, and Gutierrez (2009) are among the rare studies that have focused on the effects of mobile phones on economic growth in sub-Saharan Africa. Their findings are not different from that of previous studies. Mobile phones expansion spurs growth in sub-Saharan Africa, with a stronger impact when fixed line penetration is low. However, their study, like previous ones, faces some limitations. The authors do not test for the price effect of telecommunications on growth. Indeed, telecommunications infrastructure could exist but a high access price for consumers could dampen its use despite the high propensity to spend on this technology. In addition, the financial inclusion channel is not explored. Further, their results may be biased because the System GMM estimator is not appropriate for annual data if the variables are not stationary. Our paper attempts to address these shortcomings.

Microeconomic studies also offer some insights into the impact of mobile phones on households and firms. Jensen (2007) asserts that the availability of mobile phones enhances market functioning thereby improving welfare. The author finds that the use of mobile phones by fishermen and wholesalers reduced price dispersion and waste, and increased fishermen's profits and consumer welfare in Kerala, a state in India. Along the same line, Aker (2010) find that mobile phones reduce price dispersion by 10 percent across grain markets in Niger. On the other hand, Muto and Yamano (2009) find that in Uganda, mobile phone coverage expansion improves market participations of producers of more perishable goods. On financial inclu-

Table 1 - Summary Statistics, 1988-2007

	Observations	Average	Standard deviation	Minimum	Maximum
Real GDP growth	190	4.3	4.2	-4.9	40.9
Primary school enrollment rates	190	89.7	28.5	26.9	181.2
Government consumption in percent of GDP	190	14.7	5.4	2.6	35.0
Inflation rate	190	10.3	13.4	-5.9	83.6
Institutions	190	0.268	0.152	0.143	1.000
Fixed telephone lines per head	189	0.028	0.049	0.0	0.286
Mobile telephone subscribers per head	190	0.063	0.136	0.0	0.792
Price of 3-minute mobile local call (US dollar)	170	0.498	0.476	0.0	1.853
GDP per head (current US dollar)	190	1,207	1,816	97	14,320
Number of deposits per head	190	0.064	0.129	0.0	0.739
Number of loans per head	190	0.011	0.024	0.0	0.125
Private credit to GDP	185	0.170	0.151	0.020	0.712

sion, Mbiti and Weil (2011) find that the rapid diffusion of M-Pesa has tangible economic impact, including promoting banking penetration, increasing transfers and reducing the prices of competing money transfer services.

3 Data and Empirical Strategy

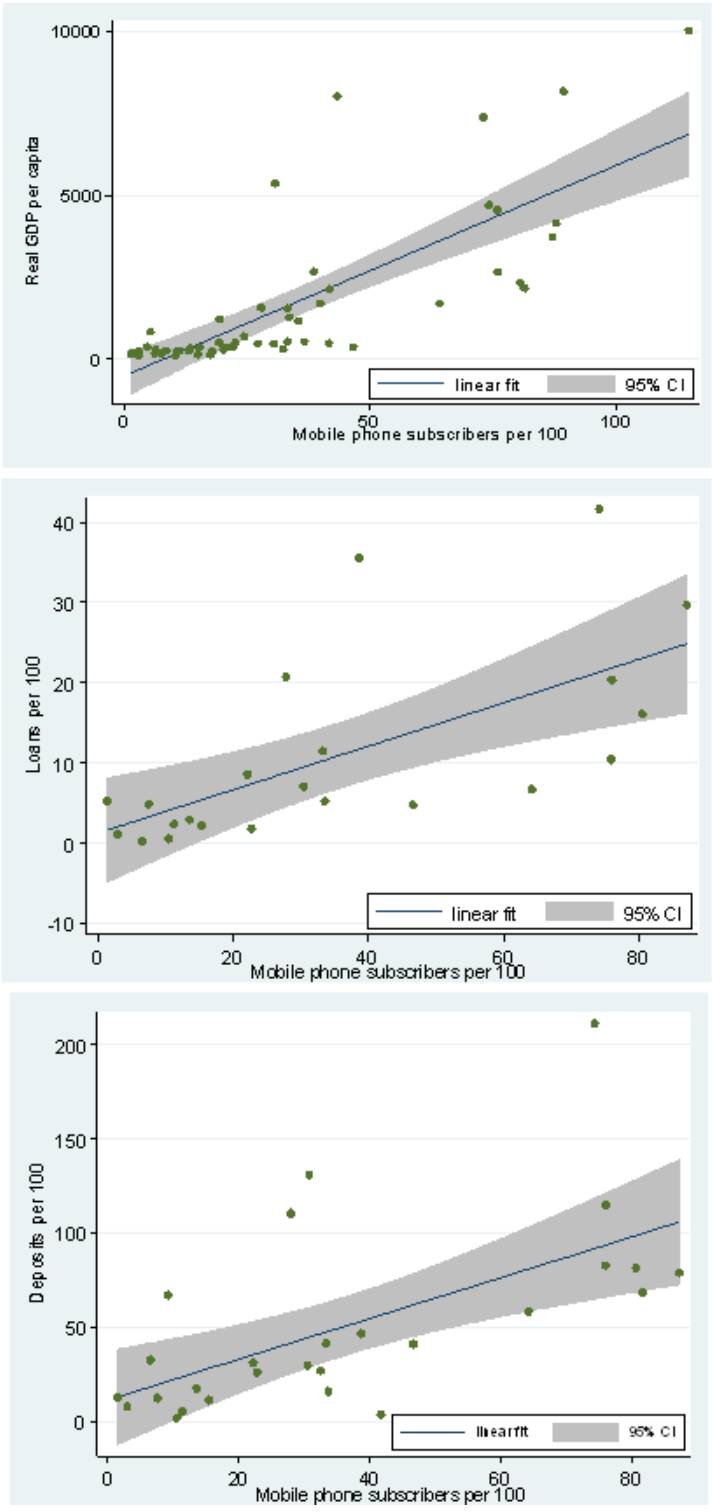
The data consists of a panel of 44 African countries. Appendix 1 shows the countries included in the sample, with data from 1988 through 2007. Deployment of mobile phones really began in the 1990s, thus dictating our study period. Because this study focuses on long-term growth, and to avoid stationary issues associated with annual data, the variables are averaged over four years. The sample period is therefore divided into five sub-periods as follows: 1988-1991, 1992-1995, 1996-1999, 2000-2003, and 2004-2007.

On average, African economies grew by 4.3 percent during the period considered, while average mobile phone penetration stood at 6.3 percent, more than twice the penetration rate of fixed lines (Table 1). The number of deposits per 100 inhabitants was 6.3, compared with 1.1 for the number of loans per 100 inhabitants, suggesting that access to credit was more constrained that that to deposit. This weak financial inclusion level reflected a shallow financial depth in African countries, with the average private credit ratio being 17 percent of GDP during the study period.

Figure 1 suggests that higher mobile phone penetration rate is associated with higher real GDP per capita and higher access to loans and deposits in African countries. Although this tends to support our main hypotheses, a more rigorous framework is needed to test these hypotheses in order to address omitted variable bias and reverse causality issues that affect simple bivariate relationships.

We use a standard endogenous growth model to examine the relationship between mobile phone development and economic growth. The equa-

Figure 1 - Mobile Penetration, GDP per capita, and Financial Inclusion



Sources: Beck, Demirguc-Kunt, and Martinez Peria (2007), International Telecommunication Union, FinMark (2009), and authors' calculations.

tion is as follows:[13]

$$y_{i,t} - y_{i,t-1} = \alpha y_{i,t-1} + \beta Mob_{i,t} + \Gamma X_{i,t} + \eta_i + \epsilon_{i,t}$$

where the variable $y_{i,t}$ is the logarithm of real per capita GDP, $Mob_{i,t}$ is the level of mobile phone development, $X_{i,t}$ a set of growth determinants (including primary school enrollment rate, inflation, government consumption, and institutional development), η_i is an unobserved country-specific effect, $\epsilon_{i,t}$ is the error term, and i and t represent country and time period respectively.[14]

Appendix 2 provides the variable definitions and sources. Data are obtained mainly from the International Financial Statistics, the Word Development Indicators, the Financial Structure Database, the International Telecom Union Database, Beck et al. (2007) and the Consultative Group to Assist the Poor (CGAP, 2009).

The covariates may not be strictly exogenous. They can be predetermined (correlated with past observation-specific disturbances) or endogenous (correlated with past and current observation-specific disturbances). Blundell and Bond (1998) (henceforth BB) develop a System GMM estimator to address issues associated with predetermined and endogenous variables. We choose the BB estimator because it performs better than Arellano and Bond's estimator when the autoregressive coefficient is relatively high, and the number of periods is small.[15]

Moreover, the validity of the internal instruments used must be checked to make sure the results are valid. As noted by Roodman (2009) the use of System GMM estimators must be done with great caution, and several checks must be done before relying on the estimation results, especially when T is small and the number of internally determined instruments is high. Because too many instruments can overfit instrumented variables-failing to remove their endogenous components and biasing the coefficient estimates (Roodman, 2009) - we keep the number of instruments to the minimum.[16] For the lagged real GDP per capita, we use as instruments the first difference lagged one period for the equations in levels assuming that it is

[13] As in the literature on finance and growth, the growth equation above could be rewritten as follows:

$$y_{i,t} = \lambda y_{i,t-1} + \beta Mob_{i,t} + \Gamma X_{i,t} + \eta_i + \epsilon_{i,t}$$

with $\alpha = \lambda - 1$.

[14] The logarithm of one plus the inflation rate is taken to avoid placing a heavy weight on a small number of high inflation observations.

[15] Blundell and Bond (1998) estimation requires that the series are mean stationary $(y_{i,1}, y_{i,2}, ...y_{i,T})$, that is, they have a constant mean $\frac{\eta_i}{1-\alpha}$ for each country i.

[16] The validity of the BB estimators is checked by using the p-values of a Hansen-Sargan test of overidentifying restrictions. It tests for joint validity of the full instrument by checking whether the instruments, as a group, appear exogenous. We also check the p-values of the Arellano-Bond test for AR(1) and AR(2) serial correlation of the residuals. In most regressions, the results of the Hansen and AR tests support the use of the BB estimator.

predetermined. For the equations in first difference, we use the first lagged value. For the other variables, which are assumed endogenous, we use the second lagged value as instruments. We adopted the two-step System GMM with Windmeijer (2005) small sample robust correction.

To test whether financial inclusion is one of the channels through which mobile phone development stimulates growth, we add to the growth model a variable of financial inclusion-captured by either the number of deposits or the number of loans per head-to check how the coefficient on mobile phone development moves. If this coefficient weakens, we can conclude that part of the beneficial impact of mobile phone development on growth is channeled through financial inclusion. This will be supplemented by a separate model explaining financial inclusion by mobile phone development and a number of control variables.

We strengthen the analysis by including in the growth model an interaction term between mobile penetration and financial inclusion. We assess whether, by improving financial inclusion, mobile penetration is at the same time reinforcing its own impact on economic growth. Similarly, this allows us to test whether the impact of financial inclusion on growth is strengthened by better mobile phone diffusion. We also refine the analysis by isolating the impact of mobile phone development on growth through financial inclusion in countries that have implemented financial services on mobile phones.

4 Results

4.1 Mobile Phone Development and Growth

Table 2 summarizes the results of the impact of mobile phone development on economic growth. Mobile penetration rate (the number of mobile telephone subscribers divided by total population) which measures mobile phone development is found to have a significant and positive impact on economic growth in Africa, consistent with the findings of Roller and Waverman (2001) and Lee et al. (2009).[17] This result suggests that an additional 10 percentage point increase in the mobile penetration rate is associated with a 0.6 percentage point increase in real GDP growth (column 2, Table 2).

Measuring mobile phone penetration is difficult, especially in African countries as data are scarce. Also, with the use of multiple SIM cards being common in Africa, the number of mobile telephone subscribers might overestimate the actual number of mobile customers. Inactive SIM cards can also weaken the accuracy of this indicator.[18]

[17] We obtained similar results with the growth rate of mobile telephone penetration.

[18] Customers use multiple SIM cards to take advantage of temporary attractive promo-

Table 2 - Impact of Mobile Phone Development on Economic Growth in Africa, 1988-2007

	(1)	(2)	(3)	(4)	(5)	(6)
Initial GDP (log)	-0.230 [0.034] ***	-0.090 [0.013] ***	-0.010 [0.007] ***	-0.060 [0.003] ***	-0.060 [0.002] ***	-0.060 [0.004] ***
Mobile telephone subscribers per head	----	0.056 [0.017] ***	----	0.300 [0.024] ***	0.162 [0.014] ***	0.112 [0.037] ***
Price of 3-minute mobile local call	----	----	-0.085 [0.020] ***	----	----	----
Fixed telephone lines per head	----	----	----	0.747 [0.058] ***	1.184 [0.097] ***	0.060 [0.089]
Fixed × Mobile telephone subscribers per head	----	----	----	-2.548 [0.088] ***	-0.855 [0.153] ***	----
Mobile telephone subscribers per head × GDP per capita	----	----	----	----	----	-0.012 [0.007] *
Education	0.005 [0.001] ***	0.003 [0.000] ***	0.002 [0.000] ***	0.000 [0.000]	0.000 [0.000] ***	0.001 [0.000] ***
Government consumption	-0.025 [0.003] ***	-0.020 [0.001] ***	-0.003 [0.002] *	-0.012 [0.001] ***	-0.013 [0.001] ***	-0.014 [0.001] ***
Inflation (log)	-0.526 [0.151] ***	-0.274 [0.100] ***	-0.435 [0.073] ***	-0.448 [0.029] ***	-0.415 [0.040] ***	-0.417 [0.038] ***
Institutions	-0.064 [0.163]	0.025 [0.056]	0.075 [0.046]	0.042 [0.018] **	0.055 [0.007] ***	0.080 [0.009] ***
Constant	5.214 [0.706] ***	2.196 [0.284] ***	-0.151 [0.153]	1.709 [0.086] ***	1.636 [0.049] ***	1.546 [0.099] ***
Observations	190	190	170	189	182	189
Number of countries	44	44	41	43	41	43
Hansen test (prob.)	0.54	0.61	0.32	0.75	0.42	0.75
AR1 (prob.)	0.89	0.10	0.05	0.45	0.32	0.28
AR2 (prob.)	0.23	0.34	0.27	0.34	0.38	0.38

Notes: Standard errors in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%

We improve on previous empirical studies by considering the cost of communication for consumers as an alternative indicator of mobile phone development, which is less subject to measurement errors. The rationale is that affordable communication costs for consumers could stimulate the use of mobile telephones and at the same time, the widespread use of mobile telephones leads to lower unit production costs for telephone companies that could be passed on to customers[19] Lower price for mobile communications entail a substitution effect (a decline in the relative price of mobile telephone calls to fixed telephone calls for example), which is reinforced by an income effect (an increase in consumers' real income). As a result, we expect a negative correlation between communication costs and the penetration rate of mobile telephone, and hence economic growth. The results confirm that the price of a 3-minute mobile telephone local call (in US dollar) is negatively associated with economic growth (column 3, Table 2). The magnitude of the mobile price effect on growth may not be negligible. For instance in Ghana, the cost of a 3-minute mobile telephone local call dropped

tions, own-network preferential rates and services from different mobile network operators (MNOs). Differences in network quality and coverage can also explain the use of multiple SIM cards.

[19] The volume of traffic such as the number of minutes of voice calls, or network indicators such as the number of Base Transceiver Station (BTS) could also be used to measure mobile phone diffusion, but the data are not readily available for most African countries.

dramatically, by 62 percent, from USD 1.18 in 1999 to USD 0.46 in 2006; this would yield a 6 percent increase in real income over eight years.[20] Egypt and Mozambique experienced a drop in mobile communication cost by a similar magnitude during the same period.

Given the widespread use of the mobile penetration rate in the literature, we keep it in the subsequent regressions, bearing in mind its shortcomings. As expected, the coefficient on the interaction term between the penetration rate of mobile and fixed telephones is negative and significant (column 4, Table 2), suggesting mobile telephones are substitutes for fixed telephones in Africa.[21] If the fixed line penetration rate moves from the bottom to the top quartile (0.35 percent to 2.8 percent), the growth impact of a 10 percentage point increase in the mobile penetration rate would drop from 2.9 to 2.2 percentage points. The latter figure is close to the marginal impact at the average fixed line penetration rate, reflecting a skewed distribution. Surprisingly, the marginal impact turns negative for fixed line penetration rates above 12 percent. This concerns about 5 percent of observations or only 2 (Mauritius and Seychelles) out of 43 countries in the sample-when considering the average fixed line penetration rate in 1988-2007 (see Figure 2). Perhaps the marginal impact does not drop as fast as implied by the data as this result might be driven by influential observations (countries with a relatively high fixed penetration rate). Also, in small and densely populated countries, it might be possible that the benefit from mobile phone development is smaller, and offset by the substitution away from fixed networks, in particular when new growth engines for fixed networks such as broadband internet and data transport services to businesses are lacking.[22] Excluding Mauritius and Seychelles from the sample confirms that the marginal impact of mobile phone development on growth drops with increasing fixed line penetration, but at a slower pace (column 5, Table 2).

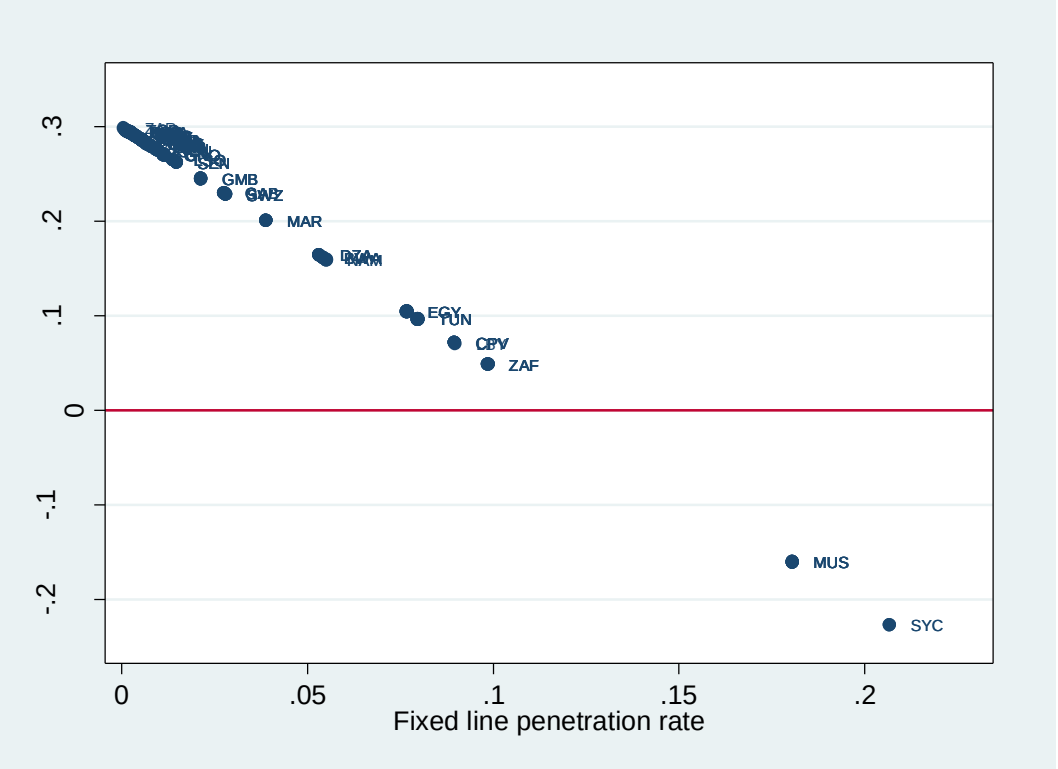
The marginal impact of the fixed penetration rate on economic growth appears stronger than that of the mobile penetration rate, which contrasts with previous findings (see Sridhar and Sridhar, 2004, on a sample of developing economies, and Waverman et al. 2005). This suggests that there is

[20] This impact is smaller when controlling for the price effect of fixed telephone (see Andrianaivo and Kpodar, 2011) as declining price of mobile phone call has also led to a fall in the price of fixed telephone call.

[21] The substitution effect shown in African countries is not surprising given the shortage of fixed telephone lines. In this case, the substitution effect results from the lack of extensive wired infrastructure and cost factors (smaller fixed costs for infrastructure and availability of cheap handsets), rather than from a change in the demand for telecommunication services. Also, market structure had played a critical role. In contrast to the fixed line market which is often dominated by state-owned monopolies, the mobile phone market is generally open to the private sector and more competitive, leading to a sharp drop in mobile phone call charges.

[22] However, the negative impact on growth should not be large. In the robustness analysis, we also checked the baseline results for sensitivity to the exclusion of Mauritius and Seychelles.

Figure 2 - Marginal Impact of Mobile Phone Diffusion on Growth, 1988-2007*



* Source: Authors' calculations

room to improve further the contribution of mobile phone development to economic growth in Africa.[23]

Further, we introduce in the model an interaction term between mobile penetration rate and GDP per capita and find that the marginal impact of mobile phone development drops with increasing level of income per capita (column 6, Table 2), reflecting probably diminishing growth returns to mobile telephone development. This is consistent with the findings of Waverman et al. (2005) that show a stronger impact of mobile telephones in lower income countries.

Turning to the control variables, we find that as shown by past studies, high government consumption and macroeconomic instability captured by high inflation rates dampen economic growth in African countries. While human capital accumulation appears to favor growth, the legal environment only come out significant in two out of five specifications, probably because the civil and political liberty indexes may not capture well the strength of the law in African economies.[24] There is also evidence of growth

[23] It is worth noting that the prospects for increasing the penetration rate of fixed telephones appear more limited than for mobile telephones, even in Africa, underlining the importance of mobile telephone development as a source of growth.

[24] Using an alternative indicator of legal environment such as the rule of law gives a better result, but unfortunately reduces the sample size by a quarter-the reason we did not retain

convergence among African countries as countries with lower initial income tend to grow faster than others with similar macroeconomic conditions, level of human capital, and institutions.

Table 3 - Robustness Tests, 1988-2007

	(1)	(2)	(3)	(4)	(5)	(6)
Initial GDP (log)	-0.040 [0.005] ***	-0.060 [0.020] ***	-0.140 [0.012] ***	-0.020 [0.006] ***	-0.020 [0.005] ***	-0.070 [0.011] ***
Mobile telephone subscribers per head	0.071 [0.010] ***	0.078 [0.032] ***	0.226 [0.006] ***	0.104 [0.019] ***	0.104 [0.018] ***	----
Mobile telephone subscribers per head (t-1)	----	----	----	----	----	0.103 [0.056] *
Mobile telephone subscribers per head × Africa	----	----	----	----	-0.034 [0.032]	----
Education	0.002 [0.000] ***	0.002 [0.001] ***	0.001 [0.000] ***	0.002 [0.001] **	0.001 [0.000] ***	0.004 [0.001] ***
Government consumption	-0.012 [0.001] ***	-0.024 [0.005] ***	-0.015 [0.001] ***	-0.017 [0.003] ***	-0.017 [0.002] ***	-0.020 [0.001] ***
Inflation (log)	-0.394 [0.021] ***	-0.514 [0.130] ***	-0.725 [0.056] ***	-0.278 [0.106] ***	-0.369 [0.075] ***	-0.188 [0.089] ***
Institutions	0.082 [0.016] ***	-0.003 [0.102]	-0.089 [0.081]	0.006 [0.043]	0.045 [0.029]	-0.044 [0.061]
Constant	0.992 [0.112] ***	1.647 [0.438] ***	3.404 [0.273] ***	0.660 [0.137] ***	0.633 [0.111] ***	1.652 [0.258] ***
Observations	205	150	157	451	451	154
Number of countries	43	42	36	114	114	43
Hansen test (prob.)	0.93	0.21	0.53	0.03	0.06	0.68
AR1 (prob.)	0.22	0.20	0.87	0.16	0.17	0.07
AR2 (prob.)	0.96	0.17	0.24	0.92	0.92	0.27

Notes: Standard errors in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%. Africa is a dummy variable taking 1 for African countries and 0 otherwise. Column: (1) Data averaged over 3-year periods. (2) Data averaged over 5-year periods. (3) Sample of sub-Saharan African countries, excluding Mauritius, Seychelles, and South Africa. (4) and (5) Sample of developing countries. (6) Baseline model with the lagged variable of mobile penetration rate.

Several robustness tests are carried out using the specification in column 2 of Table 2. Averaging the data over a three-year period increases the sample size by 8 percent, without dramatically changing the results (column 1, Table 3). Moving to a five-year average reduces the sample by 20 percent but does not affect the quality of the results (column 2, Table 3). We restricted the sample to sub-Saharan African countries, excluding the top performers in the region (Mauritius, Seychelles, and South Africa). The coefficient on mobile is positive and significant, with a larger magnitude (column 3, Table 3).[25] In addition, the regression is run on a sample of developing countries; we find that mobile telephone development stimulates economic growth and that the marginal impact for African countries is not statistically different from that of other developing economies (columns 4 and 5, Table 3).[26] Furthermore, using the lagged mobile penetration rate does not alter the previous conclusions (columns 6, Table 3). Finally, we conducted several

this indicator.

[25] Probably because the countries included in the sample have lower income per capita. The result in Table 2 (column 5) shows that the marginal impact of mobile phone penetration on growth declines as income per capita increases.

[26] Developing countries consist of low and middle income countries in line with the World Bank classification.

stability tests for the coefficient on mobile phone development and find two main results: (i) the marginal impact is heterogeneous across the sample, suggesting the growth benefits from mobile phone development may not be immediate and may depend on country-specific factors that should be accounted for; (i) the marginal impact tends to decline with increasing mobile penetration rates, reflecting a lack of network effects in African countries. [27]

4.2 Accounting for Financial Inclusion

In this section, we investigate whether mobile phone development stimulates growth by fostering financial inclusion and whether the interaction between mobile phone and financial inclusion facilitates economic growth. Before turning to the regressions, it is worth noting the challenge of measuring financial inclusion in the sense of greater access of households to financial services. Very few measures of financial inclusion exist, and those that do lack time dimension and are available for only a limited number of countries. We retained two relevant indicators for our study. The first is the number of deposits per head-including deposits at commercial banks, cooperatives, microfinance institutions, and specialized state financial institutions-and the second is the number of loans per head-also including loans granted by the previously mentioned financial institutions. Because of limited data on the number of deposits and loans per head (the data are available for 2003 and 2007), we assume the average level holds throughout the period.[28] This prevents us from using the lagged variable to address the endogeneity of financial inclusion; however, the robustness analysis would show that the quality of the results is not affected.

In columns 2 and 4 of Table 4, the coefficient on the number of deposits per head and that on the number of loans per head are positive and significant, implying that greater financial inclusion is associated with higher

[27] More details can be found in Andrianaivo and Kpodar (2011).

[28] Given that financial development and financial inclusion are closely related phenomenon, we used the tests of equality of mean and variance of the private credit ratio for the two periods (2003-2007 and 1988-2007) to assess the validity of our assumption. The correlation coefficient between the private credit ratio and the number of deposits per head was 0.43 in 2003 and 0.74 in 2007. With the number of loans per head, the correlation coefficient was 0.43 in 2003 and 0.80 in 2007. The results presented in Table 5 reject the null hypothesis of equal mean, with the average private credit ratio being 17 percent in 1988-2007, and 18 percent in 2003-2007. Therefore, using the financial inclusion indicators measured in 2003-2007 for the period 1988-2007 will tend to overestimate the true level of financial inclusion. This would not lead to biased coefficient estimates unless the "measurement error" is correlated with country characteristics. The test of equal variance and the Spearman's rank tend not to support this hypothesis as they fail to reject the null hypothesis of equal distribution, suggesting that financial development grew on average uniformly during the two periods. The implication for the financial inclusion indicators is that their coefficients are less likely to be biased since the System GMM estimator would rely on cross-country variations for the purpose of identification.

Table 4 - Mobile Penetration, Financial Inclusion, and Economic Growth in Africa, 1988-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Initial GDP (log)	-0.110 [0.009] ***	-0.150 [0.015] ***	-0.070 [0.007] ***	-0.160 [0.013] ***	-0.110 [0.009] ***	-0.080 [0.011] ***	-0.120 [0.014] ***	-0.060 [0.005] ***
Mobile telephone subscribers per head	0.075 [0.016] ***	0.042 [0.009] ***	-0.014 [0.015]	0.043 [0.011] ***	0.005 [0.024]	-0.043 [0.037]	-0.009 [0.033]	-0.040 [0.030]
Number of deposits per head	----	0.658 [0.154] ***	0.087 [0.005] ***	----	----	0.060 [0.017] ***	----	----
Mobile × Number of deposits per head	----	----	0.103 [0.034] ***	----	----	0.120 [0.072] *	----	----
Mobile × Number of deposits per head × Mobfi	----	----	----	----	----	2.199 [0.238] ***	----	----
Number of loans per head	----	----	----	3.540 [0.870] ***	0.919 [0.043] ***	----	1.059 [0.091] ***	----
Mobile × Number of loans per head	----	----	----	----	1.756 [0.311] ***	----	0.727 [0.328] **	----
Mobile × Number of loans per head × Mobfi	----	----	----	----	----	----	8.832 [0.815] ***	----
Private Credit/GDP	----	----	----	----	----	----	----	0.139 [0.049] ***
Mobile × Private Credit/GDP	----	----	----	----	----	----	----	0.132 [0.058] **
Mobile × Private Credit/GDP × Mobfi	----	----	----	----	----	----	----	0.335 [0.145] **
Mobfi	----	----	----	----	----	-0.065 [0.021] ***	-0.116 [0.021] ***	-0.072 [0.070]
Education	0.004 [0.000] ***	0.004 [0.001] ***	0.003 [0.000] ***	0.005 [0.001] ***	0.004 [0.000] ***	0.003 [0.000] ***	0.004 [0.000] ***	0.002 [0.000] ***
Government consumption	-0.020 [0.001] ***	-0.030 [0.001] ***	-0.015 [0.001] ***	-0.028 [0.001] ***	-0.022 [0.001] ***	-0.017 [0.001] ***	-0.022 [0.001] ***	-0.012 [0.001] ***
Inflation (log)	-0.293 [0.107] ***	-0.195 [0.159]	-0.360 [0.052] ***	-0.120 [0.148]	-0.194 [0.066] **	-0.377 [0.069] ***	-0.206 [0.085] **	-0.308 [0.029] ***
Constant	2.518 [0.218] ***	3.481 [0.374] ***	1.534 [0.160] ***	3.635 [0.316] ***	2.575 [0.207] ***	1.895 [0.241] ***	2.817 [0.297] ***	1.369 [0.103] ***
Observations	190	190	190	190	190	190	190	184
Number of countries	44	44	44	44	44	44	44	42
Hansen test (prob.)	0.60	0.59	0.59	0.66	0.44	0.57	0.71	0.64
AR1 (prob.)	0.16	0.03	0.38	0.03	0.06	0.34	0.05	0.43
AR2 (prob.)	0.32	0.20	0.40	0.25	0.32	0.32	0.27	0.42

Notes: Standard errors in brackets; * significant at 10%; ** significant at 5%; *** significant at 1% . Mobfi is a dummy variable taking 1 for countries where financial services on mobile telephones are available, and 0 otherwise.

Table 5 - Comparing the Level and Distribution of the Private Credit Ratio during 1988-2007 and 2003-2007

	1988-2007	2003-2007
Private credit to GDP		
Average	0.17	0.18
Standard deviation	0.15	0.17
Test of equality of means (prob.)	0.05	
Test of equality of variance (prob.)	0.13	
Spearman's rank test (prob.)	0.00	
rho statistic	0.91	

economic growth in African economies. Interestingly, the coefficient on the mobile penetration rates drops when controlling for financial inclusion, suggesting that some of the positive impact of mobile phone development on growth is channeled through financial inclusion. Further, the penetration of mobile telephones reinforces the correlation between financial inclusion and growth as shown by the positive and significant coefficient on the interaction term between the mobile penetration rate and the number of deposits

per head (column 3, Table 4). The same result holds for the interaction term between the mobile penetration rate and the number of loans per head (column 5, Table 4). These results confirm that mobile telephone penetration may foster economic growth not only by facilitating financial inclusion, but also by strengthening the link between financial inclusion and growth.

To refine our analysis, we considered that financial services on mobiles remain underdeveloped in African countries and are available only in a few countries. During the period covered by our study, three countries were operating mobile financial services: Zambia since 2001, South Africa since 2004, and Kenya since 2007. We constructed a dummy variable (named Mobfi), taking the value of 1 from the year mobile financial services become available in a country and 0 otherwise. Crossing this dummy variable with the interaction term between financial inclusion and mobile penetration shows that in countries where mobile financial services exist, the correlation between financial inclusion and growth is stronger than in countries where these services are yet to be deployed (columns 6 and 7, Table 4).

As a robustness test, we checked for the potential influence of outliers by removing from the sample observations with a residual term larger than (i) two standard deviations, (ii) one standard deviation, and (iii) one-half standard deviation of the dependent variable. Rerunning the regressions without these potential outliers does not affect the quality of the results. In addition, the results are confirmed when using the private credit ratio, an indicator of financial development, which is closely correlated to financial inclusion. Unlike the financial inclusion indicators, the private credit ratio varies across time and countries and its lagged values can be used to address endogeneity issues. The conclusions remained, nevertheless, unchanged. While financial development appears positively correlated with growth (consistent with the findings of Levine, Loayza, and Beck, 2000), the interaction term between financial development and mobile penetration is also positive and significant, suggesting that financially well-developed countries tend to grow faster when mobile penetration is high (column 8, Table 4). This effect appears stronger in countries where mobile financial services are available.

4.3 Assessing the Effect of Mobile Phone Penetration on Financial Inclusion

We found in Table 4 that the effect of mobile penetration on growth weakened once financial inclusion was controlled for, suggesting that the latter could be one of the channels through which mobile penetration positively influences growth. However, this conclusion was based solely on the change in the coefficient on mobile phone penetration, without properly modeling financial inclusion. Building on Kendall, Mylenko, and Ponce (2010), we estimate the effect of mobile phone development on financial in-

clusion, while controlling for a range of factors including income levels and population density. Our model is as follows:

$$FI_{i,t} = \gamma_0 + \gamma_1 y_{i,t} + \gamma_2 Dens_{i,t} + \gamma_3 Mob_{i,t} + \sum_{k=1}^{n} X_{i,t}^{k} + \delta_i + \epsilon_{i,t}$$

where FI the dependent variable, stands for financial inclusion, measured by the number of deposits and loans per head; Mob our variable of interest, denotes the mobile phone penetration rate; y and $Dens$ the main control variables, represent, respectively, the level of GDP per head and population density; X is a set of other control variables, including banks' overhead cost to account for the efficiency of financial intermediaries, a variable capturing the quality of the legal environment, and the number of bank branches per km2 to capture the geographical coverage of bank branches.[29] [30] Finally, δaccounts for country-specific effects and $\epsilon$is the error term.

In contrast to Kendall et al. (2010), we use a panel regression because data on the indicators of financial inclusion are available for 2003 and 2007. The data on the explanatory variables are averaged over two periods of four years each: 2000–2003 and 2004–2007. Given the limited time dimension of the data, we choose to run the model with the random effect estimator, though this estimator relies on the strong assumption of exogenous country-specific effects. However, the probability of the Hausman test is higher than 0.10, suggesting that use of a random-effect model is appropriate.

The results presented in Table 6 suggest that mobile phone development is positively correlated to financial inclusion. This holds even after controlling for GDP per head and population density, as well as for the cost of financial intermediation, the legal environment and the geographical coverage of bank branches.[31] Similarly, by using household survey data, Beck et al. (2010) find that the ownership of a cell phone increases the likelihood of using financial services in Kenya.

Interestingly, a better coverage of bank branches and good institutions enhance financial inclusion. While higher GDP per head, bank efficiency and population density are positively associated with access to deposits, the results are less clear for access to loans. For instance, population density has surprisingly a negative sign, when branch density is included in the model. One explanation could be found in the ways financial institutions handle risk diversification. Formal financial institutions such as commercial banks

[29] Kendall et. al (2010) did not include banking sector efficiency in their model, but we believe that it is a relevant explanatory variable for financial inclusion as the high cost of small loans and deposits is often viewed as one of the main reasons of a high degree of financial exclusion.

[30] For consistency purposes, the indicator of the quality of institutions is the same as in the growth model. Kendall et al. (2010) use indicators of contract enforcement, creditor right protection and creditor information.

[31] We also tested the effect of inflation and banking concentration on financial inclusion as in Kendall, Mylenko, and Ponce (2010), but none was significant.

Table 6 - Mobile Phone Development and Financial Inclusion, 2000-2007

	Number of deposits per head		Number of loans per head	
	(1)	(2)	(3)	(4)
Mobile telephone subscribers per head	0.382 [0.161] **	0.101 [0.036] ***	0.211 [0.084] **	0.071 [0.011] ***
GDP per head(log)	0.132 [0.047] ***	0.093 [0.032] ***	0.015 [0.016]	-0.001 [0.010]
Population density (log)	0.098 [0.035] ***	0.065 [0.030] **	0.007 [0.010]	-0.023 [0.010] **
Banks' overhead cost (percent of assets)	----	-1.405 [0.682] **	----	0.227 [0.202]
Institutions	----	0.95 [0.142] ***	----	0.279 [0.073] ***
Number of bank branches per km2	----	0.005 [0.001] ***	----	0.002 [0.000] ***
Constant	-1.008 [0.347] ***	-0.802 [0.227] ***	-0.104 [0.111]	0.034 [0.070]
Observations	49	39	46	36
Number of countries	36	31	34	29
R2 (between)	0.47	0.68	0.37	0.55
Hausman test (prob)	0.69	0.34	0.99	0.57

Note: Standard errors in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%

are less likely to lend to customers that are geographically concentrated so as to limit collective risk. But less formal financial institutions such as microfinance institutions tend to have geographically concentrated customers to ease group lending. As our indicators of financial inclusion possibly underestimate the access to less formal financial services, the negative sign of population density might be driven by the risk diversification strategy of commercial banks.

Further research could improve the financial inclusion model presented above by expanding the sample as additional data on the indicators of financial inclusion become available, and addressing potential reverse causality from financial inclusion to income per capita. Also, data permitting, both the financial inclusion and growth models could be jointly estimated.

5 Conclusion

This paper investigates the impact of mobile telephone development on economic growth, considering a sample of African countries during 1988–2007. Using a standard growth model and the System GMM estimator to address endogeneity issues, the results of the estimations reveal that mobile telephone development (captured by the mobile telephone penetration rate and the price of telephone calls) contribute to economic growth in Africa. In addition, financial inclusion, measured by the number of deposits and loans per head, appears to be one of the channels of transmission from mobile phone development to growth, while being itself independently correlated with economic growth. Furthermore, the interaction between mobile phone penetration and financial inclusion is found positive and significant

in the growth regression. Although the rollout of mobile banking is still at its early stage, the results show that in countries where such financial services are available, the correlation among financial inclusion, mobile phone diffusion, and growth is stronger.

The findings of this paper underline the importance of mobile phone rollout for African countries. Policies in African countries should encourage domestic and foreign investment in mobile phone development, and more generally in the ICT sector. Moreover, driving down the cost of communications is critical to stimulating the diffusion of mobile phones and spurring growth. Increased competition in the telecommunication industry could be one of the options. The experience of OECD countries suggests that prices have declined, and technological diffusion and introduction of new services have been rapid following the liberalization of the ICT sector (OECD, 2003). Also, in an attempt to mobilize revenue, governments in many African countries find it attractive to increase tax on mobile communications as this tax is easy to administer and has a large base. Because this will lead to higher communication costs, the benefit from increased government revenue should be weighed against the risk of lower growth.

Mobile phone diffusion has the potential to boost financial inclusion by easing the provision of cost-effective financial services to the poor and the nonpoor, given the low coverage of banks in African countries. Policies to promote greater interaction between the ICT and financial sectors while addressing the challenges posed by mobile banking (security concerns, compliance with AML/CFT[32] rules, and so forth) could improve the development of mobile banking. Experiences in Kenya, Zambia, and South Africa have demonstrated that mobile financial services can help reduce the financial infrastructure gap and the lack of access to financial services in Africa.

[32] AML = Anti-Money Laundering; CFT = Combating the Financing of Terrorism.

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Appendix 1

Table A1 - Sample Countries

Algeria	Libya
Angola	Madagascar
Benin	Malawi
Botswana	Mali
Burkina Faso	Mauritania
Burundi	Mauritius
Cameroon	Morocco
Cape Verde	Mozambique
Central African Republic	Namibia
Chad	Niger
Congo	Rwanda
Congo (Democratic Republic of the)	Senegal
Cote d'Ivoire	Seychelles
Egypt	Sierra Leone
Equatorial Guinea	South Africa
Ethiopia	Sudan
Gabon	Swaziland
The Gambia	Tanzania
Ghana	Togo
Guinea-Bissau	Tunisia
Kenya	Uganda
Lesotho	Zambia

Appendix 2

Table A2 - Variable Definitions and Sources

Variables	Definitions	Sources
Real GDP growth	Annual change in real GDP	Word Development Indicators and International Financial Statistics
Log of real (nominal) GDP	Logarithm of real (nominal) GDP	
Primary school enrollment rates	Ratio of total enrollment in primary schools to the population of the age group that officially corresponds to that level of education	
Government consumption in percent of GDP	Government current expenditure as a share of GDP	
Inflation rate	Annual change in Consumer Price Index	
GDP per capita (current US dollar)	Nominal GDP divided by total population	
Population density	Midyear population divided by a country's total area in square kilometers	
Institutions	Inverse of the average value of political right index and civil liberty index	Freedom House
Fixed telephone lines per head	The ratio of fixed-line subscribers to total population	International Telecommunication Union
Mobile telephone subscribers per head	Mobile telephone subscribers divided by total population	
Price of 3-minute mobile local call	Mobile cellular - price of 3-minute local call (peak - US$)	
Private credit/GDP	Private credit by deposit money banks as share of GDP	Financial Structure Database (World Bank)
Banks' overhead cost	Accounting value of banks' operating costs as a share of its total assets	
Number of deposits per head	Number of deposits by commercial banks, cooperatives, specialized state financial institutions, and microfinance institutions divided by total adult population	CGAP (2009); Beck, Demirgüç-Kunt, and Martinez Peria (2007)
Number of loans per head	Number of loans by commercial banks, cooperatives, specialized state financial institutions, and microfinance institutions divided by total adult population	
Number of bank branches per km2	Number of bank branches divided by a country's total area in square kilometers	