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Is Mobile Banking Breaking the Tyranny of Distance to Bank Infrastructure? Evidence from Kenya

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Abstract

Is the mobile banking revolution overcoming the tyranny of distance to bank infrastructure and improving financial inclusion in sub-Saharan Africa? Focusing on Kenya, this paper uses Global Positioning System (GPS) data to investigate the importance of distance and time to bank branch for personal access to both formal banking services and the mobile banking platform M-Pesa. Evidence suggests that greater distances and time to bank infrastructure reduce the likelihood an individual is formally banked and that despite the significant expansion of the bank branch network in Kenya (2006-2009), the negative relationship between distance to bank branch and the likelihood of being banked has increased. In contrast, evidence is found to support the hypothesis that mobile banking in Kenya is overcoming the tyranny of distance to bank infrastructure for the financial inclusion of all economic groups in Kenya.

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1. Introduction

Distance to financial services has long been a constraint for financial inclusion in sub-Saharan Africa, a region characterised by an especially high proportion of rural dwellers. In 2010, 63 percent of Sub-Saharan Africans lived in rural areas, and while this percentage has declined steadily from 85 percent in 1960, the absolute number of rural residents in sub-Saharan Africa has risen to 534 million from 196 million in 1960.[2] Evidence for the role played by geography in financial exclusion was provided in Honohan and King (2012) who found that the usage of formal financial services was lower in rural areas across 11 sub-Saharan African countries surveyed, with rural penetration rates less than 15 percent in the poorer countries; Kenya, Malawi, Mozambique, Rwanda, Tanzania, Zambia as well as in Nigeria.

Geographical isolation in the form of distance or time to bank branch can increase the effective cost of using financial services, shifting upwards the effective financial services supply curve out of reach of individuals with a modest demand for these services. Indeed, geographic isolation can lead to the complete absence of a supply curve, condemning rural dwellers to exclusion from formal savings, transaction and loan products irrespective of their material wealth and demand for services.

From a supply side perspective, higher levels of financial inclusion can be achieved in sub-Saharan Africa if bank networks expand into small towns and villages or the mobile banking revolution gathers pace. Branch expansion offers the potential of incremental improvements in financial inclusion but the profitability of rural bank expansion can be undermined by low levels of demand due to significant levels of informality and poverty in rural areas, and the high costs of branch expansion.

[2] Source: World Bank Development Indicators (2012).

Kenya experienced significant expansion in its financial sector infrastructure over the period 2006-2008, which resulted in a 46 percent increase in bank branches, from a total of 581 in 2006 to 849 in 2008 (Central Bank of Kenya, 2007, 2009). While there was no increase in bank branches in the north of the country, there was significant expansion into more densely populated areas in the south of the country stretching from Lake Victoria to the port city of Mombasa. The net effect of this branch expansion, together with wider economic growth in Kenya, was to increase the proportion of Kenyan adults with access to formal financial services from 16 percent in 2006 to 24 percent in 2009.

Alternatively, the rapid expansion in mobile banking in sub-Saharan Africa can help achieve greater financial inclusion by bringing increasingly sophisticated and lower cost services to rural communities, beginning with saving and transaction services. The spread of mobile banking offers developing countries the tantalising prospect of increases in financial inclusion without the need for branch expansion. It is possible that low income countries could leapfrog branch centred banking into mobile banking, in similar fashion to their leapfrog over landline telecommunication infrastructure straight to mobile technology.

Kenya has been at the forefront of the mobile banking revolution in Africa with M-Pesa, the venture launched by Safaricom, Vodafone's Kenya affiliate, reaching over 10 million registered customers, or 40 percent of Kenya's adult population, by 2010 (Beck, Maimbo, Faye and Triki, 2012). Registered M-Pesa users can store, transfer or accept sums of money through their mobile phones and turn their virtual balances into cash at any one of over 20,000 authorised Safaricom dealers. Despite the remarkable success of M-Pesa, the system is not a perfect substitute for the range of services offered by a formal bank, with the notable absence of a credit facility for customers. However, recent innovations have begun to bridge the gap with the opening up of M-Pesa to institutional payments and enabling companies to pay salaries and collect bill payments. It is conceivable that further innovations will reduce

the differences in breadth of services offered by mobile banking in Kenya when compared with the traditional service offerings by formal banks.

This paper seeks to answer two questions and test one central hypothesis. First, an attempt to quantify the nature of the tyranny of distance in financial inclusion in Kenya is made.[3] I define the tyranny of distance as the situation when an individual's chance of having a bank account depends on proximity to a branch. In the event of a saturation in the number and location of branches across a country, the distance to branch would no longer be a factor in determining whether an individual had a bank account: one could always find a branch sufficiently close to make distance a negligible factor. Specifically, Global Positioning System (GPS) coordinates for both bank customers and bank branches are used to estimate the relationship between physical distance to bank infrastructure and the likelihood of being formally banked. To complement this analysis the relationship between time to bank branch and personal financial access is also assessed. Second, this paper ascertains whether changes have taken place in the importance of distance to bank branch for financial inclusion between 2006 and 2009, a period of significant banking expansion. Finally, taking advantage of the recent mobile banking revolution in Kenya and use of M-Pesa by over 10 million Kenyans, the hypothesis that mobile banking in Kenya is overcoming the tyranny of distance to bank infrastructure for financial inclusion is tested.

In this paper, the individual level data come from the 2006 and 2009 Kenyan FinAccess surveys. In addition to containing a wealth of information on usage and perceptions of financial services and basic socio-economic data on the respondent, the surveys contain GPS coordinates for the home of the respondent. This data is combined with data from the Central

[3] The phrase tyranny of distance to banking infrastructure was first used by Petersen and Rajan (2001) in relation to small business lending.

Bank of Kenya on the names, addresses and locations of bank branches in 2006 and 2009 to answer the two questions and main hypothesis posed.

The univariate tests confirm the importance of physical access, as measured by distance and time to banking infrastructure, for formal financial inclusion and this result is backed up by more systematic bivariate probit regressions. For example, in 2009 a 1 percent increase in the distance from a bank branch leads to a decrease in the chances of being banked by 3 percent. By dividing the data into subsamples and separately using a series of interaction terms, evidence is found that distance is a binding constraint for middle income individuals, defined as those in expenditure quartiles two and three, and for those with non-zero assets.

While penetration rates of formal banking increased modestly in rural areas from 12 percent in 2006 to 17 percent in 2009, there is evidence that the financially included resided closer to bank branches in 2009 than in 2006. This is likely to reflect a combination of greater increases in financial inclusion in urban areas, the predominance of bank branch expansion in urban areas or in rural areas with higher population density and the increased use of M-Pesa by potential bank customers in rural areas.[4] The failure of the significant expansion in the Kenyan banking system to overcome, to any great extent, the tyranny of distance to bank infrastructure is perhaps an ominous sign for the potential of branch expansion to improve financial access in regions of low population density in the short term.

Evidence is found to support the hypothesis that mobile banking in Kenya is overcoming the tyranny of distance to bank infrastructure for financial inclusion. In the main specification with control variables for wealth and level of formality, it is found that distance or time to bank branch is not a statistically significant determinant of the use of mobile banking. Even before wealth and expenditure level are controlled for, increased distances from bank

[4]By comparison the usage of formal banking services increased from 27 percent in 2006 to 41 percent in urban areas in 2009.

infrastructure do not reduce the likelihood that an individual is a mobile bank user as much as it does for formal banked account holders. While this result suggests that mobile banking may be breaking the tyranny of distance for those with greater wealth, further analysis on sub-samples suggest that the non-relationship found between distance or time to bank branch and mobile banking is not overturned for any personal expenditure quartile and breadth of assets. This provides strong evidence that mobile banking is breaking the tyranny of distance (or time) to traditional bank infrastructure for greater financial inclusion of all economic groups in Kenya.

This paper is structured as follows. Section 2 provides a short review of the relevant literature. Section 3 outlines recent developments in both the formal and mobile banking systems in Kenya. Section 4 describes the data sources used in this paper - FinAccess 2006 and 2009 - and a supply side survey of bank branches by the Central Bank of Kenya. Section 5 describes the econometric model and empirical results and Section 6 concludes.

2. Literature Review

Debates over channels of causation between financial development and economic growth have existed since innovations in banking and legal currency gathered pace in Western Europe in the 17th and 18th Centuries. While acknowledging the likely bi-directionality of the causation, recent research has substantiated the position that increasing depth of the financial sector stimulates economic growth by increasing the rate of capital accumulation and improving the efficiency of capital (King and Levine, 1993). To support this hypothesis, King and Levine (1993) focus on four different measures of financial depth, one of which may be considered a crude approximation of the depth of the bank branch network; the ratio of deposit money bank domestic assets to deposit money bank domestic assets plus central bank domestic assets. The cross-country evidence from King and Levine (1993) suggests that

greater levels of bank deposits are strongly correlated with economic growth.[5] While a wide reaching branch network should go hand in hand with depth in bank deposits, it is possible that foreign deposits could inflate domestic deposit levels without necessitating the mobilisation of domestic savings through branch expansion. In addition, the depth of central bank domestic assets will differ by country and depend on the varying institutional approaches to prudent levels of assets to underpin stability in the financial system.

Irrespective of the outcome of debates over causality between the depth of banking infrastructure and growth, difficulties of physical access to banking services represent an important constraint to greater financial inclusion in developing countries as African and African-based banks tend to concentrate their branch networks in urban areas (World Bank, 2008). The importance of physical access to banking infrastructure was demonstrated by a pseudo-natural experiment in Mexico, the expansion of a savings institute (Pahnal), that showed that greater physical access increased the average saving rate of affected households by 3 to 5 percentage points (Aportela, 1999). Further evidence for the importance of physical access comes from the great post-nationalisation expansion of bank branches in India. Between 1969 and 1996, India increased the number of bank branches from 8,262 to 63,092 with the greatest expansion in rural areas; the proportion of bank branches in rural areas increased from 22 percent to 52 percent (Kohli, 1999). The aggressive supply-led bank branch expansion was motivated by social policy objectives and pursued through a policy of mandatory licensing, introduced in 1977, whereby permission to open a bank branch in an already banked location was only granted if branches were opened in four previously unbanked locations (Burgess and Pande, 2005). By exploiting this policy change, Burgess

[5] The other three measures of financial depth employed by King and Levine include the ratio of liquid liabilities of the financial system to GDP, the proportion of credit allocated to private enterprises by the financial system and the ratio of claims on the nonfinancial private sector to GDP.

and Pande found that rural branch expansion, and associated deposit mobilisation and credit disbursement, caused reductions in poverty levels.

While these studies focus on the socio-economic impacts of branch expansion, a separate strand of the literature looks at the determinants of access to financial services (Djankov, Miranda, Seira and Sharma, 2008, Beck and Brown, 2010, Honohan and King, 2012 and King, 2012). While these studies assess the role played by personal, national or regional characteristics, formal assessment of the importance of physical access to banking infrastructure is absent from the development economics literature. Conceptually, physical access can be defined as either physical distance or time to branch. In some circumstances, travel time could be a more important determinant than distance in kilometres especially in urban areas and for rural areas with varying degrees of road infrastructure and public transport.

One modest exception to this comes from Honohan and King (2012), where time to grocery store is used as a proxy for distance, not necessarily to banking services, but services more generally, and while the relationship between whether an individual respondent is formally banked or not and time to grocery store is not found when a breadth of control variables are considered, this cannot disprove the importance of physical access to banking services in financial inclusion. Indeed, these results show that living in an urban environment increases the chances that an individual is formally banked.

Related literature on the role played by physical distance in small and medium enterprise lending in developed countries suggests that physical distance to branch networks has become less important for bank lending (Petersen and Rajan, 2002 and Degryse and Ongena, 2005). According to Petersen and Rajan (2002), the increase in the physical distance between lending banks and small firms in the US between 1973 and 1993 is not due to a retrenchment

of bank branch networks but centralisation of lending functions and associated increases in labour productivity. While Degryse and Ongena (2005) find limited evidence of a similar decline in the distance between lending banks and small firms over the period 1975 to 1997 in a survey of 15,000 Belgian firms, they do find evidence of distance-based price discrimination.

3. Developments in the Kenyan Banking System

3.1 Branch Network Expansion

Since 2005 Kenya has experienced a period of significant bank branch expansion with a 46 percent increase in three years from a total of 581 branches in 2006 to 849 branches in 2008 (Central Bank of Kenya, 2007 and 2009).[6] While more bank branches are located in urban areas, the growth rate in rural areas has been higher than in urban areas since 2005. Nevertheless, the regional insurance and banking centre of Nairobi also saw significant growth in bank branches, despite experiencing lower growth rates than for rural areas. Figure 1 presents the changes in the number of bank branches in Kenya since 2001, and since 2005 for urban and rural areas.

Figure 2 traces the expansion in bank branches since 1999 for each of the eight provinces in Kenya and presents estimates of formal banking penetration rates from the two FinAccess surveys in 2006 and 2009. At year end 2008, the urban centre of Nairobi had 112 branches per million population (353 branches in total), followed by 33 branches per million in the Coast province (111 branches in total). The provinces of Nyanza (11 branches per million), Western (9 branches per million) and North Eastern (4 branches per million) all had less than 12 branches per million population. Figure 3 shows the location of Kenyan provinces.

[6] These figures and the data used in the analyses in this paper and exclude head offices (Central Bank of Kenya, 2007, 2008, 2009, 2010, 2011).

The higher growth rates in bank branch expansion in rural areas hides important differences between rural areas. Rural areas in Kenya vary greatly in terms of population density and I find evidence that the expansion in rural areas is solely confined to the more densely populated areas in the south and near large cities and towns. Figure 6 shows all the newly opened bank branches in Kenya between 2006 and 2009. It is clear from the map that there was no increase in bank branches in the north of the country and that the branch expansion occurred in more densely populated rural areas in the south of the country stretching from Lake Victoria to the port city of Mombasa.

As banks tend to expand into regions with high and growing demand for financial services, measures of proximity to banking services are likely to change as demand patterns alter because of a mix of changes in levels of income, formality, consumerism and population density as well as in changes in the supply of bank infrastructure. For example, urbanisation will naturally reduce the distance between the citizens of Kenya and urban based financial services.[7] Alternatively, improved transport networks will reduce the opportunity cost of time to access financial services. This inherent endogeneity in the expansion decision of bank infrastructure means that measures of proximity to banking services cannot be seen as solely a supply side phenomenon.

Over the period 2006 to 2009, there were notable changes in market structure and three trends are worth of note. First, there was a significant increase in the number of banks licensed in Kenya with many international, middle eastern/Indian and other African banks setting up in Kenya's large cities with very small market share of the domestic retail banking market. Second, Equity Bank achieved a remarkable increase in market share from 17 percent in 2006 to 44 percent in 2009 on the back of its significant expansion in branch network and product

[7] Indeed the fact that the average annual urban population growth rates over the period 2006 and 2009 was 4 percent, compared with 2.2 percent for rural areas is suggestive of a possible role for migratory/demographic changes in reducing the average distance to banking services.

innovation. Finally, Kenya's more established banks, Co-operative Bank and Kenya Commercial Bank lost market share as a result of Equity bank's performance and have been joined by Barclay's Bank and Post Bank in second tier of Kenyan Banks, with each of the four banks on eight to ten percent market share.

3.2 Mobile Banking Revolution

Traditionally late adopters of western technological developments, developing countries have instead been at the vanguard of innovation in the area of mobile banking. The spread of mobile banking offers developing countries the tantalising prospect of increases in financial inclusion without the need for branch expansion. It is possible that low income countries could leapfrog branch based banking into mobile banking in similar fashion to their leapfrog over landline telecommunication infrastructure straight to mobile phone technology.

Kenya has been at the forefront of the mobile banking revolution. Following a pilot in 2005, Safaricom and Vodafone launched M-Pesa, a mobile-based payment service targeting the un-banked, pre-pay mobile subscribers in March 2007 (Vaughan, 2007).[8]

In practical terms, M-Pesa acts like mobile phone credit where customers are allowed to deposit cash into their M-Pesa account to create an e-float balance, exchange this e-float back into cash at some future time or transfer some e-float to another M-Pesa user (Mbiti and Weil, 2011). A customer can check their e-float balance and transfer funds from their mobile phone whereas cash based transactions are conducted at registered M-Pesa agents throughout the country. While M-Pesa e-float transfers became the primary method of in-country remittances, increasingly e-float transfers are also used to pay for goods bank account in two

[8] The name M-Pesa is derived from “M” for mobile and “Pesa” for money in Swahili. See Vaughan (2007) and Mas and Radcliffe (2010) for further details of M-Pesa.

important ways. M-Pesa account holders do not earn interest on their e-float balances and as of 2012 it was not possible for customers to borrow money through M-Pesa and services directly (Jack and Suri, 2010). M-Pesa differs from a traditional bank account in two important ways. M-Pesa account holders do not earn interest on their e-float balances and as of 2012 it was not possible for customers to borrow money through M-Pesa.

M-Pesa makes money in three ways. First, M-Pesa charges a sliding tariff on cash withdrawals. For example, the cost of withdrawing $100 is about $1 or 33 US cents for $33 (Jack and Suri, 2010). Second, e-float transfers are charged at a fee of about 40 US cents whether the purpose is remittances or retail payments (Jack and Suri, 2010). Third, customers are charged a total of US 1.3 for balance inquiries on their mobile phone (Jack and Suri, 2010).

By June 2010, M-Pesa had more than 10 million registered customers in Kenya, or 40 percent of Kenya's adult population (Beck, Maimbo, Faye and Triki, 2012). The volume of transactions has also been impressive at US$400 million per month, or 15 percent of Kenya's GDP by June 2010 (Beck, Maimbo, Faye and Triki, 2012). In the early years of operation, M-Pesa enjoyed complete market share but by 2010 the queue of potential competitors was growing with the launch of platforms such as Mkesho, Mobicash, Orange money, Yu-cash, Elma, Pesa-Pap and Pesa-Connect (Central Bank of Kenya, 2010). However, with Safaricom still enjoying three-quarters of the market share in mobile phones it retains significant market dominance in mobile banking in Kenya. Importantly for this paper, M-Pesa enjoyed a de-facto monopoly in mobile banking in Kenya between 2006 and 2009.

Contrary to the aims of bringing banking to the poor and isolated, previous calculations of summary statistics from the 2009 FinAccess survey find that that the average M-Pesa user is younger, wealthier, better educated, banked, employed in non-farm sectors, more likely to

own cell phones and to reside in urban areas (Aker and Mbiti, 2010 and Mbiti and Weil, 2011). Using the same dataset Mbiti and Weil (2011) also find differences in the frequency of use of M-Pesa, with the already formally banked group using M-Pesa almost three times more often than the unbanked population.

The emerging literature on M-Pesa has identified a number of important substitution effects. First, M-Pesa has emerged as the dominant medium of money transfer reducing the traditional role played by the formal mechanisms such as post office and Western Union, and informal mechanisms such as bus companies (Mbiti and Weil, 2011). Second, Mbiti and Weil (2011) find that increased use of M-Pesa lowers the propensity to use informal savings mechanisms such as ROSCAS. Third, qualitative studies on M-Pesa such as Morawczynski and Pickens (2009) find that M-Pesa usage can serve as a partial substitute for the safe-keeping of savings in the formal banking system.[9]

4. Data Description

Supply side data on bank branches is provided by the Central Bank of Kenya which records the names and addresses of all bank branches in Kenya. In their annual returns to the Central Bank, financial institutions are required to provide an array of balance sheet and transactions related financial information, along with a list of operational bank branches and their addresses. The list of bank branches used in this paper comes from the 31st of December 2008 and 31st December 2006 returns as the closest dates to when the 2009 and 2006 FinAccess surveys were conducted.[10]

[9] Morawcyznski and Pickens (2009) also find that M-Pesa users send smaller but more frequent remittances, which resulted in overall larger remittances to rural areas. They also observe that urban migrants using M-Pesa visited their rural homes less frequently.

[10] FinAccess 2006 took place in the third quarter of 2006. FinAccess 2009 took place in the first quarter of 2009. An argument can be made for the use of the 31st December 2005 list of bank branches but this list was not

The GPS coordinates for bank branches in 2010 were found using the Google Maps GPS locator tool by staff of the Central Bank of Kenya.[11] By cross-referencing the names and addresses of bank branches in 2010 with the list of bank branches for 2008 and 2006, I developed a list of all bank branches with GPS coordinates for year-end 2006 and 2008. A small number of branches were closed before 2010 that existed in either the 2008 or 2006 list, and as a result these were not included in the 2010 list created by the Central Bank of Kenya. To overcome this, I used the Google Maps GPS locator to find the coordinates of these branches. In total there were 298 new branches opened and 29 branches closed between 2006 and 2008. Only three bank branches not present in the 2010 list and not identifiable from their name and address were omitted from the dataset.

The individual level data come from the 2006 and 2009 Kenyan FinAccess surveys. The 2009 survey was conducted by the Kenyan National Bureau of Statistics and was designed to be nationally representative using three-stage cluster stratified probability sampling. Of particular note is the first stage of this sampling process which selected a set of 650 clusters to ensure representation at national, provincial and urbanization levels (urban/rural). The approach taken to rural sampling is of particular interest in the case of this paper with the focus on distances between households and banking services. While a full census would produce more accurate estimates of distances between households and banking services, efforts on behalf of the samplers to be geographically representative helps overcome some concerns over the choice of clustering in rural areas. As the average distance between households and services is less than 15km, the non-inclusion of some very remote rural areas as clusters may be a source of bias that serves to underestimate the role of proximity to banking services in financial inclusion. In the second step of the sampling process, twelve

available. In any case, the growth rate in bank branches for 2006 was significantly smaller than for 2007, 2008 and 2009.

[11] To ensure the accuracy of the geo-positioning data, I audited a random sample of five percent of bank branch GPS coordinates and the accuracy of the data was confirmed.

households are targeted in each cluster and ten chosen for inclusion. Finally, the individual for interview is selected randomly from household members who are aged 16 years and older using the KISH grid method. The 2006 FinAccess sample comprised 442 clusters (143 urban and 299 rural) using a similar stratified three-stage design.[12]

The 2009 and 2006 FinAccess surveys include a series of adult weights to ensure the dataset is nationally represented. A particular characteristic of the two FinAccess surveys is a gender bias towards female respondents as a result of the absence of a greater number of males during house-to-house visits and this bias has been corrected through weights. The summary statistics and regression analyses conducted in this paper are based on this weighted dataset unless otherwise specified.

Table 1 presents the summary statistics and description of the variables employed in this paper. The list of banking services that define whether an individual is formally banked is presented in Table 1 and is identical to the approach outlined in Honohan and King (2012). In 2009, 24 percent of Kenyans were formally banked which was up from 16 percent in 2006. The binary variable for mobile banked is defined from the survey question "Are you currently a registered M-Pesa user?". Overall, 26.5 percent of the Kenya population were registered M-Pesa users in 2009. In addition, evidence is found for the dual use of formal banking products and M-Pesa by Kenyans. In the 2009 survey, 53 percent of formally banked were also M-Pesa users.

As part of the interview process for FinAccess Kenya, the interviewer used a handheld device to note three sets of GPS coordinates and an average of the three sets of coordinates was recorded as the final location for each individual. When mapped using ARC-GIS software a

[12] Further details on the 2006 survey can be found at http://www.fsdkenya.org/finaccess/documents/FinaccessReportFINALMain.pdf and further details of the 2009 survey design can be found at http://www.fsdkenya.org/finaccess/documents/09-06-10_FinAccess_FA09_Report.pdf.

small number of the observations in the 2009 dataset, 11 in total, were demonstratably incorrect and were as a result excluded.[13] In 2009, the banked population lived an average of 8.13 kilometres from a bank branch, representing a reduction on the 2006 figure of 8.88 kilometers. The decline could suggest that proximity to bank branch was a more important predictor of personal financial access in 2009. Of course this could also be due to greater urbanization or branch expansion into areas with previously banked individuals. There was a more modest fall in the average distance between the unbanked and bank branch between 2006 and 2009 from 15.84 kilometers to 15.75 kilometers. To shed light on the central hypothesis, that mobile banking is breaking the tyranny of distance to bank branch, the summary statistics suggest that M-Pesa users in 2009 were on average located a little further away from bank infrastructure than the formally banked at 8.88 kilometers. Figure 4 graphically presents these summary statistics.[14]

Acknowledging the difference between distance to banking services and time to banking services, I also use a categorical variable, time to bank branch, which records how long it would take respondents to get to the bank, if they did not combine the trip with any other activities. There are nine possible responses ranging from under 10 minutes to 7 or more hours. Figure 5 graphs the relationship between the nine categorical responses with the average distance to a bank branch for respondents in that category. Confirming the similarity of the time to bank and distance to bank variables, the graph shows a consistently positive relationship between the two variables.

Using ARC-GIS, changes to bank branch infrastructure over the period 2006 to 2009 are mapped in Figure 6. It is noticeable that the distribution of new bank branches is broadly

[13] In the 2006 data three individuals were deleted as erroneous and no GPS data was available for nine individuals.

[14] In the regression analysis which follows the distance variable is the natural log of one plus the distance in kilometres. This approach is similar to the approach taken in Degryse and Ongena (2005).

confined to the region around Nairobi and Central Province, the densely populated areas of western Kenya and the Rift Valley, Mombasa and the road between Nairobi and Mombasa. It is also apparent that some modest bank branch expansion has occurred in the mid-east of the country, along the borders of Eastern, North Eastern and Coast provinces. Figures 7, 8, 9 and 10 depict the distribution of bank branches and the location of formally banked and unbanked respondents for both 2006 and 2009. The maps show a greater distribution of unbanked respondents in rural areas with significant distances from banking infrastructure. However, there are still a sizeable number of unbanked respondents living in urban areas, centres with numerous bank branches, suggesting a significant urban or semi-urban financially excluded population. Before conducting more systematic analysis, figures 11 and 12 graphically suggest that the distribution of those with access to mobile banking and those without are broadly similar for both the banked and unbanked populations.

For consistency a number of control variables have been derived using a similar approach to Honohan and King (2012) and King (2012). First, financial sector knowledge is a normalised score (on a scale of 1-10) achieved in a financial sector knowledge quiz given during the interview. A series of financial products/terms are mentioned and the individual receives two points for “I understand", one point for "I have heard of" and zero points for "never heard of/ don’t understand". Second, education is standardised on a scale of 1-8 from “no formal education” up to “completed university education” and is transformed into four dummy variables for the regression analysis in this paper.[15] Third, risk aversion is measured by a binary variable where “1” represents agreement with the statement “You avoid taking risks with your money or resources” and “0” otherwise.

[15] Education is defined as less than completed primary education, completed primary education, completed secondary education and above secondary education.

A number of additional variables have been derived from the 2009 FinAccess Kenya dataset. First, the wealth of the household is proxied by the variable *assets breadth*, a variable that was defined originally by the World Bank LSMS questionnaire and included in FinAccess Kenya, that counts the number of household durables owned by the household. This variable is available for both the 2006 and 2009 datasets. Available for only the 2009 dataset is a measure of individual level expenditure. Expenditure is derived as the natural log of total monthly expenditure on mobile/telecommunications, personal expenses (such as clothing), education, household bills, entertainment and socializing, groceries and food, medical related expenses, loan repayments, transport, donations to religious groups, rent, savings and support for other members of family. See Table 1 for further details.

5. Econometric Model and Empirical Results

5.1 Main Results

The results of univariate tests which compare the average distance to banking services for the sub-samples of formally banked and non-formally banked for 2009 and 2006, and M-Pesa and M-Pesa non-users for 2009. The results are reported in Table 2.[16] This first step confirms the importance of physical access to banking infrastructure for financial inclusion. In 2009, both distance to branch and time to branch for the formally banked sub-sample are statistically different from those without formal bank accounts. The univariate tests of the M-Pesa user and non-user sub-samples also find similar results.

Table 5.3 shows that the distance between survey respondents and their nearest bank branch fell marginally between 2006 to 2009 from 14.54km to 14.36km. Within the context of the significant increase in the branch network this could be considered a marginal decline.

[16] The univariate tests are conducted on the unweighted surveys.

Furthermore, it is likely that urbanisation would act to reduce the average distance faced by Kenyan adults to bank infrastructure and may explain this reduction. According to the World Development Indictors the urban population growth rate in Kenya over the period 2006 and 2009 was 4 percent, compared with 2.2 percent for rural areas.

As a next step I analyse the relationship between proximity to bank branch and banking status in a multivariable setting with a bivariate probit specification where the dependent variable, banking/mobile banking status is regressed on distance to nearest bank branch and time to bank branch separately, and a series of control variables as outlined in the previous section. A bivariate probit model specifically acknowledges the likely correlation in unobservables for the decision to be banked and to be an M-Pesa user.

Different specifications of the model are estimated with increasing numbers of control variables, and including and excluding district dummy variables.[17] The basic model for both formally banked and M-Pesa user is as follows:

$$\Pr\{BANKED_{i,d}\} = f(IND_{i,d}, GEO_{i,d}, DISTRICT_d) \qquad (1)$$

for individual *i* located in district *d*. IND are a list of individual characteristics such as age, gender, education level, financial sector knowledge, three measures of wealth, a measure of informality and risk aversion. Geography related variables (GEO) alternate between distance in kilometres to bank branch and time to bank under different specifications, and also include an urban / rural dummy variable.

The second approach employed here involves a pooled cross-section probit regression to ascertain precisely whether there has been a change in the relationship between distance to

[17] There are 67 districts in the dataset with a median of 411 individuals per district and ranging from 818 in Nairobi to 8 in Moyale a market town on the border with Ethiopia.

banking services and the likelihood of being banked between 2006 and 2009, when examined using a common model.

Before considering the results of these models some reflections are worthy of note. First, if a statistically significant relationship is found between proximity to banking services and the likelihood of being banked this means that distance is a constraint to financial inclusion but not necessarily the most binding constraint. It is likely that the benefits to financial inclusion from significant branch expansion into rural areas would be hindered by low incomes, widespread informality and low levels of financial sector knowledge. Disentangling which are the most important constraints would require more sophisticated experimentation.

Second, the results should be considered within the context of the likely endogeneity of bank branch expansion into areas with higher demand for financial services. Indeed in section 3, evidence was provided that suggested that bank branch expansion occurred not in the poorer, more informal regions of northern Kenya between 2006 and 2009. For this model, important regional heterogeneity would include differences in average levels of informality, wealth, education and financial sector knowledge. To overcome these differences, I include the series of district dummy control variables at the regional level. For the same demand determinants, heterogeneity at the individual level is also likely to influence the likelihood of being banked and so far as the wealth, education, expenditure and other control variables comprehensively measure these differences, individual level heterogeneity is controlled for.

Third, the absence of an instrumental variables strategy or experimentation means that the coefficients in this model cannot strictly be considered causal. Nevertheless, the descriptive estimations in this paper make a significant contribution to the understanding of the dynamics of distance to personal access to formal and mobile banking services.

Table 3 presents the results of the bivariate probit regression investigating the determinants of being formally banked. Similar to the approach taken in King (2012), the multivariate probit regressions are conducted using a maximum likelihood (SML) estimator, specifically a Geweke-Hajivassiliou-Keane (GHK) smooth recursive conditioning simulator, which enjoys a number of desirable properties such as simulated probabilities that are unbiased, bounded within the (0,1) interval and more efficient in terms of the variance of the estimators of probabilities than other simulators (Borsch-Supan and Hajivassiliou, 1993).[18] After computing the marginal effects it is found that that a 1 percent increase in the distance from a bank branch is associated with a decrease in the chances of being banked by 3 percent in 2009, in both specifications with and without district controls (columns 4 and 5 in Table 3). A similar result is found when proximity to banking infrastructure is measured by the self reported time to bank branch (see columns 4 and 5 in Table 4). Increased time to bank branch, as measured by a one unit discrete increase in the categorical variable time to bank branch, reduces the probability of being formally banked by 2 percent or 1 percent for the full specification with district controls included.

These results provide more systematic evidence, to support the descriptive statistics and visual demonstrations, that both distance and time to banking infrastructure play important roles in formal financial exclusion. Before I consider the potential of mobile banking, these results are suggestive that rural bank branch expansion may be a necessary, but not sufficient condition to increased personal access to formal financial services.

To ascertain whether changes have taken place in the importance for financial inclusion of distance to bank branch, the model is re-estimated for the 2006 dataset; Table 5 presents the

[18] As mentioned previously, the multivariate probit model is estimated with maximum likelihood where the likelihood is estimated using the Geweke-Hajivassiliou-Keane (GHK) sampling technique that samples recursively from truncated normal distributions after a Cholesky transformation. Hajivassiliou, McFadden and Ruud (1996) find that the GHK outperforms all the other methods considered for small numbers.

results. The tyranny of distance to banking infrastructure is also confirmed for 2006. After computing the marginal effects I find that a 1 percent increase in the distance from a bank branch is associated with a decrease in the chances of being banked by 2 percent when district controls are not included and 2 percent when district controls are included, although this latter coefficient is not significant. This suggests that distance may have become a greater 'constraint' to personal financial access by 2009 despite the bank expansion described in section 3.[19] Such a scenario is likely to reflect a combination of more significant increases in financial inclusion in urban areas from 27 percent to 41 percent and the predominance of bank branch expansion (2006-2009) in urban areas or in rural areas with higher population density.

Whether distance has become a more significant constraint for financial services is formally tested by combining the two datasets into a pooled cross section and re-running the previous models; Table 6 presents the results. I find that distance to bank branch is negatively related to the likelihood of being banked, and while the signs on the coefficients for the 2009 interaction term are negative, they are not statistically significant. Comparison of the marginal effects from this model shows that the marginal effect for 2009 is higher and statistically significant for all versions of the model.[20] However, it is important to note that this pooled regression omits two important control variables, monthly expenditure and financial sector knowledge because neither of these are found in the 2006 survey. The major result from this model is the fact that the role played by the level of household assets has declined as a predictor of formally banked which may suggest that formal banking is reaching individuals with lower levels of assets.

[19] The time to bank branch is not available from the 2006 FinAccess survey.
[20] These marginal effects are not reported but are available on request from the author.

The conclusion from this is relatively profound. Over the period 2006 to 2009 Kenya experienced a uniquely high rate of bank branch expansion, unlikely to be replicated at the same level in other sub-Saharan African countries. The fact that the Kenyan expansion in branches did not help overcome the tyranny of distance suggests that penetration of formal banking services into rural areas will most likely have to wait until demand side factors, such as incomes, levels of formality etc., improve.

In line with the results in Honohan and King (2012) and King (2012), I find that greater levels of education and financial sector knowledge are associated with a higher probability of being formally banked. In previous analyses the relationship between monthly personal income and financial status was quantified (columns 4-5 in Table 3). In this paper, in the absence of income data, I find that monthly expenditure has a significant positive relationship with financial status.

As previously discussed, the mobile banking revolution offers the potential to improve financial inclusion without the need for 'bricks and mortar' branch expansion in rural areas. Table 3 (columns 6 to 10) presents the results of the multivariate probit regression on the determinants of M-Pesa usage (mobile phone banking). While a negative relationship is found between distance from bank branch and use of mobile banking in basic specifications, when household expenditure and assets, including having a mobile phone, are controlled for, this relationship holds no statistical significance. When mobile phone is excluded as a control variable, the equivalent estimation to Table 3 column 10 produces a marginally statistically significant coefficient that is half the size of the coefficient for the equivalent formally banked estimation (Table 3, column 5). However, the fact that the coefficients from either specification are smaller than the model for the formally banked respondents, suggests that greater distances from bank infrastructure do not reduce the likelihood that an individual is a mobile bank user as much as it does for formal bank account holders. Indeed, when

household expenditure, assets and having a mobile phone are controlled for, I find no evidence of a statistically significant relationship, suggesting that distance from bank infrastructure does not change the likelihood that an individual is a mobile bank account holder. Importantly, no relationship is found between time to bank branch and the likelihood of being mobile banked in regressions with or without district controls (Table 4, columns 8 to 10) and whether mobile is included as a control variable or not.[21] This provides further evidence that the likelihood of being mobile banked is not determined by proximity to bank branch.

The results in Tables 3 and 4 show that higher income (proxied for by expenditure) increases the probability of being mobile banked. This is consistent with observations made by Morawczynski (2009), who, from ethnographic fieldwork, finds evidence that M-Pesa is less likely to be used by those without mobile phones, those who do not engage in internal remittances and by the poorest residents in the rural regions in Western Kenya.

While peripheral to the central hypothesis of this paper, the wider determinants of use of mobile banking were also uncovered. I find that both the formally banked respondents and M-Pesa users enjoy higher levels of education relative to the financially excluded, and that the formally banked are characterised by higher levels of financial sector knowledge than M-Pesa users.[22] This suggests that mobile banking may open up opportunities to save and transact to those with lower levels of knowledge about finance. There is evidence to suggest that the formally banked enjoy a higher standard of living, as measured by household expenditure, and live in more formal accommodation; these results are robust to whether

[21] In other words, when the mobile phone status of the respondent is controlled for, neither distance to bank branch or time to branch are statistically significantly related to the likelihood of being mobile banked. When the mobile variable is excluded, there is evidence that that distance and mobile banked are negatively related at the 1 per cent level but a negative relationship is not found for time to bank and mobile banked. This suggests that conditional on having a mobile, there is no relationship between proximity to banking services and the likelihood of being mobile banked.

[22] Of course the causality may be the opposite direction where having a bank account improves an individual's financial sector knowledge.

proximity to banking services is measured as distance or time to branch. Importantly, I find clear evidence that M-Pesa users have lower levels of monthly expenditure than the formally banked, suggesting that M-Pesa has reached Kenyans with lower consumption levels. Unsurprisingly mobile phone ownership increases the chances that an individual is an M-Pesa user.

5.2 Heterogeneous Effects

The suggestion that tyranny of proximity to bank infrastructure may only be overcome for those with higher levels of personal expenditure and assets was explored further in a series of regressions with specific sub-groups of the population and separately using a series of interaction terms. The expectation is that both approaches will produce similar results.

First, an additional series of models were estimated for each of four personal expenditure quartiles and four different levels of education. The results are presented in Table 7. There is robust evidence to suggest that distance and time to banking services are both statistically significant constraints for middle income individuals, defined as those in expenditure quartiles two and three. Unsurprisingly, there is no statistically significant relationship between distance or time to bank branch for those with the highest level of monthly expenditure. This suggests that the additional costs of lack of proximity to banking services can be overcome by those with high incomes. Negative coefficients for both measures of proximity are found for quartile one, the low expenditure group, although neither are statistically significant.

When the sample is divided by education level there is some evidence to suggest that distance to banking services is important for those with completed primary and completed secondary education. Conversely, there is evidence to suggest that distance is not a binding constraint for those with less than primary or those with above second level education. In addition, the

model is estimated for sub-groups of the sample with different wealth levels, as proxied by the breadth of asset ownership. Reading from Table 7, there is evidence to suggest that for those with non-zero asset levels, distance and time to bank branch are negatively related with the likelihood of being formally banked.

Table 7 also presents the results of this segmented analysis for M-Pesa users. Importantly, no evidence was found to suggest that the non-relationship between distance or time to bank branch and mobile banked in the main results is overturned for any personal expenditure quartile, breadth of assets or education level. The only contrary evidence to this is the mildly significant and negative coefficient on distance to bank branch for those with completed secondary education.

An alternative approach to checking for a different impact of distance among various population sub-groups involves re-estimating our main models (from Table 3), this time including interaction terms between our distance variables and dummies capturing each of the sub-groups of interest (expenditure quartiles, education levels and assets). The objective is to estimate the changes in the marginal effect on distance or time to bank for different levels of expenditure, education level or level of assets. First, there is evidence to suggest that the interaction terms, combining distance and time to bank with dummy variables for expenditure quartile, education level and level of assets, do not explain much variation in the dependent variable as evidenced by the lack of significance on interaction term coefficients. Table 8 presents the marginal effects from separate probit regressions with formally banked and M-Pesa user as the dependent variables and with distance to branch and time to store interacted with expenditure, education and asset dummies.[23]

[23] It is worth noting that the average marginal effects are not the same as the coefficients on the interaction terms and are calculated following estimation of the models.

Similar results to the segmented sample approach are found. There is evidence to suggest that distance to bank is a stronger constraint to financial inclusion for those in the second and third income quartiles, suggesting again that for the wealthier group distance is not a barrier to financial services and that for the lowest income quartile distance is not the binding constraint. Similarly, it is found that for those with completed secondary school education and with one or more household asset, greater distances from banking infrastructure reduce the likelihood that these individuals are banked. Crucially, I find that greater distances or time to bank infrastructure are not statistically related to being mobile banked for any expenditure, education or asset group. This provides strong evidence that mobile banking is breaking the tyranny of distance (or time to bank) for all economic groups in Kenya.

5.3 Frequency of M-Pesa Usage

Further analysis was conducted into the role that proximity plays in the frequency of use of mobile banking services. Intuitively, one might expect users of mobile bank accounts who are further away from banking infrastructure, to use M-Pesa for transactions more frequently than those who are closer to banking infrastructure, even if they also have access to a formal bank account. This could occur if the costs associated with travelling to and from the nearest bank branch were high. Alternatively, the need to use transaction services is likely to be higher in urban areas. Table 9 presents the results of the multivariable probit regression assessing the role played by ease of access measures on frequency of M-Pesa use. I find no evidence that frequency of M-Pesa use is associated with distance or time to bank branch. Of particular note is the result that frequency of M-Pesa usage is increased with level of engagement with consumerism as measured by household expenditure and level of breadth of household assets.

6. Conclusion

The mobile banking revolution in sub-Saharan Africa offers the potential for countries to leapfrog the need for expensive bank branch networks to deliver savings and transactions products to their citizens. This paper presents evidence that mobile banking is not only opening up banking opportunities for lower income customers who engage is small scale transactions, but that mobile banking in Kenya has flattened geographical constraints to access.

The next step for the mobile banking revolution is to extend to more sophisticated financial services such as access to credit and insurance. Only then will mobile banking offer the complete set of banking services and serve as a full rather than partial substitute for the formal banking system.

The speed of the success of M-Pesa in Kenya may prove the exception rather than the rule in sub-Saharan Africa. Among the reasons for the success of M-Pesa are higher and more rapid urbanisation among its African peers, the poor quality of previous mediums of domestic remittances, a supportive financial regulator and perhaps most importantly, a dominant mobile phone operator (Mas and Radcliffe, 2010). Not all of these factors will be present in Kenya's neighbours across sub-Saharan Africa. For example, in 2008 M-Pesa was launched in Tanzania and the initial results were poorer than expected due to a variety of reasons, chief among them was greater competition in the mobile phone market. Despite the slow beginning, however, changes to the marketing, distribution and price plans have resulted in nearly 10 million M-Pesa registered users in Tanzania. It remains possible that mobile banking, if successfully adapted to local conditions, can revolutionise access to banking for all in sub-Saharan Africa and make a significant contribution to reducing poverty and the risk profiles of poor households.

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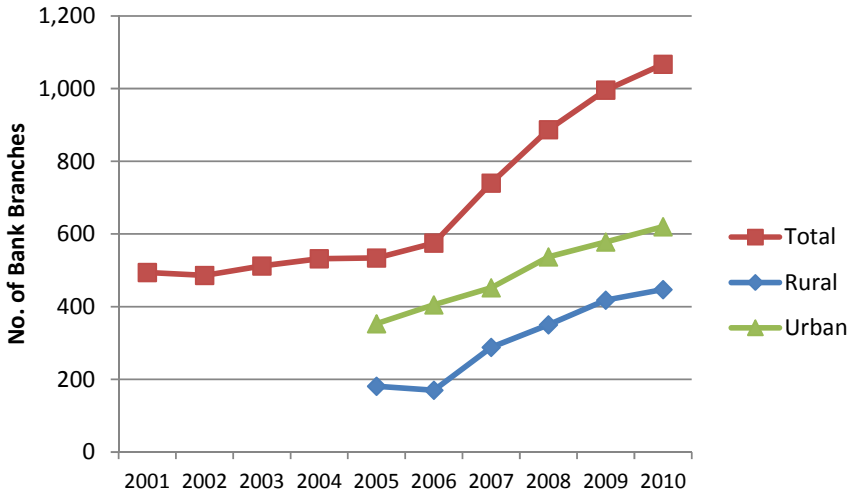
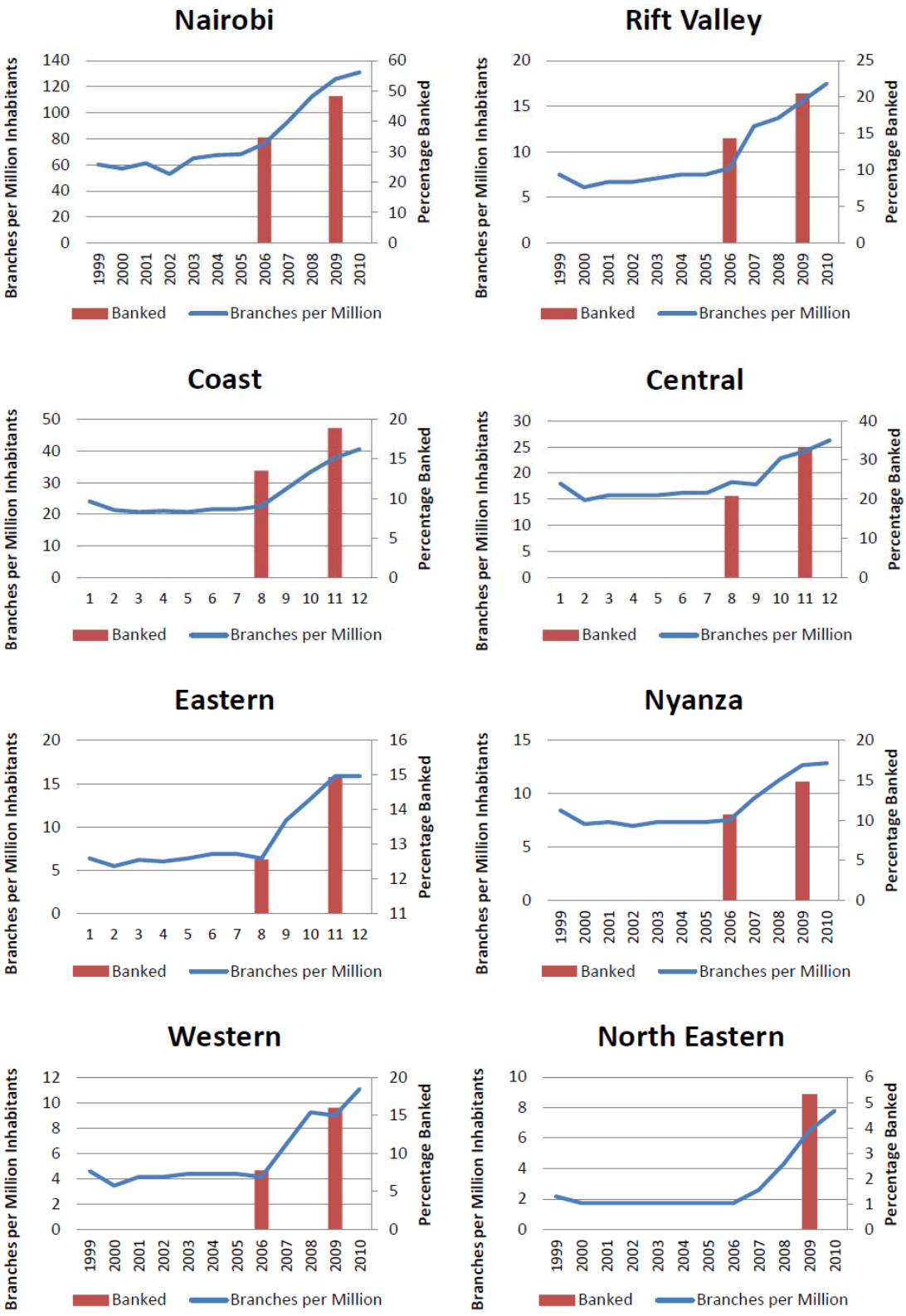
8. Appendix

Figure 1: Kenyan Bank Branch Expansion (2001-2010)



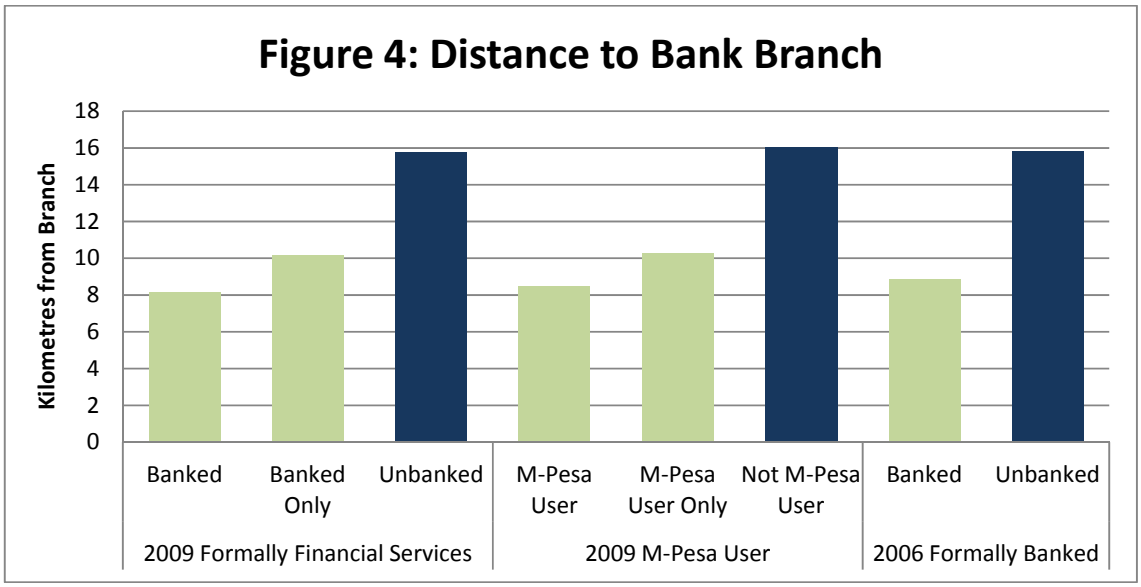
Data source: Kenyan Central Bank 2012
Note: These series are taken from Kenyan Annual Banking Supervision Reports and specifically includes bank head offices.

Figure 2: Provincial Expansion in Bank Branches and Financial Inclusion



Data source: FinAccess 2006, 2009 and Kenyan Banking Supervision Annual Reports and specifically includes bank head offices.

Figure 3: The Provinces of Kenya



Note: Banked only refers to formally banked group that do not use M-Pesa. M-Pesa user only refers to M-Pesa users who are not also formally banked.

Figure 5: Distance and Time to Nearest Branch

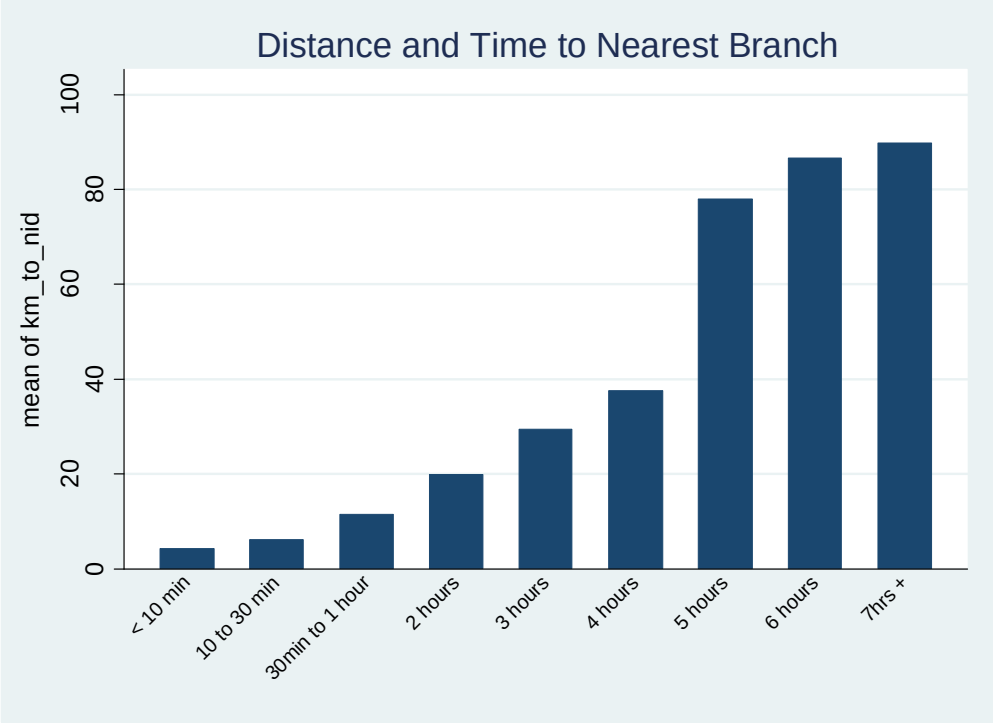


Table 1: Summary Statistics

	Coding	Obs	Mean	Std. Dev.	Min	Max
2009 Survey Variables						
Formally Banked	Formally Banked products include personal loan/business loan from a bank, Loan to buy/build a house, or to buy land from a bank or building society, Postbank account, Bank account for savings or investment, current account, bank account for everyday needs but no cheque book, overdraft, ATM card or Debit card, Credit card.	6,527	0.24 (0.22)	0.43	0	1
Mobile Banked	Registered M-Pesa user	6,527	0.28 (0.26)	0.45	0	1
KM to Branch	Kilometres to Bank Branch (Bank Branches as at 31 December 2008)	6,516	14.36 (14.05)	20.55	0.02	141.12
Time to Bank	Response to the question how long it would take the you to get to the bank, if you did not combine the trip with any other activities.					
Expenditure	Expenditure is derived as total monthly expenditure on mobile/telecommunications, personal expenses (such as clothing), education, household bills, entertainment and socializing, groceries and food, medical related expenses, paying off of loans, transport, donations to religious groups, rent or mortgages, savings and supporting other members of family.	6.519	14,311 (12.276)	30,801	20	812,500
Educ	No formal education = 1, Some primary school = 2, Primary school, completed = 3, Some secondary school = 4, Secondary school completed = 5, Professional Qualification or equivalent = 6, Some university = 7, University completed = 8.	6,527	3.12 (3.07)	1.68	1	8
Age	Exact Age	6,527	38.66 (38.92)	16.69	16	105
Female	Female = 1, Male = 0	6,527	0.59 (0.59)	0.49	0	1
Mobile	Yes = 1, No or Not Answered = 0	6,527	0.47 (0.46)	0.50	0	1
Urban	Urban = 1, Rural = 0	6,527	0.29 (0.22)	0.45	0	1
Risk Aversion	Agree or Don't Know = 0, Disagree = 1 with statement "You avoid taking risks with your money or resources".	6,527	0.70 (0.69)	0.46	0	1
FSKnow	Scaled into a 0-10 index. Score given for the following responds for each of the 16 financial terms below: Heard but do not understand = 1 point, Heard and do understand = 2 points.	6,527	5.30 (5.15)	3.00	0	10
Breadth of Assets	Which of the following items does your household own? One point for each of the following assets: Built-in kitchen sink, Fixed telephone line or outstanding application, Camera, Hi-fi/music centre, Microwave oven, Electric stove with oven, Vacuum cleaner, Free-standing deep freezer, DVD player, Video recorder/player and Electric iron.	6,527	0.70 (0.50)	1.855	0	11

2006 Survey Variables						
Formally Banked	*Formally Banked products include personal loan/business loan from a bank, Loan to buy/build a house, or to buy land from a bank or building society, Postbank account, Bank account for savings or investment, current account, bank account for everyday needs but no cheque book, overdraft, ATM card or Debit card, Credit card.*	*4,308*	*0.16 (0.15)*	*0.37*	*0*	*1*
KM to Branch	*Kilometres to Bank Branch (bank Branches as at 31 December 2006)*	*4,268*	*14.53 (14.78)*	*19.81*	*0.03*	*293.79*
Educ	*No formal education = 1, Some primary school = 2, Primary school, completed = 3, Some secondary school = 4, Secondary school completed = 5, Professional Qualification or equivalent = 6, Some university = 7, University completed = 8.*	*4,292*	*3.15 (3.15)*	*1.69*	*1*	*8*
Age	*Exact Age*	*4,308*	*36.47 (36.66)*	*15.53*	*16*	*90*
Female	*Female = 1, Male = 0*	*4,308*	*0.56 (0.51)*	*0.50*	*0*	*1*
Mobile	*Yes = 1, No or Not Answered = 0*	*4,308*	*0.27 (0.26)*	*0.44*	*0*	*1*
Urban	*Urban = 1, Rural = 0*	*4,308*	*0.32 (0.25)*	*0.47*	*0*	*1*
Risk Aversion	*Agree or Don't Know = 0, Disagree = 1 with statement "You avoid taking risks with your money or resources".*	*4,308*	*0.74 (0.73)*	*0.43*	*0*	*1*
WC Formality	*What type of toilet facilities does the household use? Coding: None =1, Bucket = 2, Uncovered pit latrine = 3, Covered pit latrine = 4, Ventilated improved pit latrine = 5 and Flush toilet = 6.*	*4,307*	*3.32 (3.28)*	*1.19*	*1*	*6*
Breadth of Assets	*Which of the following items does your household own? One point for each of the following assets: Built-in kitchen sink, Fixed telephone line or outstanding application, Camera, Hi-fi/music centre, Microwave oven, Electric stove with oven, Vacuum cleaner, Free-standing deep freezer, DVD player, Video recorder/player and Electric iron.*	*4,308*	*0.64 (0.46)*	*1.80*	*0*	*11*

Table 2: Univariate Tests: Proximity to Banking Services 2009 and 2006

	All Households	Formally Banked 2009		T-Statistic	Sample Test
		Yes	No		
KM to Branch	14.36	7.17	16.69	16.42	***
TimetoBank	2.90	2.32	3.10	18.65	***
		Mobile Banking User 2009			
		Yes	No		
KM to Branch	14.17	7.53	16.99	17.03	***
TimetoBank	2.90	2.33	3.13	19.76	***
		Formally Banked 2006			
		Yes	No		
KM to Branch	14.54	8.48	15.72	8.91	***

***, ** and * denote the significance level of the results of the linear independent sample tests. The sample tests are conducted on an unweighted pooled dataset.

Table 3: Bivariate Probit Results 2009 (Distance)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Formally Banked					Mobile Banked				
Distance	-0.28***	-0.21***	-0.19***	-0.19***	-0.18**	-0.16***	-0.10**	-0.09*	-0.07	-0.06
	(0.049)	(0.047)	(0.055)	(0.049)	(0.060)	(0.036)	(0.033)	(0.040)	(0.037)	(0.049)
Urban	0.08	0.01	-0.04	-0.22*	-0.22	0.32*	0.27*	0.25*	0.14	0.18
	(0.115)	(0.114)	(0.125)	(0.110)	(0.130)	(0.136)	(0.133)	(0.109)	(0.177)	(0.134)
Female	-0.20***	-0.00	0.01	0.01	0.01	-0.22***	-0.09*	-0.09	-0.03	-0.03
	(0.046)	(0.054)	(0.056)	(0.058)	(0.063)	(0.043)	(0.047)	(0.048)	(0.049)	(0.051)
Age/100	8.80***	7.50***	8.14***	5.01***	5.42***	5.33***	4.34***	4.86***	0.64	0.79
	(0.865)	(0.888)	(0.882)	(0.740)	(0.745)	(1.049)	(1.064)	(1.076)	(1.105)	(1.214)
Age_sq/100	-7.74***	-6.09***	-6.65***	-3.42***	-3.81***	-6.40***	-5.32***	-5.79***	-1.44	-1.60
	(1.001)	(1.041)	(1.023)	(0.874)	(0.879)	(1.270)	(1.295)	(1.299)	(1.273)	(1.361)
Completed Primary	0.64***	0.29***	0.27***	0.15*	0.16**	0.59***	0.34***	0.27***	0.19**	0.12
	(0.062)	(0.066)	(0.063)	(0.064)	(0.060)	(0.063)	(0.070)	(0.066)	(0.074)	(0.066)
Completed Secondary	1.33***	0.65***	0.63***	0.40***	0.41***	1.23***	0.74***	0.64***	0.45***	0.37***
	(0.073)	(0.076)	(0.072)	(0.078)	(0.074)	(0.065)	(0.083)	(0.070)	(0.090)	(0.080)
Above Secondary	1.89***	1.02***	0.97***	0.59***	0.58***	1.56***	0.94***	0.81***	0.50***	0.43***
	(0.099)	(0.113)	(0.112)	(0.117)	(0.116)	(0.110)	(0.123)	(0.117)	(0.126)	(0.114)
FSKnow		0.23***	0.24***	0.18***	0.19***		0.14***	0.16***	0.09***	0.10***
		(0.012)	(0.013)	(0.011)	(0.012)		(0.016)	(0.017)	(0.015)	(0.015)
RiskAversion		0.03	0.05	0.04	0.06		0.04	0.08	0.03	0.07
		(0.055)	(0.060)	(0.061)	(0.068)		(0.046)	(0.049)	(0.047)	(0.050)
Expenditure (ln)				0.29***	0.31***				0.14***	0.17***
				(0.035)	(0.038)				(0.036)	(0.040)
Mobile				0.65***	0.65***				1.66***	1.69***
				(0.062)	(0.066)				(0.104)	(0.114)
Breadth Assets				0.03*	0.03*				-0.02	-0.04
				(0.014)	(0.014)				(0.028)	(0.026)
Constant	-2.84***	-3.93***	-3.94***	-6.04***	-6.01***	-1.80***	-2.41***	-2.61***	-3.60***	-3.68***
	(0.229)	(0.231)	(0.237)	(0.411)	(0.420)	(0.209)	(0.211)	(0.212)	(0.291)	(0.307)
District Controls			Yes		Yes			Yes		Yes
Observations	6,516	6,516	6,516	6,312	6,312	6,516	6,516	6,516	6,312	6,312
Distance	-0.06***	-0.04***	-0.04**	-0.04***	-0.03**	-0.04***	-0.03**	-0.02*	-0.01	-0.01
– Marginal Effects	0.011	0.009	0.011	0.009	0.0108	0.009	0.008	0.009	0.007	0.008

District controls comprise of a series of district dummy variables.
The omitted education category is less than completed primary education.
Standard errors of marginal effects are calculated using the delta method.
Robust standard errors, clustered by district in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

Table 4: Bivariate Probit Results 2009 (Time to Bank)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Formally Banked					Mobile Banked				
Time to Bank	-0.15***	-0.11***	-0.09**	-0.10***	-0.07*	-0.08**	-0.05	-0.02	-0.02	0.00
	(0.027)	(0.025)	(0.027)	(0.026)	(0.028)	(0.029)	(0.028)	(0.020)	(0.029)	(0.024)
Urban	0.35***	0.19*	0.10	-0.04	-0.06	0.47***	0.37**	0.33***	0.22	0.26*
	(0.082)	(0.084)	(0.092)	(0.072)	(0.089)	(0.129)	(0.133)	(0.090)	(0.168)	(0.105)
Female	-0.18***	0.01	0.02	0.02	0.02	-0.20***	-0.09	-0.09	-0.03	-0.04
	(0.049)	(0.059)	(0.060)	(0.063)	(0.066)	(0.042)	(0.048)	(0.050)	(0.050)	(0.053)
Age/100	8.49***	7.32***	8.01***	4.82***	5.31***	5.06***	4.15***	4.69***	0.52	0.72
	(0.915)	(0.928)	(0.923)	(0.769)	(0.773)	(1.050)	(1.063)	(1.092)	(1.144)	(1.264)
Age_sq/100	-7.37***	-5.87***	-6.53***	-3.21***	-3.71***	-6.05***	-5.10***	-5.60***	-1.28	-1.53
	(1.048)	(1.082)	(1.065)	(0.907)	(0.909)	(1.266)	(1.286)	(1.310)	(1.310)	(1.405)
Completed Primary	0.63***	0.28***	0.26***	0.15*	0.16*	0.57***	0.32***	0.25***	0.18*	0.11
	(0.062)	(0.065)	(0.062)	(0.064)	(0.061)	(0.064)	(0.070)	(0.063)	(0.074)	(0.064)
Completed Secondary	1.30***	0.63***	0.60***	0.39***	0.39***	1.20***	0.72***	0.62***	0.44***	0.37***
	(0.074)	(0.075)	(0.073)	(0.080)	(0.077)	(0.062)	(0.080)	(0.070)	(0.089)	(0.080)
Above Secondary	1.86***	1.00***	0.93***	0.58***	0.57***	1.53***	0.92***	0.79***	0.49***	0.43***
	(0.091)	(0.108)	(0.108)	(0.114)	(0.114)	(0.114)	(0.121)	(0.113)	(0.125)	(0.113)
FSKnow		0.23***	0.24***	0.18***	0.19***		0.14***	0.16***	0.09***	0.10***
		(0.012)	(0.013)	(0.011)	(0.012)		(0.017)	(0.018)	(0.015)	(0.015)
RiskAversion		0.02	0.04	0.02	0.04		0.05	0.09	0.04	0.08
		(0.057)	(0.061)	(0.063)	(0.069)		(0.048)	(0.050)	(0.048)	(0.050)
Expenditure (ln)				0.29***	0.30***				0.14***	0.16***
				(0.035)	(0.038)				(0.036)	(0.040)
Mobile				0.65***	0.64***				1.65***	1.68***
				(0.064)	(0.067)				(0.106)	(0.117)
Breadth Assets				0.04*	0.03				-0.02	-0.04
				(0.015)	(0.015)				(0.029)	(0.027)
Constant	-3.00***	-4.03***	-4.08***	-6.12***	-6.14***	-1.88***	-2.46***	-2.70***	-3.64***	-3.78***
	(0.205)	(0.227)	(0.226)	(0.408)	(0.419)	(0.213)	(0.231)	(0.223)	(0.314)	(0.335)
Country Controls			Yes		Yes			Yes		Yes
Observations	6,269	6,269	6,269	6,082	6,082	6,269	6,269	6,269	6,082	6,082
Time to Bank	-0.04***	-0.02***	-0.02**	-0.02***	-0.01*	-0.02**	-0.01	-0.01	-0.00	0.00
– Marginal Effects	0.006	0.005	0.005	0.0055	0.005	0.007	0.007	0.005	0.006	0.005

District controls comprise of a series of district dummy variables.
The omitted education category is less than completed primary education.
Standard errors of marginal effects are calculated using the delta method.
Robust standard errors, clustered by district in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

Table 5: Probit Results 2006 (Distance)					
VARIABLES	(1)	(2)	(3)	(4)	(5)
Distance	-0.17**	-0.17**	-0.15*	-0.15**	-0.12*
	(0.060)	(0.058)	(0.067)	(0.052)	(0.062)
Urban	0.10	0.10	0.03	-0.23*	-0.14
	(0.110)	(0.110)	(0.128)	(0.097)	(0.118)
Female	-0.16*	-0.16*	-0.16*	-0.16	-0.16
	(0.075)	(0.075)	(0.080)	(0.081)	(0.087)
Age/100	5.88***	5.84***	6.43***	4.89***	5.37***
	(1.171)	(1.169)	(1.260)	(1.040)	(1.098)
Age_sq/100	-4.80***	-4.77***	-5.41***	-3.65**	-4.22**
	(1.389)	(1.384)	(1.500)	(1.223)	(1.311)
Completed Primary	0.47***	0.47***	0.45***	0.32***	0.30***
	(0.082)	(0.081)	(0.086)	(0.079)	(0.083)
Completed Secondary	1.14***	1.14***	1.12***	0.77***	0.77***
	(0.093)	(0.093)	(0.104)	(0.111)	(0.120)
Above Secondary	1.79***	1.80***	1.82***	1.10***	1.15***
	(0.111)	(0.112)	(0.114)	(0.106)	(0.112)
RiskAversion		0.12	0.04	0.11	0.04
		(0.120)	(0.137)	(0.112)	(0.128)
Mobile				0.86***	0.89***
				(0.091)	(0.093)
Breadth Assets				0.16***	0.15***
				(0.023)	(0.021)
Constant	-2.69***	-2.78***	-2.94***	-2.77***	-2.90***
	(0.274)	(0.264)	(0.253)	(0.268)	(0.269)
District Controls			Yes		Yes
Observations	4,268	4,268	4,058	4,268	4,058
Distance	-0.03**	-0.03**	-0.035*	-0.02**	-0.02*
– Marginal Effects	0.011	0.011	0.012	0.009	0.010

District controls comprise of a series of district dummy variables.
The omitted education category is less than completed primary education.
Standard errors of marginal effects are calculated using the delta method.
Robust standard errors, clustered by district in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

Table 6: Pooled Cross Section: Probit Regression
Dependent Variable: Formally Banked

VARIABLES	(1)	(2)	(3)	(4)	(5)
09 Dummy	0.09	0.08	-0.12	-0.38	-0.53
	(0.389)	(0.365)	(0.356)	(0.388)	(0.396)
Distance	-0.15*	-0.15*	-0.14*	-0.14*	-0.12*
	(0.061)	(0.060)	(0.056)	(0.054)	(0.053)
Distance*09	-0.12	-0.12	-0.07	-0.11	-0.07
	(0.078)	(0.076)	(0.072)	(0.072)	(0.072)
Urban	0.10	0.11	0.02	-0.21*	-0.18*
	(0.109)	(0.108)	(0.088)	(0.098)	(0.090)
Urban*09	-0.01	-0.01	0.08	0.09	0.16
	(0.142)	(0.142)	(0.130)	(0.161)	(0.157)
Female	-0.12	-0.12	-0.13	-0.13	-0.14
	(0.075)	(0.075)	(0.078)	(0.081)	(0.084)
Female*09	-0.06	-0.06	-0.06	-0.01	-0.00
	(0.090)	(0.089)	(0.095)	(0.098)	(0.104)
Age_100	5.60***	5.56***	6.03***	4.72***	5.08***
	(1.147)	(1.147)	(1.201)	(1.024)	(1.066)
Age_100*09	2.73	2.73	2.93*	2.75*	2.90*
	(1.431)	(1.434)	(1.449)	(1.278)	(1.302)
Age_100_sq	-4.02**	-3.99**	-4.47**	-3.17**	-3.56**
	(1.348)	(1.346)	(1.414)	(1.186)	(1.244)
Age_100_sq*09	-3.05	-3.04	-3.27	-2.69	-2.90
	(1.700)	(1.697)	(1.718)	(1.485)	(1.517)
Educ	0.40***	0.40***	0.40***	0.26***	0.27***
	(0.021)	(0.020)	(0.022)	(0.023)	(0.024)
Educ*09	0.00	0.00	0.00	0.03	0.03
	(0.031)	(0.031)	(0.032)	(0.035)	(0.036)
RiskAversion		0.12	0.07	0.11	0.05
		(0.118)	(0.122)	(0.110)	(0.114)
RiskAversion*09		0.02	0.08	0.03	0.08
		(0.153)	(0.160)	(0.149)	(0.157)
Mobile				0.82***	0.83***
				(0.090)	(0.090)
Mobile*09				0.05	0.05
				(0.101)	(0.104)
Breath_assets				0.15***	0.15***
				(0.022)	(0.021)
Breath_assets*09				-0.06**	-0.06**
				(0.020)	(0.021)
Constant	-3.58***	-3.67***	-3.70***	-3.33***	-3.31***
	(0.288)	(0.279)	(0.265)	(0.290)	(0.303)
			Yes		Yes
Observations	10,768	10,768	10,768	10,768	10,768
Adj. R-squared	.	.	.	.	.

District controls comprise of a series of district dummy variables.
Education is included in this model as a 1 to 8 variable. See table 1 for details.
Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Table 7: Segmented Sample Bivariate Probit Results 2006
Full Specification with District Controls

	Formally Banked		Mobile Banked	
VARIABLES	Distance	Time to Bank	Distance	Time to Bank
Expenditure Level				
Quartile 1	-0.20	-0.01	-0.17	0.05
	(0.122)	(0.084)	(0.165)	(0.105)
Quartile 2	-0.24*	-0.09	-0.12	0.01
	(0.105)	(0.070)	(0.128)	(0.064)
Quartile 3	-0.38***	-0.15*	-0.10	-0.10
	(0.099)	(0.061)	(0.079)	(0.074)
Quartile 4	-0.02	0.03	-0.00	0.03
	(0.086)	(0.050)	(0.071)	(0.049)
Asset Level				
No Assets	-0.10	0.02	-0.12	-0.09
	(0.165)	(0.111)	(0.114)	(0.056)
Asset >=1	-0.23***	-0.07*	-0.00	0.03
	(0.062)	(0.029)	(0.061)	(0.030)
Education Level				
LCPE	-0.17	-0.14**	-0.01	0.00
	(0.089)	(0.047)	(0.076)	(0.037)
CPE	-0.24**	0.00	-0.06	0.06
	(0.086)	(0.046)	(0.087)	(0.044)
CSE	-0.38***	-0.11	-0.21*	-0.10
	(0.101)	(0.076)	(0.105)	(0.055)
ASE	-0.06	-0.18	0.00	0.07
	(0.106)	(0.102)	(0.090)	(0.078)

District controls comprise of a series of district dummy variables.
Education variables include Less than Completed Primary Education (LCPE), Completed Primary Education (CPE), Completed Secondary Education (CSE) and Above Secondary Education (ASE).
Robust standard errors, clustered by district in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

Table 8:Average Marginal Effects from Probit Regression with Interaction Terms

	Formally Banked		Mobile Banked	
	Distance	Time to Bank	Distance	Time to Bank
Expenditure (Q1)	-0.162	-0.055	0.010	0.011
Expenditure (Q2)	-0.380*	-0.016	-0.297	-0.000
Expenditure (Q3)	-0.400**	-0.018	-0.246	-0.165
Expenditure (Q4)	-.0.345	0.009	0.002	0.188
LCPE	-0.276	-0.024***	-0.011	0.000
CPE	-0.033	-0.003	-0.013	0.011
CSE	-0.045***	0.310	-0.237	-0.015
ASE	-0.027	-0.037	0.160	0.010
Household Assets = 0	-0.030	-0.007	-0.019	-0.007
Household Assets >= 1	-0.032**	-0.013*	-0.008	0.004

Education variables include Less than Completed Primary Education (LCPE), Completed Primary Education (CPE), Completed Secondary Education (CSE) and Above Secondary Education (ASE).
Robust standard errors in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

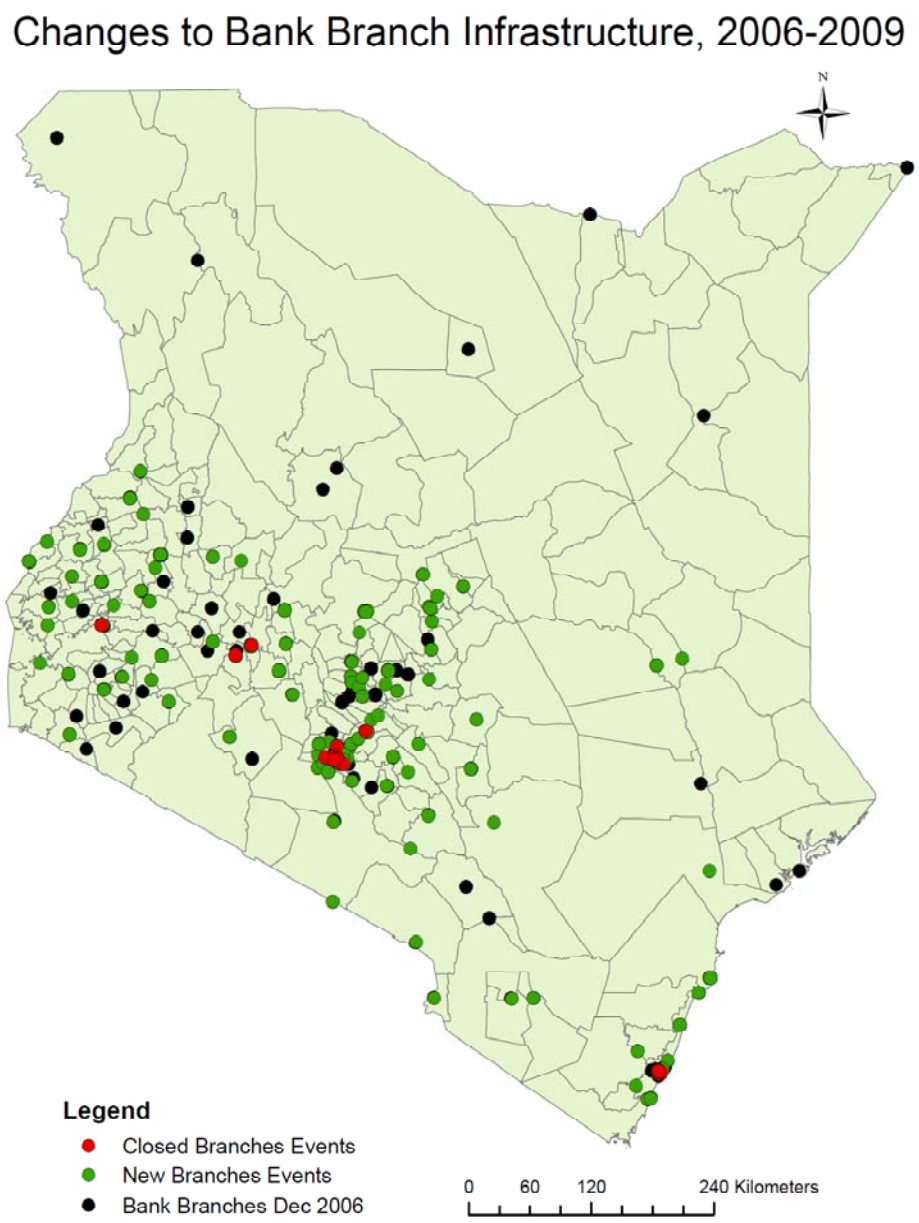
Table 9: Frequency of M-Pesa Use and Proximity to Bank Branches, OLS Regression

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distance	-0.03	-0.01	-0.02	0.02	-0.01					
	(0.054)	(0.055)	(0.048)	(0.056)	(0.053)					
TimetoBank						0.03	0.04	0.04	0.06	0.05
						(0.056)	(0.055)	(0.049)	(0.055)	(0.051)
Urban	0.31*	0.27*	0.09	0.08	-0.04	0.39**	0.32*	0.16	0.11	0.04
	(0.120)	(0.114)	(0.096)	(0.110)	(0.106)	(0.121)	(0.124)	(0.084)	(0.120)	(0.090)
Female	-0.31***	-0.23***	-0.17**	-0.24***	-0.20**	-0.31***	-0.23***	-0.17**	-0.24***	-0.19**
	(0.057)	(0.058)	(0.061)	(0.062)	(0.067)	(0.055)	(0.054)	(0.059)	(0.058)	(0.065)
Age/100	3.89***	3.04***	3.37***	0.66	0.90	3.87***	3.02***	3.37***	0.66	0.86
	(0.763)	(0.678)	(0.674)	(0.679)	(0.713)	(0.752)	(0.670)	(0.664)	(0.668)	(0.705)
Age_sq/100	-4.29***	-3.45***	-3.53***	-1.21	-1.24	-4.28***	-3.44***	-3.54***	-1.22	-1.23
	(0.831)	(0.738)	(0.713)	(0.729)	(0.766)	(0.813)	(0.723)	(0.701)	(0.715)	(0.761)
Completed Primary	0.27**	0.12	0.11	0.05	0.06	0.28**	0.13	0.12	0.06	0.07
	(0.089)	(0.091)	(0.088)	(0.091)	(0.088)	(0.091)	(0.092)	(0.088)	(0.093)	(0.089)
Completed Secondary	0.65***	0.35*	0.35*	0.17	0.20	0.67***	0.36*	0.36*	0.18	0.21
	(0.099)	(0.132)	(0.133)	(0.141)	(0.137)	(0.104)	(0.135)	(0.135)	(0.142)	(0.138)
Above Secondary	1.15***	0.75***	0.71***	0.38**	0.40***	1.16***	0.76***	0.72***	0.39**	0.41***
	(0.106)	(0.132)	(0.124)	(0.125)	(0.114)	(0.108)	(0.131)	(0.123)	(0.123)	(0.114)
FSKnow		0.10***	0.12***	0.07**	0.08**		0.11***	0.12***	0.07**	0.08***
		(0.021)	(0.024)	(0.020)	(0.023)		(0.021)	(0.024)	(0.019)	(0.023)
RiskAversion		-0.05	-0.00	-0.04	0.00		-0.05	0.00	-0.04	0.00
		(0.054)	(0.057)	(0.054)	(0.058)		(0.054)	(0.057)	(0.055)	(0.059)
Expenditure (ln)				0.21***	0.22***				0.21***	0.22***
				(0.049)	(0.048)				(0.049)	(0.048)
Mobile				0.48***	0.44***				0.48***	0.44***
				(0.063)	(0.059)				(0.064)	(0.063)
Breadth Assets				0.08***	0.06***				0.08***	0.07***
				(0.019)	(0.017)				(0.018)	(0.017)
Constant	0.82***	0.46	0.39	-1.05**	-0.97*	0.64*	0.29	0.23	-1.18**	-1.16**
	(0.218)	(0.247)	(0.271)	(0.385)	(0.392)	(0.257)	(0.280)	(0.299)	(0.414)	(0.422)
District Controls										
Observations	2,534	2,534	2,534	2,533	2,533	2,516	2,516	2,516	2,515	2,515
R-squared	0.13	0.15	0.22	0.21	0.26	0.13	0.15	0.22	0.21	0.26
Adj. R-squared	0.13	0.15	0.20	0.20	0.24	0.13	0.15	0.20	0.20	0.24

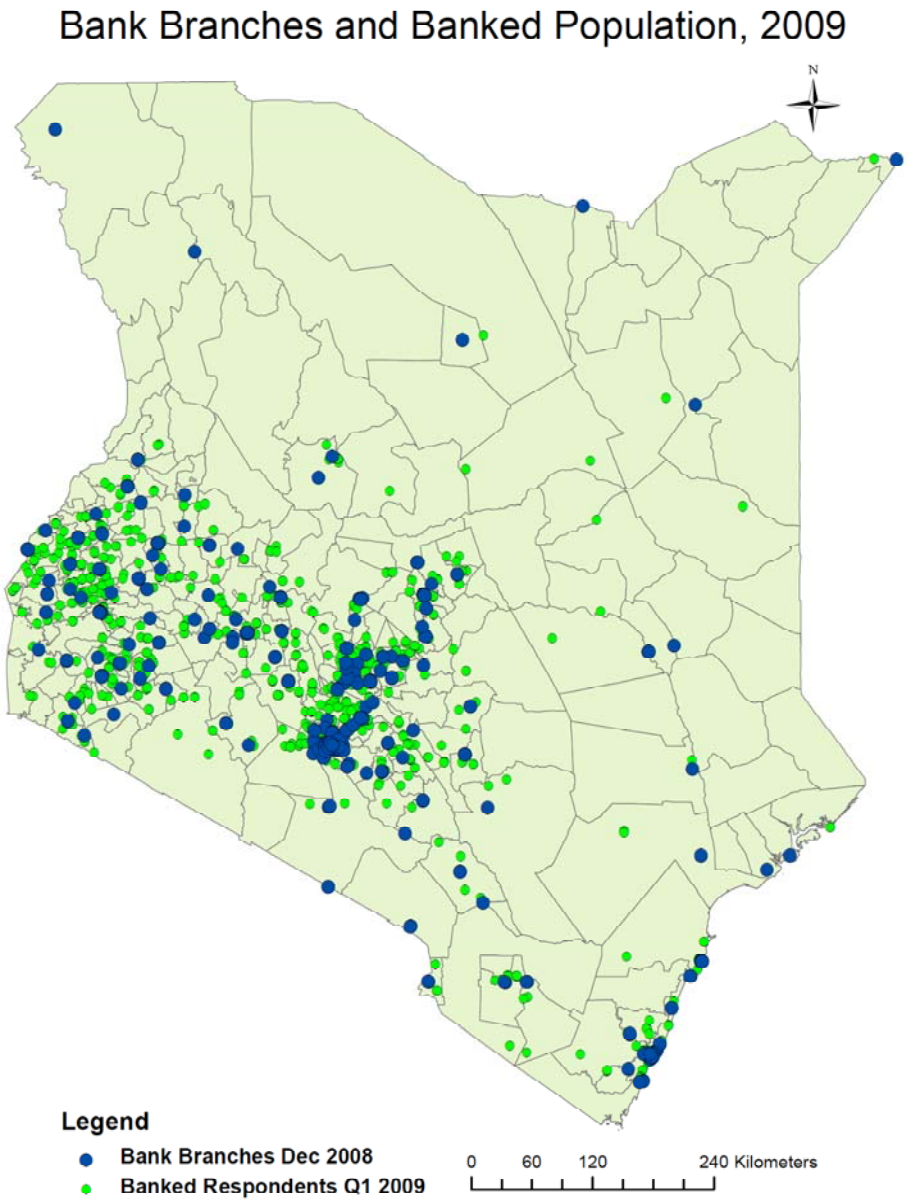
District controls comprise of a series of district dummy variables.
The omitted education category is less than completed primary education.
Robust standard errors, clustered by district in parentheses.

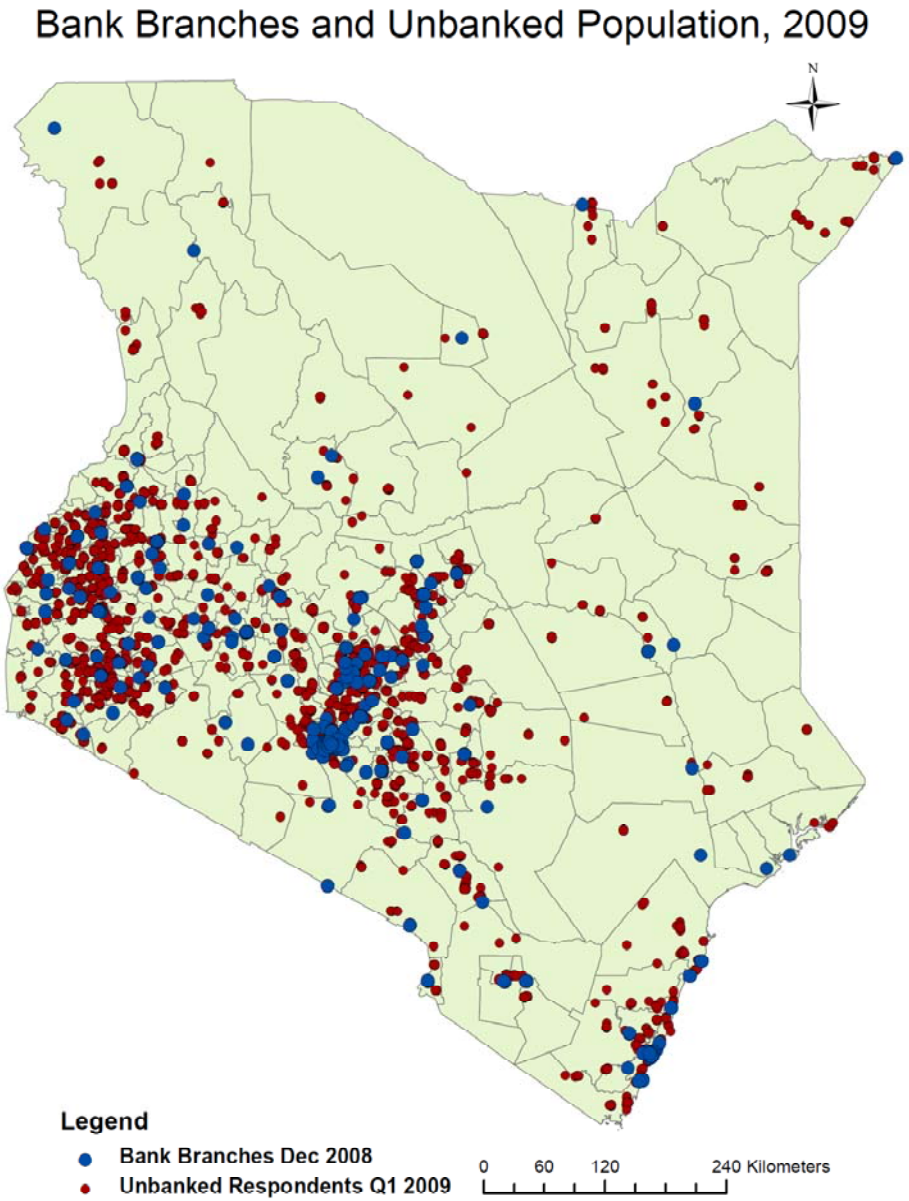
*** p<0.001, ** p<0.01, * p<0.05

Figures 6: Geographical Distribution of Branches, Formally Banked and M-Pesa Users

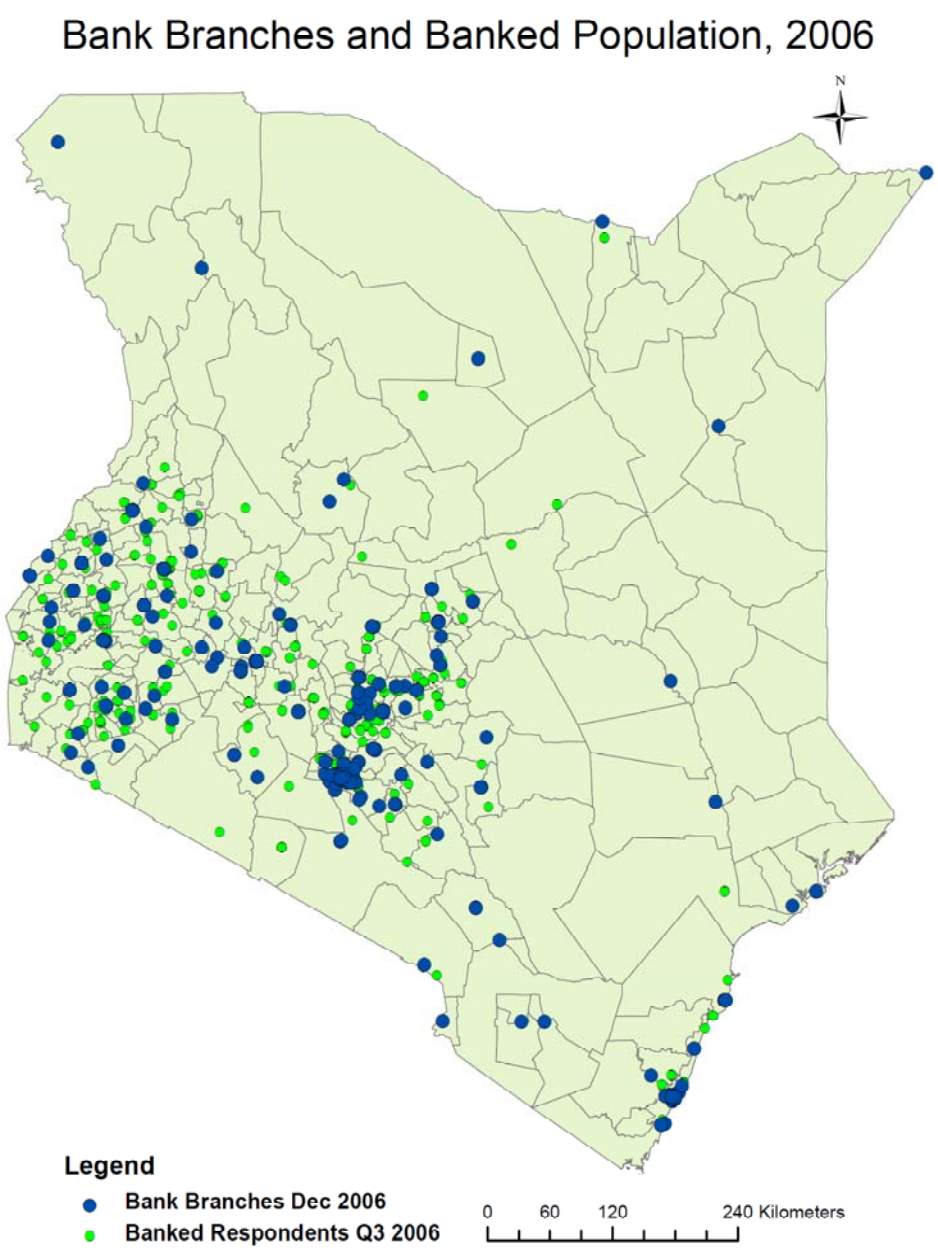


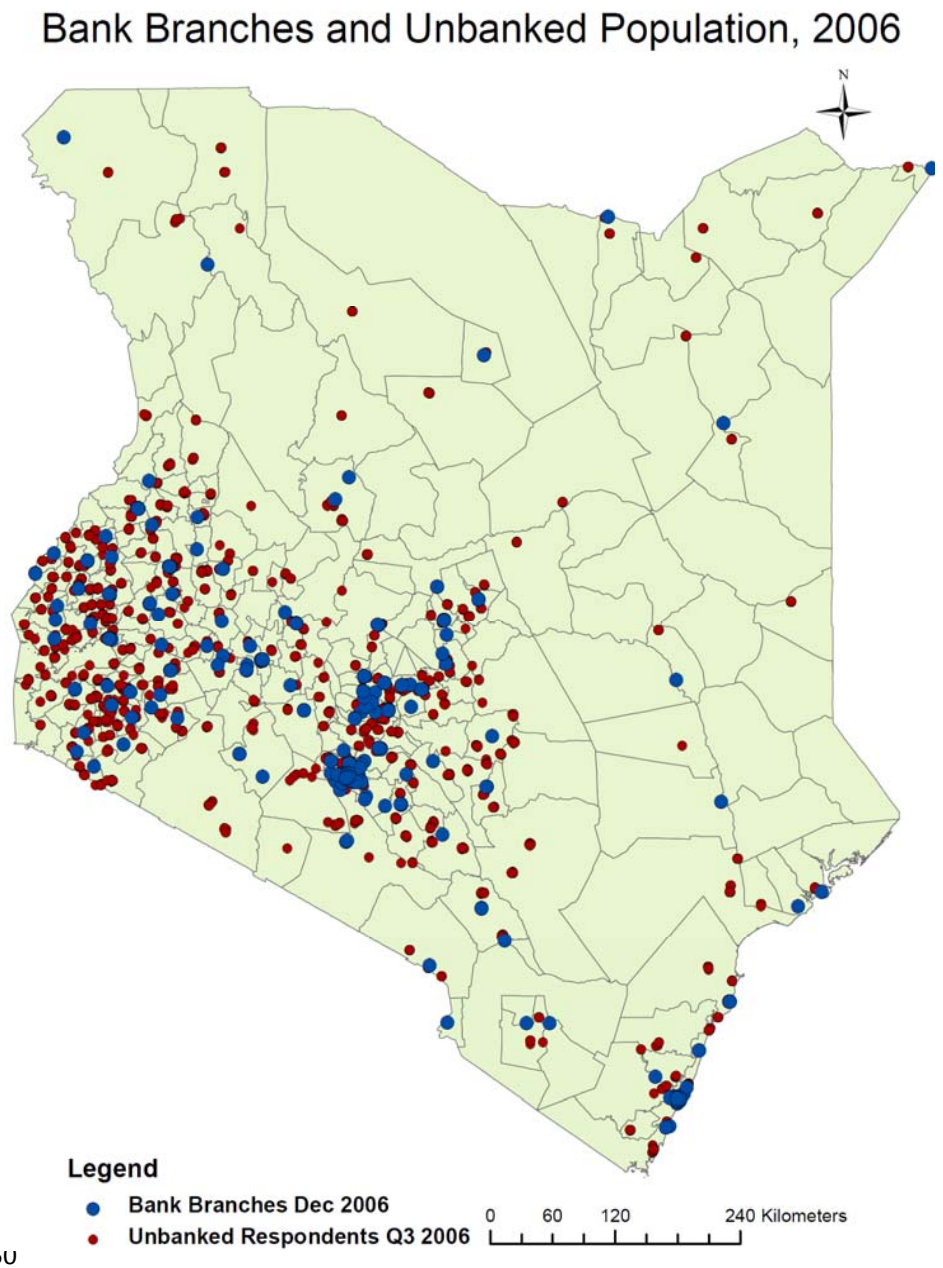
Figures 7 and 8: Geographical Distribution of Branches, Access Status of Respondents 2009





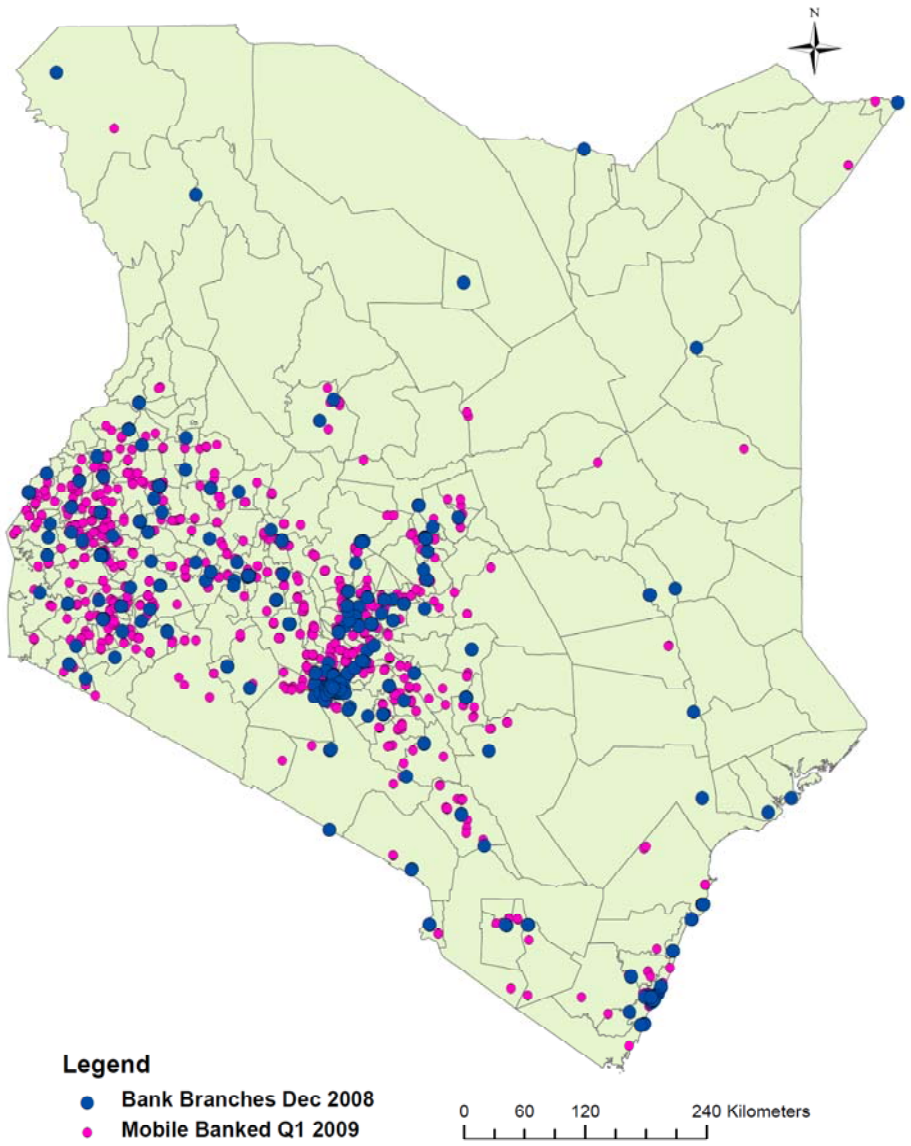
Figures 9 and 10: Geographical Distribution of Branches, Access Status of Respondents 2006



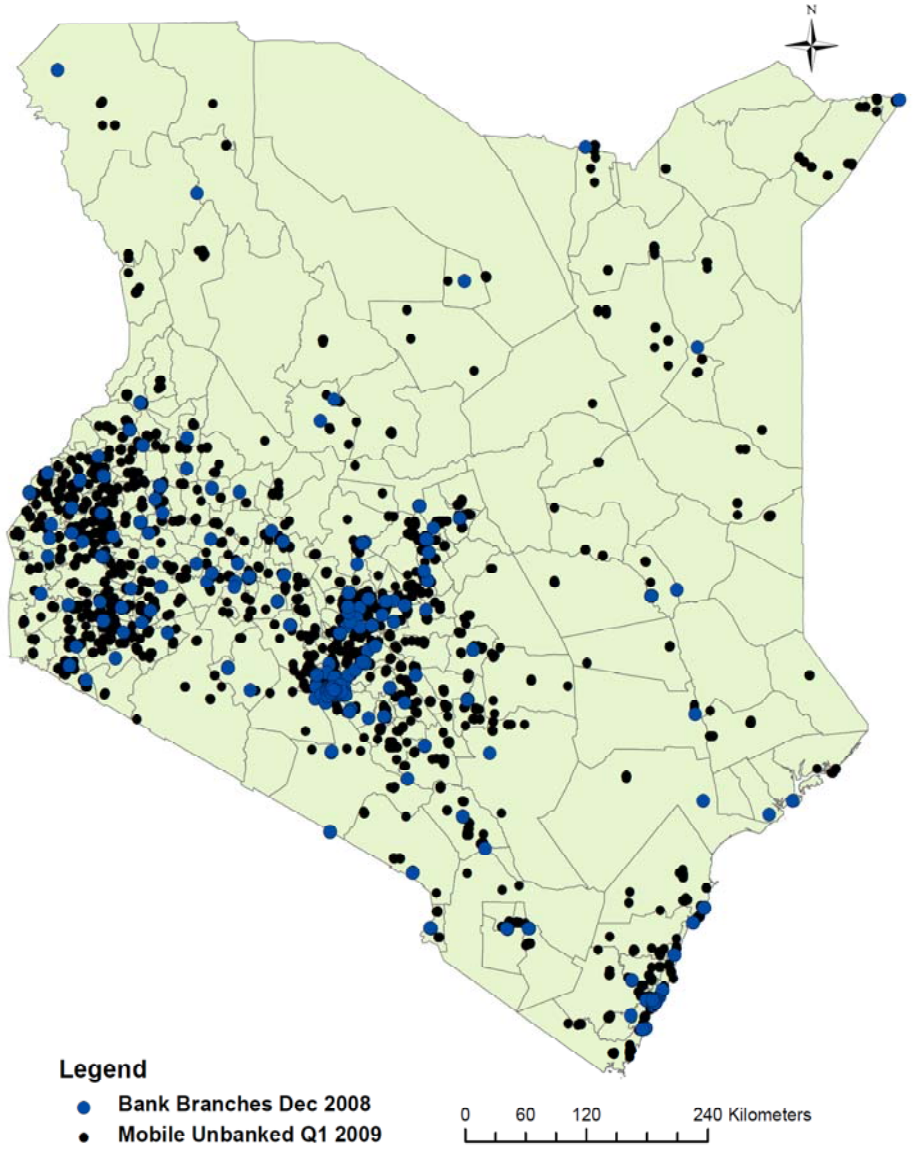


Figures 11 and 12: Geographical Distribution of Branches, M-Pesa Users 2009

Bank Branches and Mobile Banked Population, 2009



Bank Branches and Mobile Unbanked Population, 2009



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