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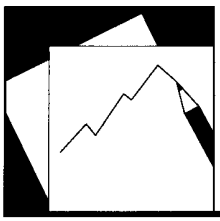

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ICT, Financial Inclusion, and Growth: Evidence from African Countries

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ICT, Financial Inclusion, and Growth: Evidence from African Countries

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Abstract

This paper studies the impact of information and communication technologies (ICT), especially mobile phone rollout, on economic growth in a sample of African countries from 1988 to 2007. Further, we investigate whether financial inclusion is one of the channels through which mobile phone development influences economic growth. In estimating the impact of ICT on economic growth, we use a wide range of ICT indicators, including mobile and fixed telephone penetration rates and the cost of local calls. We address any endogeneity issues by using the System Generalized Method of Moment (GMM) estimator. Financial inclusion is captured by variables measuring access to financial services, such as the number of deposits or loans per head, compiled by Beck, Demirguc-Kunt, and Martinez Peria (2007) and the Consultative Group to Assist the Poor (CGAP, 2009). The results confirm that ICT, including mobile phone development, contribute significantly to economic growth in African countries. Part of the positive effect of mobile phone penetration on growth comes from greater financial inclusion. At the same time, the development of mobile phones consolidates the impact of financial inclusion on economic growth, especially in countries where mobile financial services take hold.

JEL Classification Numbers: O30, O40, G20

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I. INTRODUCTION

In recent years, there has been a rapid diffusion of information and communication technologies (ICT) in African countries, in line with similar patterns in other regions of the developing world.[2] Figures show that, in Africa, growth in telephone subscribers, personal computer users, and Internet users has been fast since the 1990s. Currently, mobile phone penetration is overcoming fixed line coverage. The coverage of mobile cellular networks is around 55 percent of the population in sub-Saharan Africa, and more than 80 percent of the population in Middle East and North African (MENA) countries between 2002 and 2007. Nonetheless, Africa remains challenged by a financial infrastructure gap. This is shown by very low numbers of bank branches and automated teller machines (ATMs) (Beck, Demirguc-Kunt, and Martinez Peria, 2007),[3] and also by very low figures of financial inclusion. According to FinMark (2009), most of the population in African countries is using informal finance or is financially excluded (88 percent of the population in Mozambique and 41 percent in Botswana in 2009). Bank penetration is lower than 10 percent in some regions of Africa. In fact, there will be 1.7 billion unbanked customers with mobile phones by 2012, according to the Global System for Mobile Communications Association (GSMA).[4] As a consequence, a number of schemes aim at overcoming the financial infrastructure gap by using well-deployed ICT. Branchless banking services, like mobile financial services, are becoming increasingly popular. Therefore, it is worth investigating what ICT and these schemes can bring to financial inclusion and hence economic growth.

The purpose of this paper is to shed light on the role ICT development, especially mobile phone penetration, can play in promoting financial inclusion and economic growth. Specifically, we analyze the impact of mobile phone penetration on economic growth rates in Africa. Then we add to the model an indicator of financial inclusion to assess whether mobile phone penetration influences growth by improving financial inclusion. Further, we investigate how interaction among mobile penetration, financial inclusion, and growth is at play in countries where mobile financial services take hold.

Recent literature on mobile phones and 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, 2006, and Donner, 2006), and some look at the impact of mobile phones on institutions and social domains (such as civil society organizations, libraries, and so forth).

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[2] 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. We focus here on new information and communication technologies like telephones, computers, and the Internet. We concentrate more deeply on mobile phone technology.

[3] The average number of bank branches in sub-Saharan Africa was less than 700 in 2007, and the average number of ATMs was less than a thousand.

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

However, very few studies have been conducted on the macroeconomic impacts of mobile phones in developing countries. A few, such as Hardy (1980) and Waverman, Meschi, and Fuss (2005), did not focus on Africa, and to our knowledge none of them has yet analyzed the channel of financial inclusion. ICT and mobile phone penetration can indeed reduce the transaction costs of financial intermediaries including formal commercial banks, microfinance institutions and cooperatives, and therefore expand their businesses. ICT also facilitate the emergence of branchless banking by increasing the flexibility of businesses.[5] Moreover, a good telecommunication network allows better information flows that reduce information asymmetries and hence ease deposit taking and access to credit. The data show that the correlation between average real GDP per capita and mobile penetration is positive in Africa. Similarly, the correlation between financial inclusion and mobile penetration is positive, suggesting that ICT rollouts could stimulate economic growth and financial inclusion (Figures 1 and 2). Fulfilling the financial infrastructure gap in Africa, by using branchless banking services such as mobile financial services, is seen as a promising way to increase financial inclusion.[6] Therefore it is critical to assess the extent to which mobile penetration improves financial inclusion and therefore growth in Africa.

We follow the works of Barro (1991) and Waverman, Meschi, and Fuss (2005) and focus on 44 African countries between 1988 and 2007. We include regressors such as initial levels of GDP to account for convergence, human capital development, government consumption, and institutional development, as well as mobile telephony variables such as penetration rates. We also use more specific indicators of financial inclusion, such as the number of deposits per head and the number of loans per head in all financial intermediaries including commercial banks, microfinance institutions, cooperatives, and specialized state financial institutions. We undertake robust estimations addressing reverse causality of good telecommunication networks and growth and treat any endogeneity between other control variables and economic growth by using the System Generalized Method of Moment (GMM) estimator. We also use other variables accounting for telecommunication development by testing the effects of the prices of a three-minute fixed and mobile telephone local call on economic growth rates.

As in previous literature such as Hardy (1980), Roller and Waverman (2001), Waverman, Meschi, and Fuss (2005), Sridhar and Sridhar (2004), and Lee, Levendis, and Gutierrez (2009), we find that ICT development, and notably mobile phone penetration, contribute to economic growth in Africa. We find as in Roller and Waverman (2001) and Waverman, Meschi, and Fuss (2005) that mobile phones and fixed lines are substitutes and that the effect of mobiles is higher in lower-income countries. In addition, a part of the growth effect of mobile penetration comes from improved financial inclusion. Further, the effect of financial

[5] According to Rasmussen (2010), branchless banking is about 26 percent cheaper than conventional banking.

[6] Financial services on mobile phones or mobile financial services benefit all actors involved. They are seen by mobile network operators and banks as a tremendous opportunity to increase their respective client base. Further, clients may also find these schemes better at responding to their financial needs than formal banks and informal lenders.

inclusion on growth is improved by mobile phone development, especially in countries where mobile financial services are available.

The rest of the paper is organized as follows. First, we review the theory behind the economic impact of ICT on economic growth and social development. We then present some stylized facts on ICT and financial inclusion, followed by the presentation of our econometric specification and the results. Our last section concludes and offers policy recommendations.

II. LITERATURE REVIEW

A. Theoretical Background

Macroeconomic impact of ICT development

ICT development is increasingly considered a factor in economic growth rather than a consequence of it, as mentioned by Tcheng and others (2007). 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.

But in earlier research, ICT development was regarded as a concern only for developed economies because only these economies were capable of mobilizing resources to promote the sector. In fact, early studies showed evidence of growth effects through network externalities, especially relevant for telephone services and the Internet. As explained by Grace, Kenny, and Qiang (2003), because of network effects the value of a telephone line goes up exponentially with the number of users connected to the system. Moreover, once a threshold of users is reached, an explosive growth is recorded. This explains why only developed economies were believed to benefit from ICT development. Roller and Waverman (2001) estimate that ICT affect economic growth only when the penetration rate reaches 40 lines per 100 inhabitants.

However, recent research shows that the positive impacts of ICT can be large in developing countries because ICT compare to utilities such as water, electricity, and transportation. In fact, Waverman, Meschi, and Fuss (2005) explain that telecommunication networks are part of social overhead capital (SOC); as are expenditure on education, health services, and roads.[7] As a result, the economic and social return of ICT development is larger than the private return of the network provider. The externalities of ICT development highlight its potential positive impact on economic growth, similar to that of public infrastructure. Haacker (2010) notes that the growth impacts of rising productivity in the production of ICT equipment are weak in low- and middle-income countries because ICT equipment is often imported. But, the benefit of capital deepening arising from falling prices of ICT equipment can be large in low- and middle-income countries, even though it remains lower than that in high-income countries owing to higher absorption capacity.

[7] SOC is 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.

Datta and Agarwal (2004) point out that the economic benefits of ICT can be direct, through increases of employment and demand, and can also be indirect, notably through social returns (Table 1). Lewin and Sweet (2005) note that the direct effects can come from the supply side, that is, the supply of telecommunication services. This supply of telecommunication networks generates employment for manufacturers, administrators, network builders, system managers, and also employment through new retailing networks. In African countries, the economic benefits of ICT are mainly indirect. Because prepaid services dominate the continent, selling the prepaid cards requires an effective retailing network of wholesalers, individual agents, and even informal sellers (Tcheng and others, 2007). ICT supply also affects government revenues through income taxes on companies and on employees, VAT, and social security contributions. Tcheng and others (2007) observe that in Africa, revenues from telecommunication services represented about 5 percent of GDP compared with only 2.9 percent in Europe.

Table 1. Transmission Channels from ICT to Growth

Direct effects of ICT	Indirect effects of ICT
From supply side	From ICT use
• Contribute to domestic output and employment creation	• Spur capital accumulation
• Increase government revenues	• Improve firms' productivity
• Affect balance of payments	• Favor better and larger markets
	• Deepen financial inclusion
	• Contribute to rural development

Moreover, ICT supply influences the balance of payments as it increases foreign direct investment (FDI) flows. The increase in FDI is due to new FDI in telecommunication services. Also, foreign companies are more likely to invest in countries with increased ICT development. For instance, investment from high-tech industries is lured by rapidly growing markets in developing countries, and the boom in consumer demand for computing and telecom machinery. In addition, ICT attract portfolio and venture capital. They improve market efficiency because they allow wider dispersion of market information to investors, thereby reducing information costs. Additional investments, jobs, new skills, and better local services stemming from FDI all benefit economic growth.

Productivity gains and reduction in transaction costs

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 costs (for instance on inventory costs). Further productivity gains also come from better management, through better intrafirm communication, and increased flexibility, owing to the removal of physical constraints on organizational communication (Grace, Kenny, and Qiang, 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).

According to Lewin and Sweet (2005), indirect social returns also come from use of ICT. ICT use improves market functioning and increases trade. Investments in ICT reduce costs because better communication systems lower transaction costs (Datta and Agarwal, 2004, and Waverman, Meschi, and Fuss, 2005). By reducing the cost of retrieving information, ICT improve information flows, increase arbitrage abilities, and facilitate price discovery. They allow better functioning markets and regulation of supply and demand. Therefore it increases information regarding prices (of commodities, for example), job opportunities, and markets (Sridhar and Sridhar, 2004). Moreover, good communication networks substitute for costly physical transport and therefore widen networks (of buyers and suppliers) and markets. Grace, Kenny, and Qiang (2003) show that reduced transaction costs from ICT favor trade because it gives developing countries opportunities to tap into global markets and increase sales range. The development of e-commerce fostered by ICT development increases efficiency and opens markets for developing countries. Businesses, such as handicrafts or ecotourism, reach global audiences, marketplaces become digital, and transactions are automated. Trade in services such as back office support or data entry and software management also benefit from new opportunities as ICT allow the outsourcing of information-intensive administrative and technical functions.

Financial inclusion

Mobile telephony allows expansion and access to financial services to previously underserved groups in developing countries. It reduces transaction costs, especially the costs of running physical bank branches. The increasing use of mobile telephony in developing countries has contributed to the emergence of branchless banking services, thereby improving financial inclusion. This increased access to financial services for underserved people helps narrow the financial infrastructure gap, especially in developing economies, where the costs of distance and time are very high for formal banking services. ICT favor better information flows, and the data collected on depositors can be used to analyze credit worthiness more efficiently and to facilitate deposit taking. Therefore ICT and mobile phone in particular improve access to credit and deposit facilities, allow more efficient allocation of credit, facilitate financial transfers, and boost financial inclusion. In turn, this would stimulate private investment, and hence economic growth.

Considering the tremendous interest in finding new ways of increasing financial inclusion in Africa using ICT, such as mobile financial services, it is of utmost importance to assess whether these schemes can indeed favor financial inclusion and therefore economic growth. Service providers—including banks, mobile network operators, and even microfinance institutions—and policy makers are keen on developing mobile financial services rapidly. The financial infrastructure gap is a niche for service providers, and policy makers can improve access to financial services.

Rural development

ICT have a positive effect on 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.

Opportunity costs and threshold effects

Grace, Kenny, and Qiang (2003) point out that it may be difficult to establish a causal link between ICT and economic growth or even economic development.[8] Negative impacts might even arise because of the opportunity costs of investments and expenses in ICT rather than in education and health (Heeks, 1999). Studies indeed 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. This reduces households' budgets for food, health, education, and so on. Grace, Kenny, and Qiang (2003) also mention that some developing countries might fall into a poverty trap if ICT threshold effects are at play. Consistent with the network and scale literature mentioned earlier, if a minimum level of ICT is needed to benefit from new opportunities, and if ICT provision is correlated with income per capita, low-income countries might not be able to benefit from the opportunities provided by ICT development.

To summarize, ICT can influence economic growth through various channels, even though the causal link may be difficult to establish. ICT development generates employment and government revenues. ICT also allow better information flows, leading to increased efficiency, wider markets, increased productivity, and new capital and investments such as FDI and portfolio and venture capital. ICT can also lead to better financial inclusion and therefore facilitate financial development. To our knowledge this link has not been studied before. It is important, therefore, to investigate it, considering that financial development in Africa is low whereas ICT penetration, through mobile phone rollouts, is growing fast.

B. Empirical Studies

Earlier cross-country studies found a positive and significant impact of telecommunication infrastructure on economic growth. For instance, Hardy (1980) analyzes the impact of telecom penetration. He finds that the impact of radio rollout on economic growth is not statistically significant, in contrast to the impact of the telephone. Two-way networks (telecommunications) are more important for growth than one-way networks (broadcasting) such as radio and television. Although Hardy (1980) uses previous-year values of radio penetration and telephone penetration to account roughly for reverse causality, he did not control for country-specific effects. The issue of reverse causality comes up because better communication systems may bring higher incomes, and higher incomes in turn could lead to

[8] Poorly designed programs can be undertaken, and, because technological change is very fast, programs can be even more difficult to implement.

better communication systems. Similarly, Norton (1992) tests the argument that improvement in telecommunications reduces transaction costs in a sample of 47 developed and developing countries. The author includes the initial-year value of the stock of telephones in the cross-section model to overcome the issue of reverse causality. He finds that the association between telecommunication infrastructure and economic growth is positive and significant.

Roller and Waverman (2001) address the two-way causality issue by using a structural model with a hybrid production function that endogenizes the telecommunications investment. To assess the effects of telecom infrastructure on economic growth, the authors specify a micromodel of supply and demand of telecommunication investment and jointly estimate this with the macro growth equation for 21 Organization for Economic Co-operation and Development (OECD) countries and 14 developing countries over a 20-year period. They find little impact once simultaneity and fixed effects are controlled for and only a positive causal link when a critical mass of telecom infrastructure is reached. This result indicates that telecommunications infrastructure creates network externalities that are an increasing function of the number of participants. Therefore the impact of telecommunications infrastructure on growth might not be linear, with the growth impact being larger beyond a certain network size. The expansion of networks intensifies the social value of networks and in consequence the social return, representing the value of an additional person connected or the value of an additional dollar invested in the network. This exceeds the private return for the network provider. As a consequence, universal service is not only a question of equity but also a vehicle to enhance economic growth.[9]

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. They undertake separate estimations for fixed lines, and mobile phones to disaggregate their effects in 63 developing countries between 1990 and 2001. They find that the elasticity of aggregate national output with respect to main telephone lines is smaller than that of mobiles and that, in developing countries, cellular services contribute significantly to national output.

Waverman, Meschi, and Fuss (2005) use a modified version of Roller and Waverman (2001) for 92 countries between 1980 and 2003 and show that mobiles in developing countries play the same role as fixed lines played in the 1970s and 1980s in OECD countries. In developing countries, mobile phones are substitutes for fixed lines; in developed countries they are complements for fixed lines.[10] Their impacts on growth are positive and significant—twice as large as their impacts in developed countries. The starting hypothesis is that mobile phone rollout has greater effects on economic growth in developing countries because mobiles have more network effects and have more effects on mobility than in developed countries. They also find that the price and income elasticities of mobile phone demand are superior to 1 in developing countries.

[9] Universal service means there is at least one phone per household and per firm.

[10] In fact, mobile phones require less investment than fixed lines and therefore are faster and less expensive to roll out.

Kathuria, Uppal and Mamta (2009) assess the impact of mobile penetration on economic growth across Indian states. Using a modified version of Roller and Waverman (2001), they estimate a structural model with three equations for 19 Indian states from 2000 to 2008. They specifically examine the links through which mobile phones affect growth and the constraints, if any, that limit their impact. They find 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. Telecom networks, more than any other infrastructure, are subject to network effects: the growth impact is larger when a significant threshold network size is achieved. Moreover, the authors (2009) find substantial variation across urban and rural areas and between rich and poor households in cities.

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. They correct the potential endogeneity between economic growth and telephone expansion by using the generalized method of moments. They also consider varying degrees of substitutability between mobile phones and landlines as in Waverman, Meschi, and Fuss (2005). They find indeed that the marginal impact of mobile telecommunication services is even greater where landline phones are rare. However, as in previous studies, the authors do not test for the price effect of telecommunications on growth. In some countries, telecommunications infrastructure could exist but a high access cost could dampen its use. Moreover, the channels through which telecommunications stimulate growth, financial inclusion, for instance, are not investigated. Further, their regressions may be subject to statistical shortcomings because the System GMM estimator is not appropriate for annual data if the variables are not stationary. Our paper addresses some of these issues in the following sections.

To sum up, some cross-sectional studies have been undertaken on telecommunications and economic growth in developing countries. The issue of reverse causality is difficult to address, and studies have shown the existence of network externalities in telecommunication infrastructure leading to higher growth effects. Further, in developing countries, mobile phones and fixed lines appeared substitutes rather than complements. However, very few studies have focused on the African continent, despite the significant growth of mobile rollouts experienced by many African countries.

III. STYLIZED FACTS

A. Growth of ICT in African Countries and Other Developing Countries

Rapid spread of ICT in all developing countries.

Progress in ICT is fast, and ICT growth is not restricted to developed countries. ICT are spreading rapidly in developing countries. Figure 3 shows that since the 1990s, the average number of telephone subscribers, personal computer users, and Internet users per 100 inhabitants has increased. In fact, even though the figures are lowest in sub-Saharan Africa and in South Asia, the upward trend is also present in these regions.

Robust growth of telephone subscribers.

Use of telephone technology—fixed and mobile—is widespread, compared to use of personal computers and Internet use (Figure 4), although Internet use has increased sharply. Data also show that in all developing regions, the growth rates of telephone subscriptions are high compared to those of personal computer users and Internet users per 100 inhabitants, and the latter are actually decreasing in some regions like Africa after the dramatic increase in the 1990s.

Africa experienced the highest growth rates of telephone subscribers.

The data suggest that the growth rate of telephone subscribers in Africa was the highest of all developing regions at the end of the 1990s and the beginning of the 2000s (except for South Asia in the 2000s), albeit from low levels. This could be partly explained by the two waves of telecom privatization in Africa. The first was between 1995 and 1997 and the second between 2000 and 2001.

B. Growth of Mobile Technology in Africa

Mobile phone subscriptions are overtaking fixed lines.

Figure 5 shows that in all developing regions, although mobile technology had started to spread at the end of 1990s, the number of mobile phone subscribers per 100 inhabitants is now above the number of fixed telephone lines per 100 inhabitants. Mobile phone penetration and coverage have increased rapidly (Figure 6), probably reflecting liberalization and privatization policies and lack of wired infrastructure in many developing countries.[11]

Positive growth perspectives in Africa.

In Africa, studies have shown that people consider the investment in mobile technology necessary even though it is a significant part of their earnings. Their willingness to pay for this technology is higher than people's willingness to spend in higher income countries,[12] but the price elasticity of their demand is also higher (Grace, Kenny, and Qiang, 2003; Waverman, Meschi, and Fuss, 2005). The telecommunications sector is expected to continue

[11] Do-Nascimento (2005) noted that in 2004 only 14 African countries out of 55 had not yet liberalized the telecommunications sector. With technological progress and globalization of networks, liberalization policies started to emerge in developed countries in the 1980s and 1990s, before spreading to African countries from 1990s. Other reasons are mentioned by Do-Nascimento (2005) to explain the growth of mobile penetration in Africa. Among them is the strategy of service providers to adapt their products to African consumers. For example, service providers introduced prepaid contracts to suit clients who did not have the usual and formal means of payment like checks, credit cards, and so forth. Also, families and friends are very close in Africa, and the social fabric is made of numerous relationships. Communication is vital to maintaining these ties, and the mobile phone overcomes travel difficulties.

[12] Tcheng and others (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.

to grow rapidly, and the limits to this growth are uncertain (Tcheng, Huet, and Romdhane, 2010).

Preference for prepaid contracts.

In most developing countries prepaid contracts are more common than postpaid contracts (Figure 7). In African countries, many customers do not earn regular income and are unbanked. They are therefore less capable of affording fixed costs associated with postpaid contracts. In addition, fixed lines require monthly payments, regardless of use. Prepaid mobiles, on the other hand, take into account use and variability of consumption, although at a higher cost. This explains the success of prepaid mobile phones compared to postpaid offers.[13]

C. Opportunities Offered by Mobile Financial Services

Exclusion from formal financial services is very high in Africa.

In many African countries, a large share of the population is financially excluded or using informal financial services (Figure 8).

Formal financial services are dominated by banks.

Formal bank service is the most-used formal system in most developing countries. Figure 9 suggests that deposits are more common than loans in all regions. Although the number of loans and deposits per head is relatively low in sub-Saharan Africa, and to a lesser extent in MENA, the average size of loans and deposits relative to GDP per capita is high. This suggests that the propensity to save in these regions is high, but constrained by lack of access to financial services or suitable financial instruments. Collins and others (2009) explain that people with low incomes lead active financial lives because they are poor not in spite of it.

In developing countries, the lack of financial infrastructure is significant.

Figure 10 shows that the total number of bank branches and ATMs is very low in developing countries compared to the same figures in high-income countries. Moreover, figures in sub-Saharan Africa and MENA are among the lowest. But when looking at the geographical coverage and penetration rates of bank branches and ATMs, the picture is less clear.

Mobile financial services could be the answer.

The previous figures illustrate clearly a financial infrastructure gap in developing countries where the coverage of mobile cellular is close to that of high-income countries, but bank

[13] It is interesting to note, however, that fixed line contracts and postpaid contracts are more advantageous to the service provider. This is because their clients can be located by the physical address, and their revenues are more stable. Moreover, the provision of prepaid mobile contracts, compared to postpaid mobile contracts, is more costly for a service provider because the costs of producing and selling scratch cards are high.

penetration and financial inclusion are very low compared to that of the same group of countries (see Figure 11).

In summary, ICT rollout, in particular mobile phones with prepaid contracts, is growing rapidly in developing countries, especially in Africa. Nonetheless, financial development and financial inclusion are very low in these countries, and the expansion of the financial system lags behind mobile telephone development (Figure 12). Considering the growth of mobile technology—its use and spread—and taking into account low access to financial services, mobile financial services are regarded as an opportunity to reach unbanked customers and as a new source of profits for mobile network operators.

According to GSMA and Mobile Money for the Unbanked (MMU) deployment tracking, 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. In these countries, branchless banking services enable households to save, pay bills, and transfer money through mobile phones (see more details on mobile financial services in Annex 1). These schemes are becoming more sophisticated as partnerships between mobile telephone companies and microfinance institutions strengthen and widen the range of banking services available via mobile phones. Currently, the most common mobile financial services include domestic money transfers, air time top ups, and bill payments; but there also is a strong desire for savings (Rasmussen, 2010).

In addition, international money transfer and loan repayments via mobile phones are becoming widely used. In fact, following the stagnation of traditional markets in Europe and the success of M-PESA (with more than 9 million subscribers), mobile network operators are now seeking new growth engines for their sales in Africa through new services with a social dimension. Recently, mobile financial services have been launched in 16 other African countries.[14] Although prospects for further development of mobile financial services remain strong, they rely on the long-term strategies 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).

IV. ECONOMETRIC SPECIFICATION

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

[14] According to GSMA and MMU deployment tracking, 16 African countries launched financial services via mobile phones between 2008 and 2010—Uganda, Tanzania, Ghana, Cote d'Ivoire, Rwanda, Democratic Republic of Congo, Nigeria, Sierra Leone, Malawi, Niger, Somalia, Morocco, Madagascar, Egypt, and Senegal. Competitive schemes have also started in Kenya with ZAP and YUCASH; in South Africa with Community Banking, Mopay, Send Money from FNB, and in Zambia with Mobile Transactions.

are averaged over four years. The sample period is therefore divided into five subperiods as follows: 1988–1991, 1992–1995, 1996–1999, 2000–2003, and 2004–2007.[15]

Following Barro (1991) and Waverman, Meschi, and Fuss (2005), we examine the relationship between ICT and economic growth using a standard endogenous growth model. The equation is as follows:[16]

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

This is a dynamic panel data model, with temporal and individual dimensions and a lagged variable. Unlike Hardy (1980) who uses cross-country regressions, we use panel data, taking into account country-specific effects and estimating a dynamic specification. In addition, we improve on Lee, Levendis, and Gutierrez (2009) by using four-year averages and by considering a wider range of ICT variables. The variable $y_{i,t}$ is the logarithm of real per head GDP, $X_{i,t}$ is a set of growth determinants other than lagged per capita GDP, η_i is an unobserved country-specific effect, $\varepsilon_{i,t}$ is the error term, and *i* and *t* represent country and time period respectively.

We start our estimations with a set of variables determining economic growth: the initial level of real GDP per capita (representing conditional convergence), primary school enrollment rate (accounting for human capital), and other control variables such as inflation, government consumption, and institutional development.

Appendix 2 presents descriptive statistics for all the variables. Data are obtained mainly from the International Monetary Fund, the World Bank, and the International Telecom Union databases (see Appendix 3 for variable definitions and sources).

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.[17]

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[15] By taking four-year averages, we smooth out any short term fluctuations in growth rates. Evidence also has shown that business cycles tend to be shorter in developing countries (see for instance Rand and Tarp 2002). Moreover, the four-year averages allow us to obtain five data points per country, enough to run the System GMM estimator.

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

$$y_{i,t} = \lambda y_{i,t-1} + \beta ICT_{i,t} + \Gamma X_{i,t} + \eta_i + \epsilon_{i,t}, \text{ with } \alpha = \lambda - 1$$

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

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.[18] For the lagged real GDP per capita, we use as instruments the first difference lagged one period for the equations in levels. 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. Finally, 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 ICT improve growth, we retain the model in which ICT development is measured by mobile penetration and add a variable of financial inclusion in the growth model—captured by either the number of deposits or the number of loans per head—to check how the coefficient on ICT moves. If this coefficient weakens, we can conclude that part of the beneficial impact of ICT development on growth is channeled through financial inclusion.[19] We strengthen the analysis by including 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 ICT infrastructure. We also refine the analysis by isolating the impact of ICT on growth through financial inclusion in countries that have implemented financial services on mobile phones.

V. RESULTS

A. Impact of ICT on Economic Growth

Table 2 summarizes the results of the impact of ICT on economic growth, particularly that of mobile and fixed telephones. The baseline growth model is presented in the first column. As shown by past studies, high government consumption and macroeconomic instability captured by high inflation rates dampen economic growth in African countries. The results of the baseline regression also suggest that human capital accumulation favors growth. The legal environment, however, does not appear significant, probably because the civil and political liberty indexes may not capture well the strength of the law in African economies. They do have the advantage, however, of being available for a large sample of countries

[18] 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(2) serial correlation of the residuals.

[19] The validity of this conclusion is confirmed by estimating a model for financial inclusion with mobile phone penetration as an explanatory variable.

during a long period.[20] There is also evidence of growth convergence among African countries, suggesting that countries with lower initial income tend to grow faster than others with similar macroeconomic conditions, level of human capital, and institutions.

In columns 2 through 8 of Table 2, we introduced a wide range of ICT variables in the baseline model. The penetration rates of fixed and mobile telephones are found to have a significant and positive impact on economic growth in Africa (column 2, Table 2), consistent with the findings of Hardy (1980) for developing and developed economies, and that of Roller and Waverman (2001) for OECD countries.[21] This result holds even when including the fixed and mobile penetration rate alternatively (column 3 and 4, Table 2) or jointly (column 5, Table 2) in the baseline regression.

Taking the specification in column 5, an additional 10 percentage point increase in the mobile penetration rate could lead to a 0.7 percentage point increase in real GDP growth, compared to a 1.1 percentage increase for an increase in the fixed penetration rate by the same magnitude. 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, Meschi, and Fuss, 2005). This suggests that there is room to improve further the contribution of mobile phone development to economic growth in Africa.[22]

We improve on previous studies by considering communication costs in addition to penetration rates as alternative indicators of ICT development. The main reason is that affordable communication costs could stimulate the use of fixed and mobile telephones. At the same time, widespread use of fixed and mobile telephones leads to lower unit production costs for telephone companies that in turn could be passed on to customers. As a result, we expect a negative correlation between communication costs and the penetration rate of mobile and fixed telephone, and hence economic growth. The results confirm that the price of a 3-minute fixed or mobile telephone local call is negatively associated with economic growth (columns 6, 7, and 8, 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 dramatically, by 62 percent, from US$1.18 in 1999 to US$0.46 in 2006; this would yield a 3.6 percent increase in real income over eight years. Egypt and Mozambique experienced a drop in mobile communication cost by a similar magnitude during the same period.

In Table 3, we tested a nonlinear relationship between ICT and economic growth and the impact of other forms of ICT, such as computer and Internet use. First, we tested whether

[20] 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 this indicator.

[21] We obtained similar results with the growth rate of mobile and fixed line penetration.

[22] 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.

mobile and fixed telephones are complements or substitutes by including in the model an interaction term between the penetration rate of mobile and fixed telephones (column 1, Table 3). As expected, the coefficient on the interaction term is negative and significant (see also Waverman, Meschi, and Fuss, 2005), suggesting mobile telephones are substitutes for fixed telephones in Africa. In other words, the marginal impact of mobile telephone development on growth is stronger in countries with low fixed telephone penetration rates. The substitution effect shown in African countries is not surprising given the shortage of fixed telephone lines on the continent. In this case, the substitution effect results from the lack of extensive wired infrastructure and not from a change in the demand for communication services. Second, we introduced in the model an interaction term between mobile penetration rate and GDP per capita and found that the marginal impact of mobile telephone development decreases with the level of income per capita (column 2, Table 3), probably reflecting diminishing growth returns to mobile telephone development. This is consistent with the findings of Waverman, Meschi, and Fuss (2005) that show a greater impact of mobile telephones in lower income countries. Finally, we tested the effect of computer and Internet use on economic growth. Although the coefficient on computer use is positive, it is not statistically significant (column 3, Table 3) probably because the penetration rate of computer use is still very low in Africa. Internet access, which is closely linked to computer access, appears to have a positive effect on economic growth only when GDP per capita is high enough, consistent with what Grace, Kenny, and Qiang (2003) called Internet traps.[23]

B. Robustness Tests

To test the robustness of our results, we checked the sensitivity of the coefficient on mobile penetration, our main variable of interest, to the composition of the sample using the specification in column 4 of Table 2. We started by selecting randomly 98 percent of the observations (without replacement) and ran the baseline regression. This process, repeated 250 times, gives values of the coefficient on mobile penetration, for which the normal distribution is shown in Figure 13. Although the average coefficient on mobile penetration remains very close to the coefficient of the full sample (represented by the vertical line, which is equivalent to sampling 100 percent of the observations), the base of the distribution widens.

We used the same procedure to select randomly 95 percent of the observations. The results showed that leaving 5 percent of observations out of the sample shifted away the average coefficient on mobile penetration from the coefficient of the full sample. With 95 percent of observations, the average coefficient on mobile penetration is 0.37, compared to 0.56 for the full sample. Further reducing the size of the random sample shows that the average coefficient on mobile penetration gets closer to zero, although its distribution has a heavier tail. In other words, the probability of replicating the full sample estimate of the coefficient on mobile penetration weakens rapidly as the size of the subsample shrinks. This suggests

[23] We also tested an interaction term between computer and Internet use and between computer use and education, without concluding results.

that the coefficient estimated for the full sample hides significant country heterogeneity. This country heterogeneity could be partly explained by the nonlinear relationship between mobile penetration and growth we found earlier.[24] Caution is therefore needed when interpreting the results in the tables discussed above; the growth benefits from mobile phone development may not be immediate and depend on country-specific factors that should be accounted for. As a result, it could be useful, if data permit, to complement panel studies on the impact of ICT on growth with country-specific studies.

We also conducted recursive estimates to test the stability of the coefficient on mobile penetration. The observations are first ranked in increasing order of the mobile penetration rate. Starting with a sample of low mobile penetration rates, we added subsequent observations with higher penetration rates to the sample and reran the regressions. The results show that the coefficient on mobile penetration remains positive and significant (Figure 14), but the marginal impact of mobile phones on growth is heterogeneous across the sample and declines as the mobile penetration rate increases.[25] This may suggest a lack of network effects (Roller and Waverman, 2001) in African countries, probably because their penetration rates are still below the threshold above which network effects are at play.

Despite country heterogeneity, the model does a good job of predicting the dependent variable (Figure 15). Within 10 percent confidence interval, the model predicts well the level and growth of real GDP for all countries in the sample.

We performed additional robustness tests (Table 4). Averaging the data over a 3-year period increases the sample size by 8 percent, without dramatically changing the results. The coefficient on mobile phone penetration retains its positive sign and remains significant at 1 percent (column 1). Moving to a five-year average reduces the sample by 20 percent but does not affect the quality of the results (column 2). We restricted the sample to sub-Saharan African countries, excluding the top performers in the region (Mauritius, Seychelles, South Africa). The coefficient on mobile is positive and significant and has a larger magnitude (column 3).[26] Finally, the regression is run on a sample of developing countries; we found 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).

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[24] Indeed, as shown in Table 3, the marginal impact of mobile penetration rates on growth is larger when income per capita is low and/or fixed telephone penetration is low.

[25] This contrasts with the finding that low levels of computer and Internet use do not positively impact growth (Table 3). One could argue that a low level of mobile penetration seems to be favorable to growth because of the relatively low fixed cost of mobile phones and the fact that it is a substitute for fixed lines, which facilitates a rapid and increasing adoption of mobile phones. However, computer and Internet use may be constrained by equipment cost, lack of broadband access, and widespread illiteracy. With a low level of computer and Internet use, a country can be locked into a poverty trap (Grace, Kenny, and Qiang, 2003).

[26] Probably because the countries included in the sample have lower income per capita. The results in Table 3 (column 2) show that the marginal impact of mobile phone penetration on growth declines as income per capita increases.

C. Financial Inclusion

In this section, we investigate whether ICT development stimulates growth by fostering financial inclusion and whether the interaction between ICT 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 by the previously mentioned financial institutions.[27] As these two measures appear highly correlated with the level of financial development, we do not include the latter in the model; we will, instead, use it as a broader indicator of financial inclusion. Regarding the ICT variable, we considered the particular case of mobile telephones as shown by the baseline specification in column 1 of Table 5, which replicates the model presented in column 4 of Table 2.[28]

In columns 2 and 4 of Table 5, the coefficient on the number of deposits per head and that on the number of loans per head are positive and significant as expected, implying that greater financial inclusion is associated with higher economic growth in African economies. Indeed, better access to finance facilitates economic growth by allowing households to undertake productive investments. Moreover, a greater access to deposit facilities enhances the ability of financial intermediaries to mobilize savings, which are allocated to projects with the highest returns.

Interestingly, the coefficient on the mobile penetration rates drops when controlling for financial inclusion, suggesting that some of the positive impact of ICT on growth is channeled through financial inclusion (see Annex 2 for more details on the link between financial inclusion and mobile phone penetration).[29] Further, the penetration of mobile telephones enhances the growth impact of financial inclusion 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 5). The same result holds for the interaction term between the mobile penetration rate and the number of loans per head (column 5, Table 5).

These results confirm that mobile telephone penetration can foster economic growth not only by facilitating financial inclusion, but also by consolidating the impact of financial inclusion on economic growth. Through higher mobile penetration, it becomes easier to have access to deposits and loans. Better information flows through mobiles improve information

[27] 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] Without the variable measuring institutions because it was not significant.

[29] Note that Figure 1 shows a positive correlation between mobile penetration and financial inclusion, even after controlling for GDP per capita level.

acquisition of both depositors and financial institutions, and enhance monitoring. Higher mobile penetration indeed reduces the physical constraints and costs of distance and time. Also, better ICT development reduces the cost of financial intermediation and contributes to the emergence of branchless banking services, therefore improving access to finance for households that would be credit constrained otherwise.

To refine our analysis, we considered that financial services on mobiles remain underdeveloped in African countries and are available only in a few countries. Therefore, it is worth assessing whether mobile financial services penetration further strengthens the growth effect of financial inclusion in these 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 if mobile financial services are operating in the countries 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, mobile penetration further enhances the contribution of financial inclusion to economic growth compared to countries where these services are not yet deployed (columns 6 and 7, Table 5).

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. The results are also confirmed when replacing financial inclusion with financial development. Although financial development—captured by the ratio of private credit to GDP—appears positively correlated to 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 5). Consistent with the previous results, this effect appears stronger in countries where mobile financial services are available.

VI. CONCLUSION

This paper investigates the impact of ICT development on economic growth, considering a sample of African countries during 1988–2007. Focusing on mobile telephone development, the paper argues that financial inclusion could be one of the channels through which mobile phone diffusion contributes to growth. Using a standard growth model and the System GMM estimator to address endogeneity issues, the results of the estimations reveal that ICT development (captured by the penetration rates of mobile and fixed telephone and communication costs) contribute to economic growth in Africa. In addition, financial inclusion, measured by the number of deposits and loans per head, is conducive to economic growth and appears to be one of the channels of transmission from mobile phone development to growth. More importantly, 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 joint impact of financial inclusion and mobile phone diffusion on growth is stronger.

The findings of this paper underline the importance of ICT development, in particular mobile phone rollout, for African countries as a source of growth, and the potential of ICT to improve financial inclusion, which itself benefits growth. Policies in African countries should encourage domestic and foreign investment in ICT and promote development of the sector. Moreover, driving down the cost of communications is critical to stimulating the diffusion of ICT 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.

Further, 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[30] 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.

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

REFERENCES

Barro, Robert J., 1991, "Economic Growth in a Cross Section of Countries," *The Quarterly Journal of Economics*, 106(2), pp. 407–43.

Beck, Thorsten, Asli Demirguc-Kunt, and Maria Soledad Martinez Peria, 2007, "Reaching Out: Access to and Use of Banking Services Across Countries," *Journal of Financial Economics*, 85(1), pp. 234–66.

Beck, Thorsten, Robert Cull, Michael Fuchs, Jared Getenga, Peter Gatere, John Randa, and Mircea Trandafir, 2010, "Banking Sector Stability, Efficiency, and Outreach in Kenya," Policy Research Working Paper Series 5442 (Washington: World Bank).

Blundell, Richard, and Stephen Bond, 1998, "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models," *Journal of Econometrics*, 87(1), pp. 115–43.

Chowdhury, Shyamal, 2006, "Investments in ICT-Capital and Economic Performance of Small and Medium Scale Enterprises in East Africa," *Journal of International Development*, Vol. 18(4), pp. 533–552.

Collins, Daryl, Jonathan Morduch, Stuart Rutherford, and Orlanda Ruthven, 2009, *Portfolios of the Poor: How the World's Poor Live on $2 a Day* (Princeton, N.J.: Princeton University Press).

Consultative Group to Assist the Poor, 2007, "Notes on Regulation of Branchless Banking in Kenya," Technical Report (Washington: CGAP).

Consultative Group to Assist the Poor, 2009, *Financial Access 2009—Measuring Access to Financial Services around the World*, Technical Report (Washington: CGAP).

Datta, Anusua, and Sumit Agarwal, 2004, "Telecommunications and Economic Growth: A Panel Data Approach," *Applied Economics*, 36(15), pp. 1649–54.

Do-Nascimento, José, 2005, "Le développement du téléphone portable en Afrique," in *Télécommunications entre biens publics et marchandises*, ed. by Djilali Benamrane, Bruno Jaffré, Marie-Laure Urvoy Sangharé, and François Xavier Verschave (Paris: Charles Léopold Mayer Ed.), pp.173–90.

Donner, Jonathan, 2006, "The Use of Mobile Phones by Microentrepreneurs in Kigali, Rwanda: Changes to Social and Business Networks," *Information Technologies and International Development*, Vol. 3(2), pp: 3–19.

Donner, Jonathan, 2008, "Research Approaches to Mobile Use in the Developing World: A Review of the Literature," *The Information Society*, 24(3), pp. 140–59.

FinMark, Trust, ed., 2009, *FinScope South Africa 2009* (Johannesburg: FinScope).

Global System for Mobile Communications Association (GSMA), 2008, "Understanding Financial Regulation and How it Works," Technical Report, (London: GSMA).

Grace, Jeremy, Charles Kenny, and Christine Zhen-Wei Qiang, 2003, "Information and Communication Technologies and Broad Based Development: A Partial Review of the Evidence," World Bank Working Paper, Technical Report 12 (Washington: World Bank).

Haacker, Markus, 2010, "ICT Equipment Investment and Growth in Low- and Lower-Middle-Income Countries," IMF Working Paper 10/66 (Washington: International Monetary Fund).

Hardy, Andrew P., 1980, "The Role of the Telephone in Economic Development," *Telecommunications Policy,* 4(4), pp. 278–286.

Heeks, Richard, 1999, "Information and Communication Technologies, Poverty and Development" Development Informatics Working Paper Series, No.5/1999 (Manchester: Institute for Development Policy and Management).

Jensen, Robert, 2007, "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector," *The Quarterly Journal of Economics*, 122(3), pp. 879–24.

Kathuria, Rajat, Mahesh Uppal and Mamta, 2009, "An Econometric Analysis of the Impact of Mobile," The Vodafone Policy Paper Series (9), pp 5–20.

Kendall, Jake, Nataliya Mylenko, and Alejandro Ponce, 2010, "Measuring Financial Access around the World," Policy Research Working Paper, No 5253 (Washington: World Bank)

Lee, Sang H., John Levendis, and Luis Gutierrez, 2009, "Telecommunications and Economic Growth: An Empirical Analysis of sub-Saharan Africa," Documentos de trabajo 005512 (Bogota: Universidad del Rosario—Facultad de Economia).

Levine, Ross, Norman Loayza, and Thorsten Beck, 2000, "Financial Intermediation and Growth: Causality and Causes," *Journal of Monetary Economics*, No 46, pp. 31–77.

Lewin, David, and Susan Sweet, 2005, "The Economic Impact of Mobile Services in Latin America," Technical Report (London: Report for the GSMA, GSM Latin America, and AHCIET).

Mas, Ignacio, and Amolo Ng'weno, 2009, "Three Keys to M-PESA's Success: Branding, Channel Management and Pricing," Technical Report (Bill & Melinda Gates Foundation).

Mas, Ignacio, and Dan Radcliffe, 2010, "Mobile Payments Go Viral: M-PESA in Kenya," Technical Report (Bill & Melinda Gates Foundation).

Norton, Seth W., 1992, "Transaction Costs, Telecommunications, and the Microeconomics of Macroeconomic Growth," *Economic Development and Cultural Change*, 41(1), pp. 175–96.

OECD, ed., 2003, *ICT and Economic Growth: Evidence from OECD Countries, Industries and Firms* (Paris: Organization for Economic Co-operation and Development).

Rand, John, and Finn Tarp, 2002, "Business Cycles in Developing Countries: Are They Different?" *World Development*, Vol. 30(12), pp 2071–2088.

Rasmussen, Stephen, 2010, "Mobile Banking in 2020," in CGAP Technology Program (Washington: Consultative Group to Assist the Poor).

Roller, Lars-Hendrik, and Leonard Waverman, 2001, "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach," *American Economic Review*, 91(4), pp. 909–23.

Roodman, David, 2009, "A Note on the Theme of Too Many Instruments," *Oxford Bulletin of Economics and Statistics*, 71(1), pp. 135–58.

Sridhar, Kala Seetharam, and Varadharajan Sridhar, 2004, "Telecommunications Infrastructure and Economic Growth: Evidence from Developing Countries," Working Paper 04/14 (New Delhi: National Institute of Public Finance and Policy).

Tarazi, Michael, and Paul Breloff, 2010, "Nonbank E-Money Issuers: Regulatory Approaches to Protecting Customer Funds," Technical Report 63 (Washington: CGAP).

Tcheng, Henri, Jean Michel Huet, and Mouna Romdhane, 2010, "Les enjeux financiers des télécoms en Afrique sub-saharienne," Technical Report (Paris: Institut Français des Relations Internationales).

Tcheng, Henri, Jean-Michel Huet, Isabelle Viennois, and Mouna Romdhane, 2007, "Telecoms and Development in Africa: the Chicken or the Egg?" *Convergence Letter* No 8.

Waverman, Leonard, Meloria Meschi, and Melvyn Fuss, 2005, "The Impact of Telecoms on Economic Growth in Developing Countries," The Vodafone Policy Paper Series, (2), pp. 10–23.

Windmeijer, Frank, 2005, "A Finite Sample Correction for the Variance of Linear Efficient Two-Step GMM Estimators," *Journal of Econometrics*, 126 (1), pp. 25–51.

Figure 1. Correlation among Mobile Penetration, Growth, and Financial Inclusion

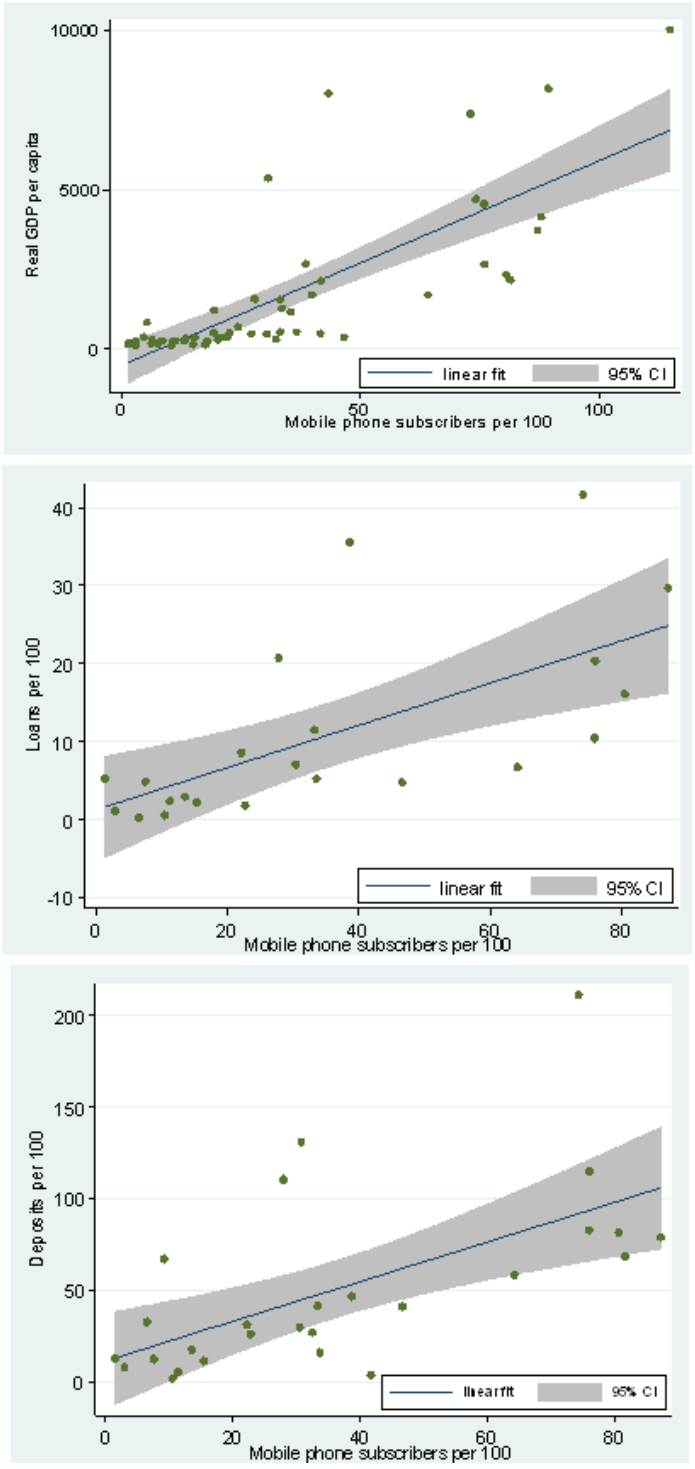


Figure 2. Financial Inclusion and Mobile Penetration by Type of Financial Institution

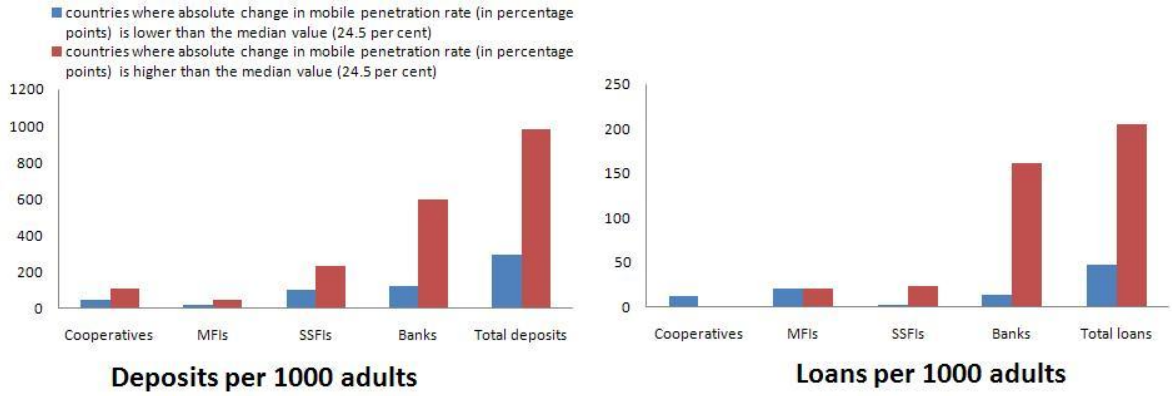


Figure 3. Trends in ICT Use: International Comparison

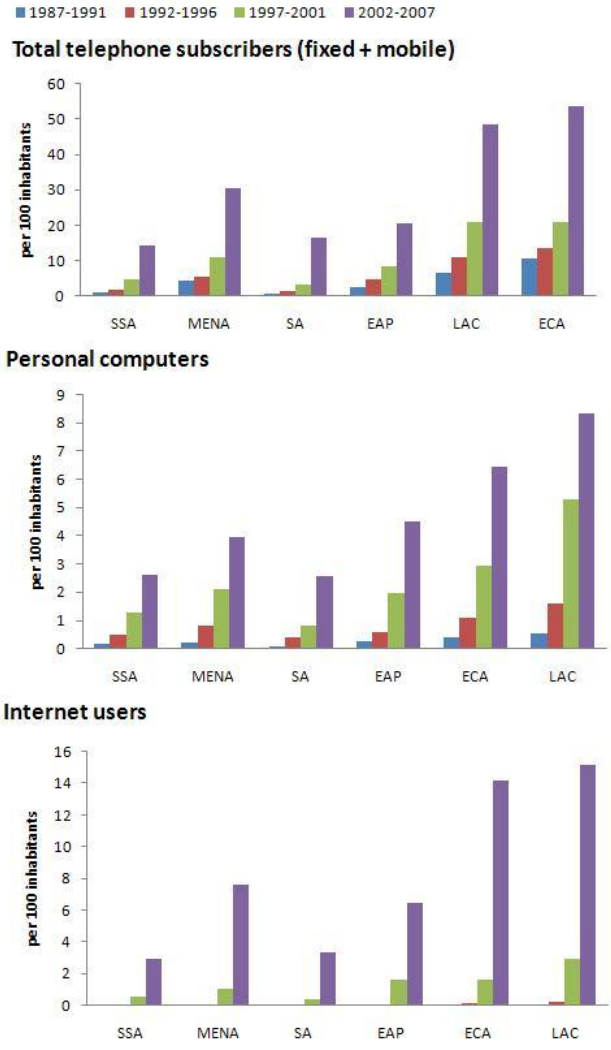


Figure 4. ICT Growth in Developing Countries

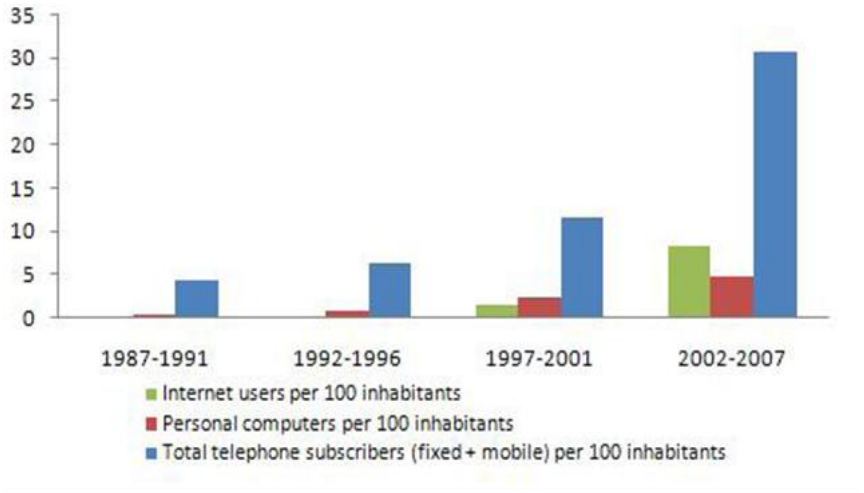


Figure 5. Trends in Fixed versus Mobile Phone Subscribers: International Comparison

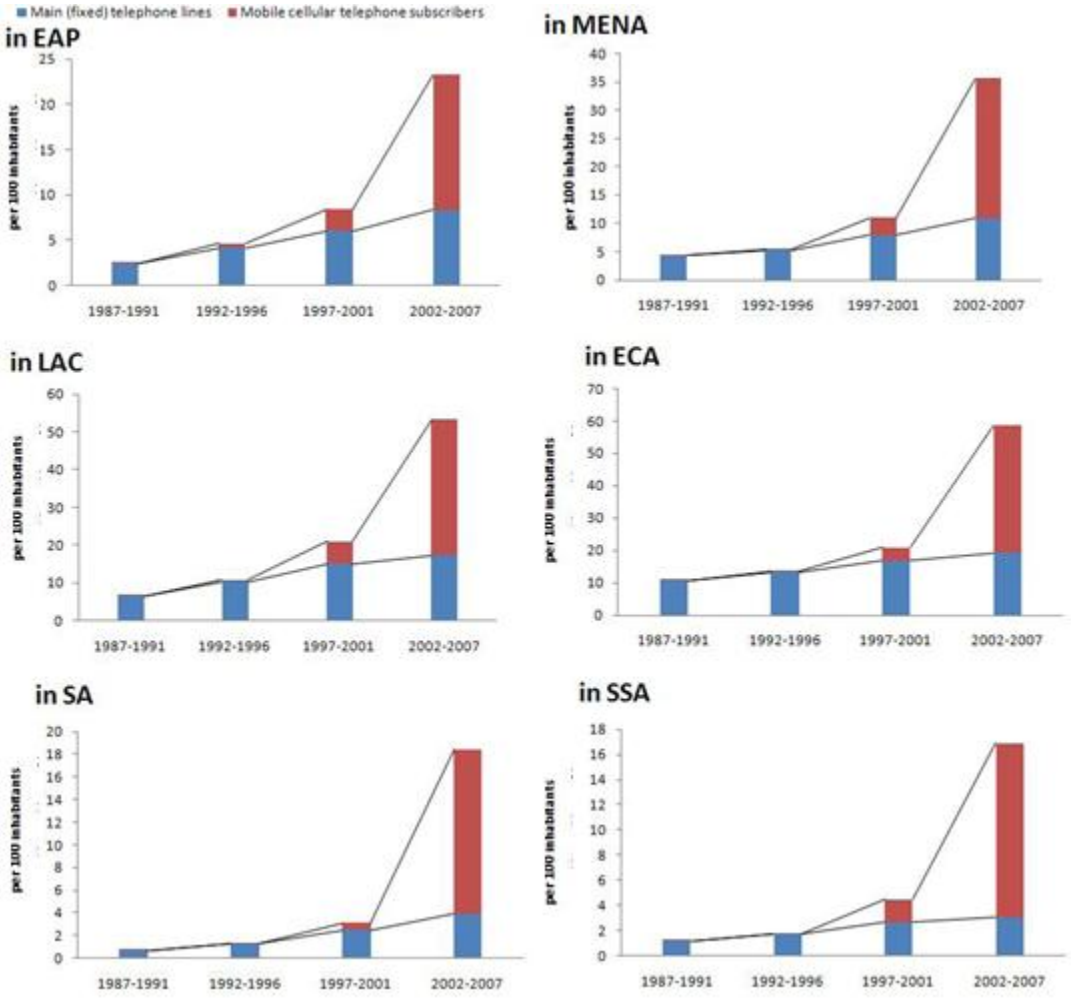


Figure 6. Trends in Mobile Penetration: International Comparison

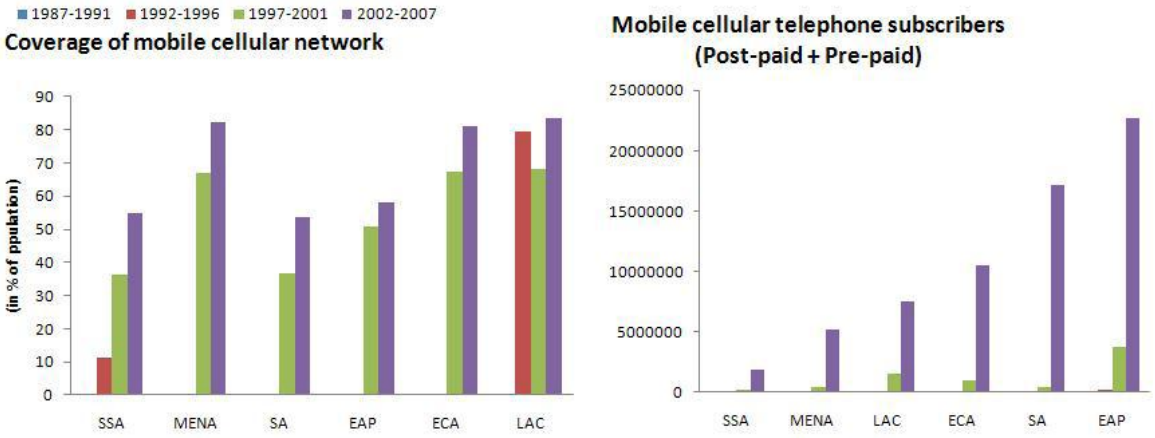


Figure 7. Trends in Prepaid versus Postpaid Phone Subscribers: International Comparison

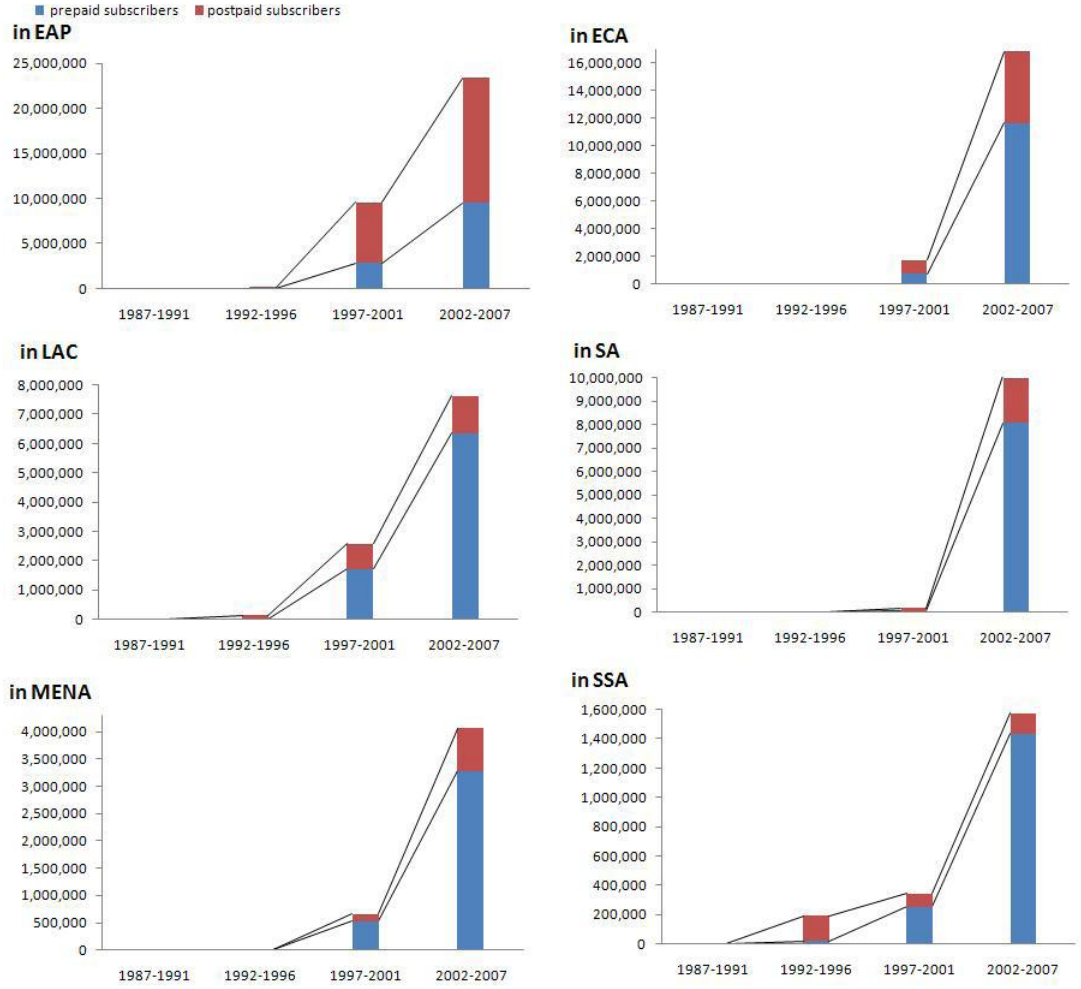


Figure 8. Access to Financial Services in Selected African Countries
(Percent of total population)

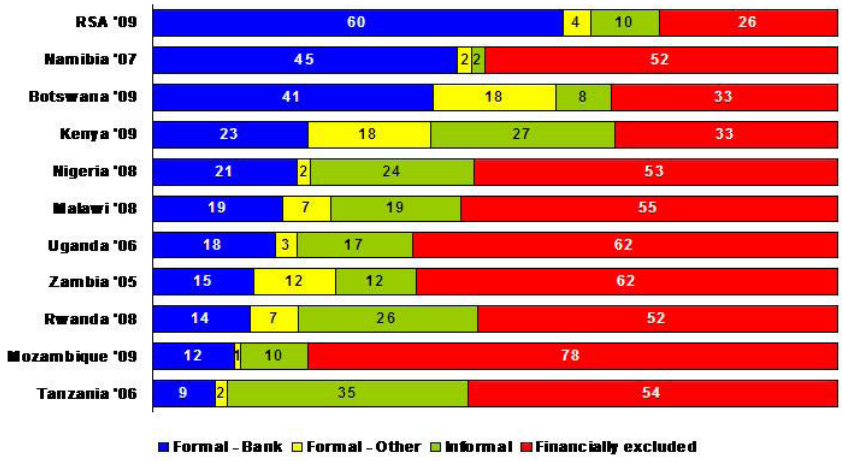


Figure 9. Bank Loans and Deposits: International Comparison

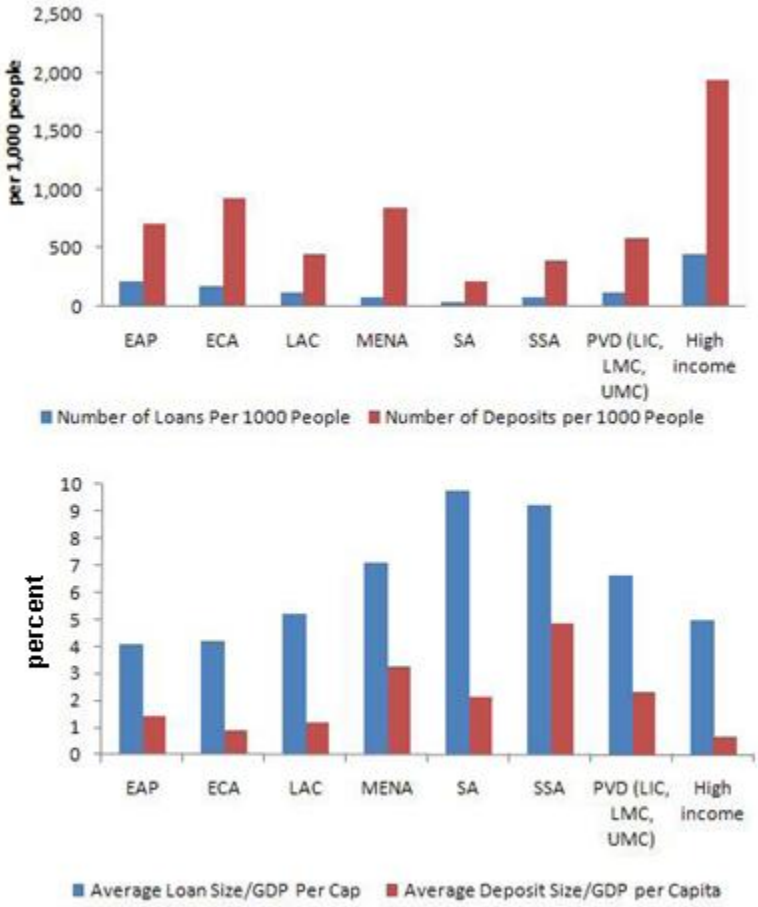


Figure 10. Bank Branches and ATMs

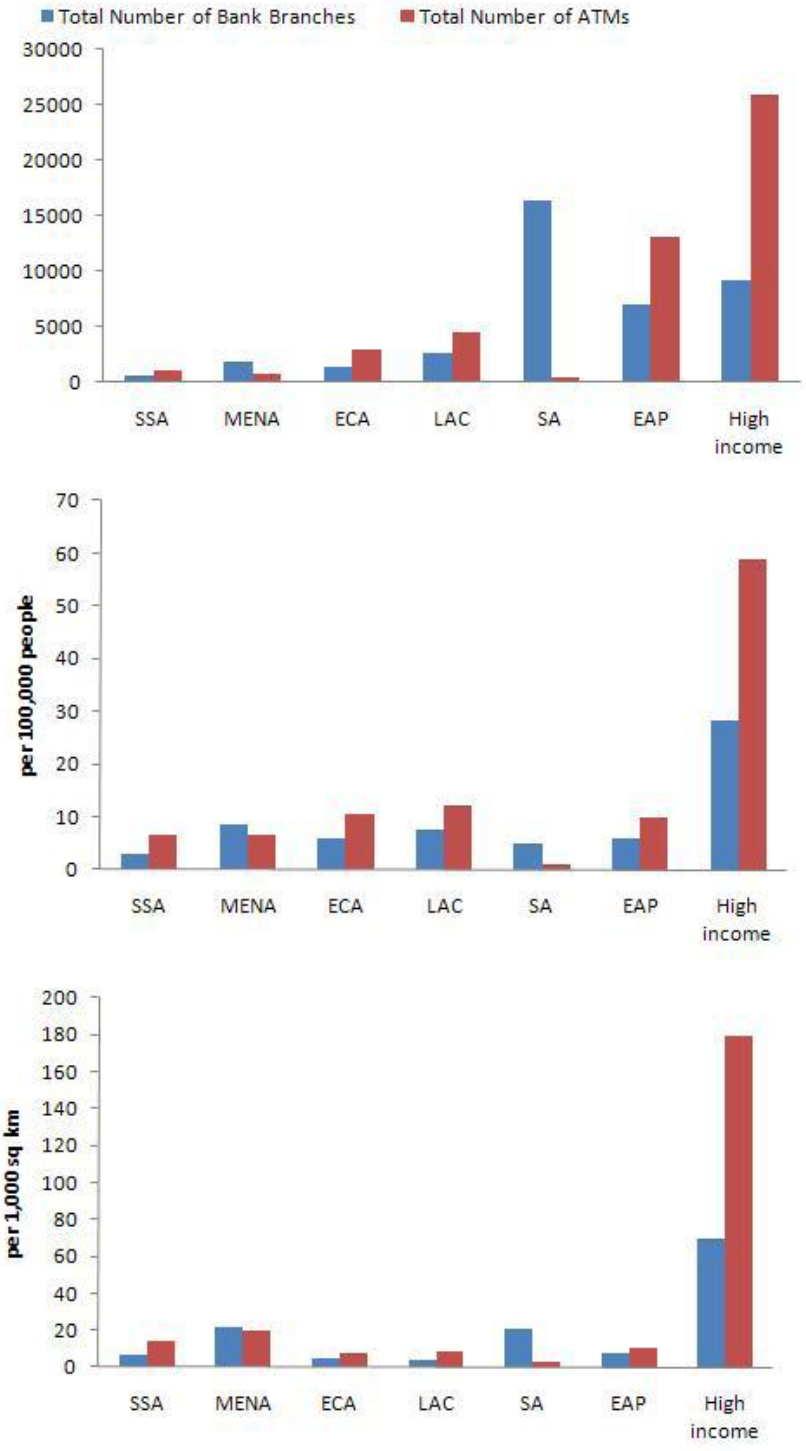


Figure 11. Financial Infrastructure Gap

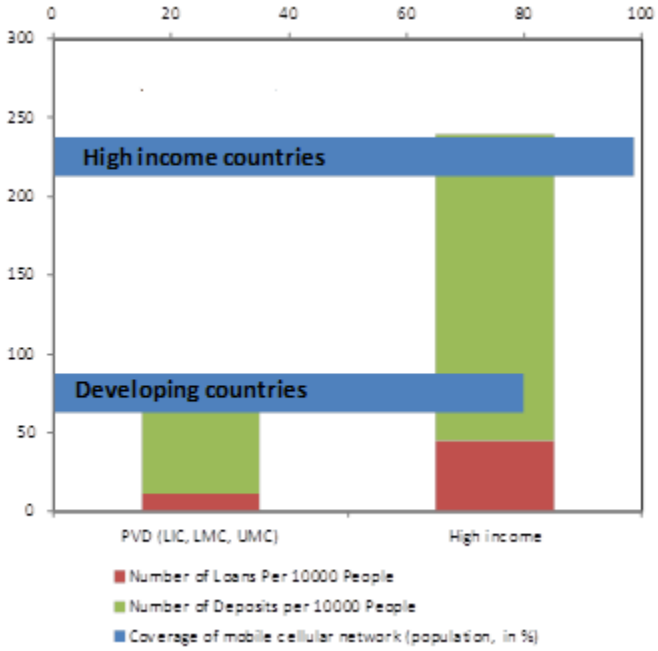


Figure 12. Comparing Trends in Bank Credit and Mobile Penetration

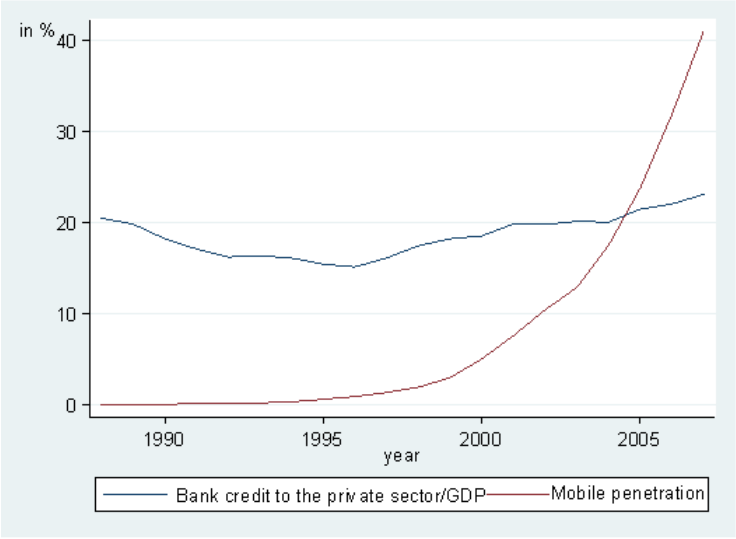


Figure 13. Testing for the Stability of the Coefficient on Mobile Penetration Using Random Samples

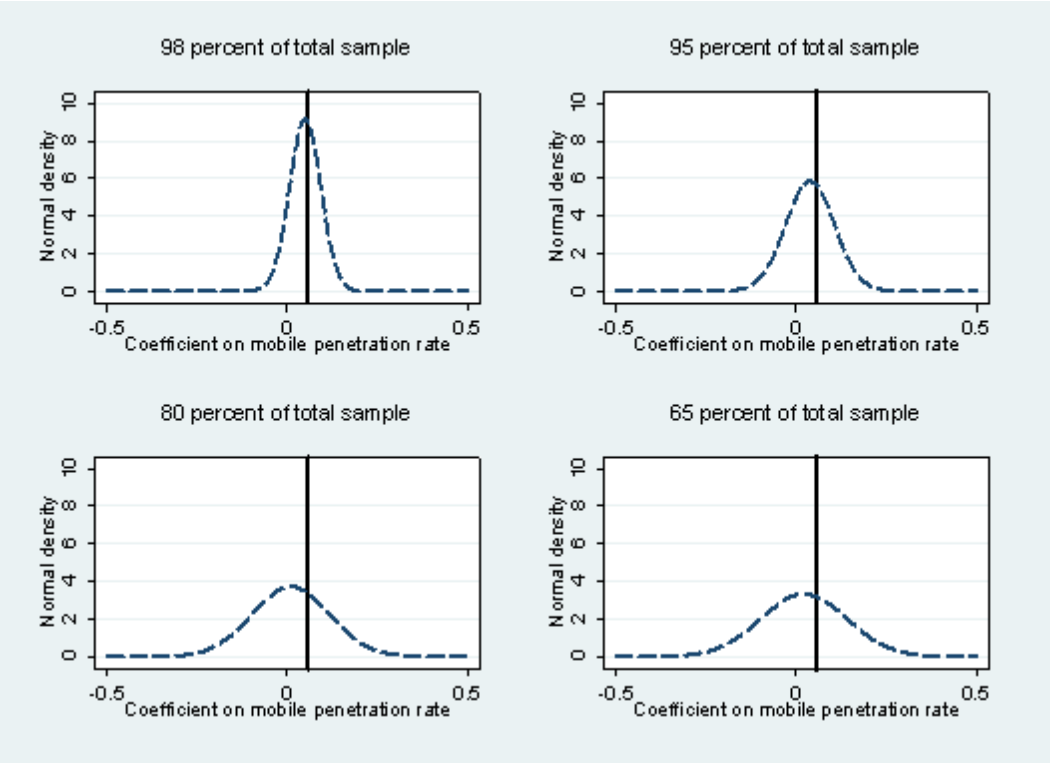


Figure 14. Recursive Estimates of the Coefficient on Mobile Penetration

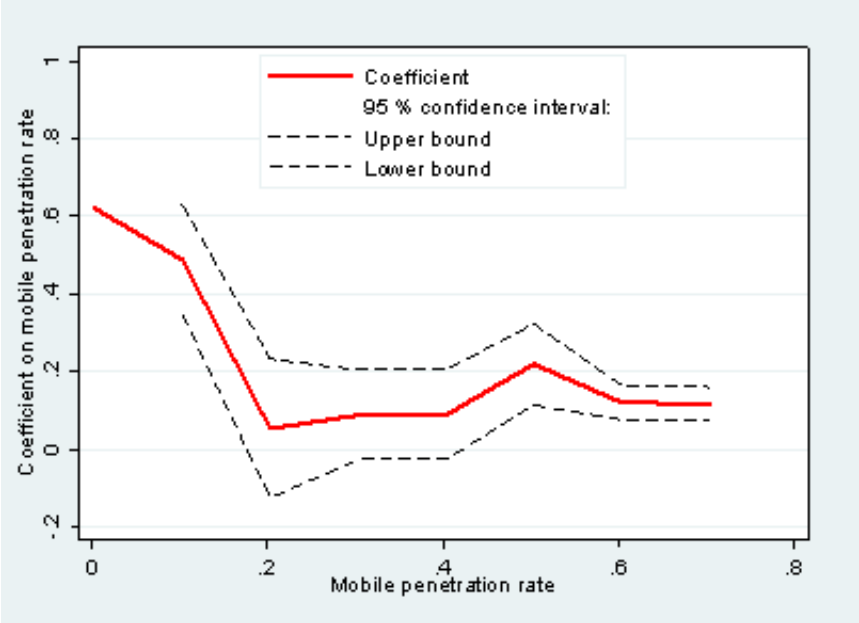
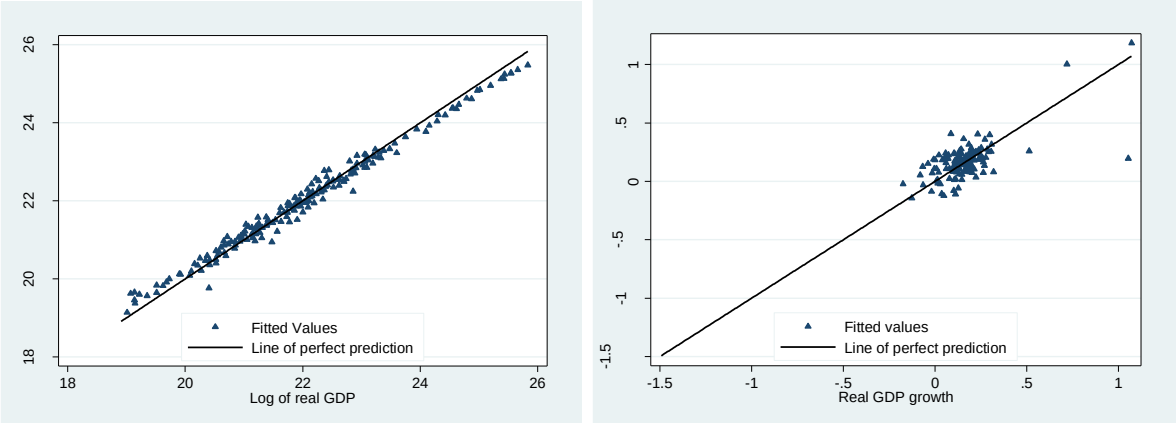


Figure 15. Quality of the Prediction



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

Notes for the figures: MFIs = microfinance institutions; SSFIs = specialized state financial institutions; automated teller machines (ATMs); SSA = sub-Saharan Africa; ECA = Europe and Central Asia; MENA = Middle East and North Africa; SA = South Asia; LAC = Latin America and Caribbean; EAP = East Asia and Pacific; LICs = low-income countries; LMC = lower middle income countries; UMC = upper middle income countries.

Table 2. Impact of Mobile and Fixed Telephone Penetration on Economic Growth in Africa

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Initial GDP (log)	-0.230	-0.190	-0.190	-0.090	-0.100	-0.040	0.010	-0.010
	[0.034]***	[0.018]***	[0.019]***	[0.013]***	[0.009]***	[0.007]***	[0.007]***	[0.004]***
Total telephone subscribers (fixed + mobile) per head		0.116						
		[0.027]***						
Fixed telephone lines per head			0.700		0.114			
			[0.169]***		[0.031]***			
Mobile telephone subscribers per head				0.056	0.073			
				[0.017]***	[0.009]***			
Price of a 3-minute fixed telephone local call						-0.401		-0.356
						[0.033]***		[0.021]***
Price of 3-minute mobile local call							-0.085	-0.050
							[0.020]***	[0.011]***
Education	0.005	0.003	0.004	0.003	0.003	0.001	0.002	0.002
	[0.001]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
Government consumption	-0.025	-0.025	-0.025	-0.020	-0.020	-0.004	-0.003	-0.001
	[0.003]***	[0.002]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.002]*	[0.001]
Inflation (log)	-0.526	-0.608	-0.451	-0.274	-0.353	-0.683	-0.435	-0.663
	[0.151]***	[0.091]***	[0.086]***	[0.100]***	[0.024]***	[0.058]***	[0.073]***	[0.071]***
Institutions	-0.064	-0.015	-0.056	0.025	0.065	-0.033	0.075	0.040
	[0.163]	[0.043]	[0.055]	[0.056]	[0.007]***	[0.046]	[0.046]	[0.038]
Constant	5.214	4.393	4.376	2.196	2.503	1.024	-0.151	0.369
	[0.706]***	[0.410]***	[0.423]***	[0.284]***	[0.198]***	[0.141]***	[0.153]	[0.078]***
Observations	190	189	189	190	189	168	170	157
Number of countries	44	43	43	44	43	41	41	39
Hansen test (prob.)	0.54	0.60	0.60	0.61	0.59	0.37	0.32	0.78
AR2 (prob.)	0.23	0.17	0.20	0.34	0.31	0.45	0.27	0.19

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

Table 3. Testing for Interaction Terms and other Forms of ICT

	(1)	(2)	(3)
Initial GDP (log)	-0.060	-0.060	-0.030
	[0.003]***	[0.004]***	[0.005]***
Fixed telephone lines per head	0.747	0.060	
	[0.058]***	[0.089]	
Mobile telephone subscribers per head	0.300	0.112	
	[0.024]***	[0.037]***	
Fixed × Mobile telephone subscribers per head	-2.548		
	[0.088]***		
Mobile telephone subscribers per head × GDP per capita		-0.012	
		[0.007]*	
Personal computers per 100 head			0.247
			[0.368]
Internet users per 100 inhabitants			-0.579
			[0.193]***
Internet users per 100 inhabitants × GDP per capita			0.350
			[0.039]***
Education	0.000	0.001	0.001
	[0.000]	[0.000]***	[0.000]**
Government consumption	-0.012	-0.014	-0.007
	[0.001]***	[0.001]***	[0.001]***
Inflation (log)	-0.448	-0.417	-0.530
	[0.029]***	[0.038]***	[0.051]***
Institutions	0.042	0.080	-0.006
	[0.018]**	[0.009]***	[0.043]
Constant	1.709	1.546	1.011
	[0.086]***	[0.099]***	[0.102]***
Observations	189	189	128
Number of countries	43	43	41
Hansen test (prob.)	0.75	0.75	0.95
AR2 (prob.)	0.34	0.38	0.45

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

Table 4. Robustness Tests

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

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 average over 5-year periods;

(3) sample of sub-Saharan African countries, excluding Mauritius, Seychelles, and South Africa;

(4) and (5) sample of developing countries.

Table 5. Mobile Penetration, Financial Inclusion, and Economic Growth in Africa

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Initial GDP (log)	-0.110	-0.150	-0.070	-0.160	-0.110	-0.080	-0.120	-0.030
	[0.009]***	[0.015]***	[0.007]***	[0.013]***	[0.009]***	[0.011]***	[0.012]***	[0.003]***
Mobile telephone subscribers per head	0.075	0.042	-0.014	0.043	0.005	-0.044	-0.033	0.011
	[0.016]***	[0.009]***	[0.015]	[0.011]***	[0.024]	[0.040]	[0.034]	[0.027]
Number of deposits per head		0.658	0.087			0.079		
		[0.154]***	[0.005]***			[0.013]***		
Mobile × Number of deposits per head			0.103			0.130		
			[0.034]***			[0.078]*		
Mobile × Number of deposits per head × Mobfi						1.392		
						[0.119]***		
Number of loans per head				3.540	0.919		1.100	
				[0.870]***	[0.043]***		[0.100]***	
Mobile × Number of loans per head					1.756		0.570	
					[0.311]***		[0.344]*	
Mobile × Number of loans per head × Mobfi							7.419	
							[0.889]***	
Private Credit/GDP								0.050
								[0.022]**
Mobile × Private Credit/GDP								0.096
								[0.056]*
Mobile × Private Credit/GDP × Mobfi								0.107
								[0.021]***
Education	0.004	0.004	0.003	0.005	0.004	0.003	0.004	0.002
	[0.000]***	[0.001]***	[0.000]***	[0.001]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
Government consumption	-0.020	-0.030	-0.015	-0.028	-0.022	-0.016	-0.021	-0.010
	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***
Inflation (log)	-0.293	-0.195	-0.360	-0.120	-0.194	-0.412	-0.301	-0.296
	[0.107]***	[0.159]	[0.052]***	[0.148]	[0.066]***	[0.066]***	[0.072]***	[0.017]***
Constant	2.518	3.481	1.534	3.635	2.575	1.900	2.769	0.894
	[0.218]***	[0.374]***	[0.160]***	[0.316]***	[0.207]***	[0.247]***	[0.260]***	[0.071]***
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	0.56	0.66	0.44	0.50	0.60	0.73
AR2 (prob.)	0.32	0.20	0.40	0.25	0.32	0.34	0.26	0.43

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

Annex 1. Mobile Financial Services

Mobile financial services (MFS) belong to the category of branchless banking services that allows banks to provide remote financial services to their customers. Branchless banking services can be in addition to services already offered to existing customers. In that case they are called additive, because they are not specifically designed for customers with low access to financial services. On the other hand, they can be tailored for customers who would not be reached profitably with traditional branch-based financial services; in that case, they are called transformational. Whereas mobile financial services generally are additive in developed countries, they are mainly transformational in developing countries with the objective of improving financial inclusion of unbanked people.

Currently, two main models exist: the bank-based and the nonbank-based models. In the bank-based model, customers have a direct contractual relationship with the bank (the financial institution), but transactions are handled by retailers outside the bank branch network. In mobile financial services, the retailer is a mobile network operator (MNO) that offers a technological channel for delivering banking services. Because the bank is licensed, it is subject to prudential regulation; and customers and the regulatory authorities, therefore, may be more reassured. The Brazilian model, the South African models (MTN and WIZZIT), and the Indian model are examples of bank-based models. In the nonbank-based model, there is no direct contractual relationship between the user of financial services and the bank. The user gives cash to the retailer in exchange for an electronic record of value on a virtual account kept through the MNO or an issuer of stored value card. In contrast to banks, nonbanks providing MFS are not subject to prudential regulation because they are not allowed to intermediate the repayable deposits they collect. Nonbank mobile money providers make profits in other ways; for example, through transaction charges or lowered airtime distribution costs, reduced churn, and so forth (Tarazi, and Breloff, 2010). M-PESA in Kenya and Orange Money in Ivory Coast are examples of nonbank-based models.

It is worth describing one of the most successful MFS: M-PESA in Kenya. M-PESA, a mobile payment and transfer service provided by Safaricom, offers to its customers an electronic wallet (e-wallet) stored on their cell phones. Users can deposit into, and withdraw money from their e-wallet at an M-PESA agent. They also can transfer electronic money to other users (including sellers of goods and services to pay, for instance, electricity bills or taxis fares) and buy prepaid airtime via text messages.[31] According to Mas and Radcliffe (2010), 75 companies are now using M-PESA to collect payments from their customers; the biggest user is the electricity company (20 percent of their customers pay through M-PESA). M-PESA also intends to deliver a full range of payment services such as institutional payments, by allowing companies to use M-PESA to pay for salaries, for example, or even allowing payments for in-store purchases. In other countries, such as Egypt, governments are

[31] Regulation on anti-money-laundering (AML) and combating the financing of terrorism (CFT) has, among other requirements; imposed thresholds on transaction values. With M-PESA, there is no minimum account balance. However, there is a maximum account balance, and daily transactions and withdrawals are only allowed within a predetermined band (CGAP, 2007).

also considering the possibility of using mobile phones and mobile money to pay for government subsidies or pensions in Government to People (G2P) transactions.

M-PESA charges fees for sending electronic float (e-float) and for cash withdrawal. Registration for M-PESA service is possible for any owners of a Safaricom SIM card and requires a formal ID card.[32] M-PESA agents handling customers' deposits and withdrawals of cash receive a commission. They hold e-float, purchased from Safaricom or customers, on their own cell phones, and must maintain cash on their premises (to meet customers' withdrawals).[33]

The cash collected by M-PESA in exchange for e-float is held by M-PESA Trust Company, Ltd., in trust accounts with two commercial banks that pool client funds. However, any interest earned from this pooled account cannot benefit Safaricom and cannot be passed through to customers whose funds actually earned the interest because Safaricom would then be acting as a bank.[34]

Since its launch in March 2007, M-PESA has experienced extraordinary growth. As of January 2010, there were more than 9 million registered users of M-PESA (40 percent of Kenyan adults and 23 percent of the population), of which the majority is active; about $320 million per month of person-to-person (P2P) transfers have occurred. M-PESA has 16,900 agents who are Safaricom dealers or other entities such as petrol stations (Mas and Radcliffe, 2010). In January 2010, thanks to a partnership with Equity Bank (one of the biggest lenders in Kenya by number of accounts), M-PESA customers can also withdraw money (but not deposit) at any Equity Bank ATM, regardless of whether they are clients of Equity Bank. This further increases access to financial services for M-PESA customers and helps mitigate liquidity problems for customers when M-PESA agents do not have cash on hand.[35]

[32] The ID card requirement is part of AML and CFT regulations. Even if the ID requirement for opening a mobile money account is not as constraining as the number of formal documents required when opening a bank account, it can still represent an impediment to mobile banking growth and financial inclusion. Indeed, unbanked and low-income customers targeted by mobile banking service rarely possess any kind of formal ID.

[33] Managing agents' liquidity is essential for M-PESA and mobile money service in general (Mas and Ng'weno, 2009).

[34] In that case, M-PESA would not be a payments service anymore but a banking service. Discussions are ongoing with the Central Bank of Kenya on what to do with the interest (CGAP, 2007). Tarazi and Breloff (2010) mention that because interest has accrued on the trust accounts established for M-PESA customers, Safaricom is negotiating with the authorities to donate the interest to charity.

[35] A savings service called M-Kesho, which will allow mobile-phone based deposit accounts, is also being launched. There are also partnerships between M-PESA and other commercial banks, with the objective of achieving a closer integration between the non-bank based model of MFS and the conventional banking system, and ultimately improving financial inclusion.

Annex 2. Assessing the Effect of Mobile Phone Penetration on Financial Inclusion

We found in Table 5 that the effect of mobile penetration on growth weakened once financial inclusion was controlled for, suggesting that the latter could be one channel 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 inclusion, while controlling for a range of factors Kendall, Mylenko, and Ponce (2010) have found important in explaining cross-country variations in deposit account and loan penetration (measured as number of accounts or loans per 1000 adults). For instance, the authors find that income levels and population density are two of the best predictors of the penetration of deposit and loan products. Our model is as follows:

$$FI_{i,t} = \gamma_0 + \gamma_1 y_{i,t} + \gamma_2 dens_{i,t} + \gamma_3 mob_{i,t} + \sum_{k=1}^{n} X_{i,t}^{k} + \delta_i + \varepsilon_{i,t}$$

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, respectively, represent 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,[36] a variable capturing the quality of the legal environment,[37] and the number of bank branches per km2 to capture the geographical coverage of bank branches. Finally, δ accounts for country-specific effects and ε is the error term.

In contrast to Kendall, Mylenko, and Ponce (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 strongly positively correlated to financial inclusion.[38] This holds even after controlling for GDP per

[36] Kendall, Mylenko, and Ponce (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 why a high share of share of the population in developing countries is financially excluded. However, the shortcoming of this measure is that it captures only the efficiency of commercial banks.

[37] For consistency purposes, the indicator of the quality of institutions is the same as in the growth model presented in Table 2. Kendall, Mylenko, and Ponce (2010) use indicators of contract enforcement, creditor right protection and creditor information.

[38] Kendall, Mylenko, and Ponce (2010) use fixed line density as a measure of the development of physical infrastructure and found that it is positively associated with financial inclusion.

head and population density, as well as for the cost of financial intermediation, the legal environment and the geographical coverage of bank branches.[39] Similarly, by using household survey data, Beck and others (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 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, which is needed for group lending. As our indicators of financial inclusion possibly underestimate the access to less formal financial services, the negative sign of population density could be attributable to the risk diversification strategy of commercial banks.

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	0.101	0.211	0.071
	[0.161]**	[0.036]***	[0.084]**	[0.011]***
GDP per head(log)	0.132	0.093	0.015	-0.001
	[0.047]***	[0.032]***	[0.016]	[0.010]
Population density (log)	0.098	0.065	0.007	-0.023
	[0.035]***	[0.030]**	[0.010]	[0.010]**
Banks' overhead cost (percent of assets)		-1.405		0.227
		[0.682]**		[0.202]
Institutions		0.95		0.279
		[0.142]***		[0.073]***
Number of bank branches per km2		0.005		0.002
		[0.001]***		[0.000]***
Constant	-1.008	-0.802	-0.104	0.034
	[0.347]***	[0.227]***	[0.111]	[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%

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

Appendix 1. 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. Summary Statistics and Correlation Matrix

	Observations	Average	Standard deviation	Minimum	Maximum
Real GDP growth	190	4.3	4.2	-4.9	40.9
Log of real GDP	190	22.0	1.5	19.0	25.8
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 a 3-minute fixed telephone local call	168	0.114	0.094	0.014	0.774
Price of 3-minute mobile local call	170	0.498	0.476	0.0	1.853
Personal computers per head	134	0.012	0.017	0.0	0.081
Internet users per head	170	0.012	0.025	0.0	0.175
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

Variables/Correlation coefficients		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Real GDP growth	(1)	1.00															
Log of real GDP	(2)	-0.03	1.00														
Primary school enrollment rates	(3)	0.13	0.08	1.00													
Government consumption in percent of GDP	(4)	-0.12	-0.10	0.24	1.00												
Inflation rate	(5)	-0.05	-0.04	-0.15	-0.06	1.00											
Institutions	(6)	0.06	-0.02	0.21	0.16	-0.12	1.00										
Fixed telephone lines per head	(7)	0.00	0.24	0.30	0.19	-0.17	0.51	1.00									
Mobile telephone subscribers per head	(8)	0.05	0.19	0.26	0.10	-0.19	0.29	0.60	1.00								
Price of a 3-minute fixed telephone local call	(9)	-0.11	-0.22	-0.02	-0.09	-0.26	-0.13	-0.18	0.12	1.00							
Price of 3-minute mobile local call	(10)	0.00	0.23	0.18	-0.01	-0.22	0.15	0.16	0.32	0.02	1.00						
Personal computers per head	(11)	0.01	0.27	0.27	0.21	-0.19	0.46	0.71	0.57	-0.02	0.07	1.00					
Internet users per head	(12)	0.00	0.24	0.26	0.12	-0.17	0.28	0.62	0.83	0.09	0.22	0.61	1.00				
GDP per capita (current US dollars)	(13)	0.15	0.23	0.36	0.10	-0.18	0.26	0.64	0.62	0.00	0.21	0.43	0.41	1.00			
Number of deposits per head	(14)	0.04	0.13	0.23	0.11	-0.07	0.57	0.63	0.22	-0.23	-0.05	0.39	0.28	0.31	1.00		
Number of loans per head	(15)	0.03	0.15	0.24	0.13	-0.07	0.63	0.63	0.23	-0.21	0.02	0.52	0.29	0.33	0.92	1.00	
Private credit to GDP	(16)	-0.12	0.46	0.21	0.27	-0.22	0.36	0.65	0.38	-0.18	0.12	0.54	0.44	0.32	0.55	0.62	1.00

Appendix 3. 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 GDP	Logarithm of real 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	
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	
Price of a 3-minute fixed telephone local call	Price of a 3-minute fixed telephone local call (peak rate - US$)	
Price of 3-minute mobile local call	Mobile cellular - price of 3-minute local call (peak -	
Personal computers per head	Number of personal computers divided by total population	
Internet users per head	Number of people with access to the worldwide network divided by total population	
Private credit/GDP	Private credit by deposit money banks as share of GDP	Financial Structure Database (World Bank)
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	