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Fighting competition from Mobile Network Operators in the banking sector: The case of Kenya

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Abstract

This paper studies how Mobile Network Operator (MNO) impacts traditional banks' coverage decision in a model of vertical and horizontal differentiation with asymmetric transportation costs. The competitive pressure triggered by MNOs entry on traditional banking sector leads to prices decrease and broadens financial inclusion as the traditional banking sector expands its network in response to the entry of MNOs. The model's predictions are checked against data from Kenya, where mobile banking has been most successful. Results from the econometric model for the period 2000-2011, suggest that, roughly, for each 7 new mobile agents in a sub-locality, one new bank branch opened.

Keywords: Financial inclusion; Regulation; Mobile banking; Development
JEL classification: G18; L51; L88; L96; O16

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1 Introduction

According to the World Bank, approximately 1.89 billion people were unbanked in 2021, most of them living in developing countries. However, the percentage of adults with access to financial services increased 50% in one decade, from 51% of adults in 2011 to 76% of adults in 2021. Mobile money is one of the key factors explaining the rapid expansion of financial access among the world's poor, especially in Sub-Saharan Africa (Demirguc-Kunt et al., 2022).[1] There are many success stories in the "financial revolution" brought about with mobile banking, such as M-Pesa in Kenya, Celpay in Zambia, Wizzit in South Africa, and DR in Congo, but also in Asia, such as SmartMoney and GCash in the Philippines, or Little World in India. Thus, financial inclusion through mobile banking has become a major policy issue. In this paper we focus on Kenya as it leads the world in mobile money: 79% of adults reported using a mobile phone for money transactions in 2021, to be compared with around 55% of the population on average in Sub-Saharan Africa (Demirguc-Kunt et al., 2022). Our main contribution to the literature is to explore, both theoretically and empirically, the competitive effects of mobile banking on the incentives of traditional banks to expand coverage. We show that much of the increase in financial inclusion in Kenya is due to this competitive effect.

There is considerable empirical evidence of a positive link between access to finance and economic development and poverty reduction (Banerjee and Duflo, 2012; Burgess and Pande, 2005; Levine, 2005; Rajan and Zingales, 2001). From a financial inclusion perspective, allowing a mobile banking platform to deliver services to individuals who otherwise would not have access to traditional banks seems to be a clear-cut answer. However, from a regulatory perspective, the issue at hand is complex. This innovation poses regulatory challenges, as a new player, typically a Mobile Network Operator (MNO), enters the market of financial intermediation. Policy makers around the world are still struggling on how to regulate this

[1] If globally, in 2021, 76 % of adults had an account at a bank or regulated institution such as a credit union, microfinance institution, or a mobile money service provider, the "financial access divide" is still pronounced as in Sub-Saharan Africa, almost 45% of adults (above 15 years old) did not have access to a formal financial service in 2021, compared to less than 4% in advanced economies (Demirguc-Kunt et al., 2022).

platform (i.e. tie the mobile account to a bank account, impose banking regulation on the MNO, or opt for regulatory forbearance). The regulatory burden should be tailored to the specific risks this new platform poses to the banking sector when adopted by a large portion of the population, balanced with the social benefit of extending coverage of financial services. In the case of Kenya this is a serious issue as more than half of the country's GDP transits in its mobile accounts (see figure 11). A key issue in this cost-benefit analysis is how the competition from MNO will affect the traditional banking sector. If it shrinks under the pressure of competition and is *de facto* replaced by the MNO, then the MNO should be facing banking regulation. If this innovation in payments platform extends coverage of all financial services, including traditional ones, then regulators may opt to lower entry barriers for this new service to foster financial inclusion. A strong traditional banking sector is necessary to guarantee the stability of the financial system as a whole, not least because mobile network operators (MNOs) in general, and specifically in the case of Kenya, do not need to comply with prudential regulations. Banks' reactions to the new competition has therefore important welfare implications.

From the supply perspective, the analysis of the competitive effects that mobile banking might have on traditional banks coverage is still lacking. This paper is a first attempt to model the competition between an incumbent traditional bank and an entrant MNO that occurs in a context where much of the population does not have access to traditional banks, and is particularly based on Kenya's example. The model involves two type of networks. These networks initially provide two distinct services (i.e., banking and telecommunication services) that become connected thanks to the mobile-banking innovation. Accordingly, we first model a monopoly bank that, due to prudential regulation and fixed costs, is unwilling to cover the whole country (thus, there is a fraction of the population that remains unbanked). Then, we model an Entrant (e.g. a telecommunication operator with ubiquitous coverage) that has the potential of covering latent demand for financial services at a lower quality and cost, in particular because it is subject to a lower regulatory burden than the banking sector. We show that the bank reacts to the MNO competition by decreasing the price of its services. As a result of this aggressive pricing strategy it generally is able to increase its market share. This prediction is next brought to the data.

What is tested empirically is that the entry of this new player in the financial services market exerts sufficient competitive pressure so that the incumbent bank changes its coverage decision. In this sense, the entry of a new player fosters financial inclusion through the delivery of new financial services of lower quality, (i.e., payment platform with small credits), but also induces traditional banks to expand their coverage and their services that generally are of higher quality. Our main focus is on the supply side of the banking market. We study how the deployment of mobile-money agents have impacted the number of formally prudentially regulated bank branches and agents per sub-localities in Kenya.

We use geographical data of both banks and mobile agents per sub-locality for the years 2000-2016, what allows us to shed light on coverage decisions by banks due to the entry of M-Pesa, the Kenyan mobile application providing branch-less financial services of Safaricom the telecommunication incumbent. As there are endogeneity concerns of unobserved factors that influence both banking branching strategies and establishment of mobile agents, we use as an instrument the mobile network GSM coverage per sub-locality in Kenya. That is, our identification strategy relies in using mobile coverage data as an instrument, as every thing else being equal, mobile cell towers only influence bank coverage indirectly, through the impact this variable has on mobile banking agents. However, this instrument is only valid up until 2011, as after that, agency banking, that allows third parties to offer prudentially banking services, renders this instrument invalid. When running the IV regressions for the period 2000-2011, and instrumenting mobile banking agents by mobile network coverage, we find that for each 7 mobile banking agents in a sub-locality, there is an additional bank branch.

After 2011, banks subject to prudential regulation were authorized to use local agents to offer their services, on the same model as MNOs. This corresponds to an interoperability of the local agent network, which was previously only available to MNOs. After 2011, the impact of MNO competition on traditional banks is likely to be greater, thanks to the development of the banking agent network. Simple OLS results of the number of banks (branches, and after 2011 agents as well) versus the number of mobile money agents for the whole period 2000-2016 yields that for every 6 new mobile banking agents in a sub-locality, an additional bank branch and/or, after 2011, bank agents as well, is likely to be set up there. We cannot identify more precisely the causal impact of the competition on the expansion of the coverage of prudentially regulated banks because our instrument is no more valid after 2011. However, this result is very likely to be a lower bound, as shown by our results for the period 2000-2011. Failure to take into account the endogeneity of banks' decision to open branches and set up agents leads to an underestimation of the real impact of competition on this decision. In any case, as our study shows, this impact is significant.

The rest of the paper is organized as follows. Section 2 provides a literature review on mobile banking in Kenya. Section 3 presents a quick overview of the market for mobile banking in Kenya. Section 4 presents the theoretical analysis. Section 5 describes the data and the empirical application using geo-spatial data of financial service providers in Kenya in order to test how the traditional banking sector reacts to the MNO competition. Section 6 concludes.

2 Related Literature

The literature on mobile banking in Kenya is structured around three axes. First there is the literature that focuses on the determinant of the demand of mobile banking services. Second there is the literature that focuses on the welfare/social impact of the adoption of mobile banking. Finally there is a small literature that focuses on the supply side of the market. We review them in turn.

Mobile payments/banking use and adoption: tyranny of distance and trust In sub-Saharan Africa, one of the main reasons why people are unbanked is the distance to a formal bank. Because of time and expense associated with banking, poor people, especially in rural areas, do not usually have access to formal banks. Using FinAccess Survey Data for Kenya from 2006 and 2009, King (2012) measures the real distance of households to banks in order to understand the determinants of formal banking usage. In Kenya, at the time of his study, an unbanked individual was on average 16 km away from a bank branch, while a banked individual was only 8 km away. Using bivariate probit regressions, with controls for confounding variables, he finds that, in both 2006 and 2009, distance to the bank branch is a statistically significant determinant of an individual's having a formal bank account. King (2012) emphasizes that mobile banking is a way of breaking the "tyranny of distance", which is a real barrier to financial inclusion.

Subramaniam (2013) using the same FinAccess data and same type of methodology, finds that individuals more distant to banks are more likely to use M-Pesa, which reduces the risk from carrying cash. This result suggests that mobile payment technology serves as a substitute for banks. However when we reproduce the regressions of both King (2012) and Subramaniam (2013), with the inclusion of new waves of the FinAccess survey data, we confirm the results by King (2012) on the negative impact of distance on the probability to be banked but we do not find that mobile payment acts as a substitute for banks. In our regressions, which include more recent waves of the survey, they appear to be complement (see appendix **??**).

The problem with these results is that they are based on repeated cross-section and are therefore very likely to be biased. To address this concern, Munyegera and Matsumoto (2016) exploit panel data in rural Uganda. They remove time-invariant household heterogeneity with household fixed effects and some time-variant household heterogeneity with location-by-time dummies. It includes many individual controls (e.g. control for ownership of a mobile phone, distance to the nearest mobile money agent and a migrant worker in the family) further helping to reduce endogeneity. They find that education and wealth matter, but not gender nor age for rural adopters. More importantly they find again that distance to the nearest mobile money agent is key. The tyranny of distance result is both intuitive and very robust.

While distance may explain why people don't hold accounts with prudentially regulated banks (i.e., it is a push factor), it doesn't explain M-Pesa's incredible popularity (i.e., it is not a pull factor). Trust is the key. Morawczynski and Miscione (2008) explore the role of trust in mobile banking transactions for the case of M-Pesa. To that end, they conduct a survey about trust in Kibera, one of the largest slums in Kenya, and their findings suggest that customers use M-Pesa because they believe that their money will be kept safe by the telecommunication incumbent Safaricom. In contrast, Dupas et al. (2012), combining survey and experimental evidence from Western Kenya, find that the level of trust in the local financial institutions, which are not prudentially regulated banks, is quite low among rural households. This lack of trust, fueled by embezzlement scandals and cash shortages, explains farmers' reluctance to open an account with their unregulated local banks. When a bank or financial institution is nearby, but is not prudentially regulated and has a poor reputation, people don't use it anyway.

Impact of mobile banking on development outcomes in Kenya. There has been an influantial literature from the demand side perspective on the positive impact that the adoption of mobile banking with M-Pesa has had on the population (Eijkman et al., 2010; Jack and Suri, 2014; Mbiti and Weil, 2016).

Mbiti and Weil (2016) use two waves (2006 and 2009) of FinAccess Survey data in Kenya to examine the impact of M-Pesa on financial inclusion, saving and money-transfer services. They find that an increase in the use of M-Pesa lowers the propensity of people to use informal saving mechanisms such as ROSCAS, and increases the probability of acquiring a banking service. Furthermore, they find that M-Pesa, which offers a remittance service, has exerted sufficient competitive pressure on existing money-transfer services, driving companies such as Western Union to decrease prices.[2] Overall, their results suggest that M-Pesa improves

[2] In 2008 the World Bank estimated that the market for remittances totalled 420 USD billion, out of which 338 USD billion went to developing countries. High rates of mobile penetration provides fertile ground for mobile money transfers which bear great importance for developing countries.

individual welfare by promoting financial inclusion and by increasing the use of services such as saving and transfers.

As shown by Jack and Suri (2014) this is important for people welfare, as in Kenya, where families and social networks are widely-dispersed from internal migration, remittances on average travel 200 km. Jack and Suri (2014) use demand-side data to shed light on the effects of M-Pesa on household consumption and household insurance. They estimate the effect of mobile money on household consumption using a two year period household panel, and found that shocks do not affect consumption of user household, whereas they reduce per capita consumption by 7% in non-user households. In other words, Jack and Suri (2014) show that mobile money fosters risk sharing in Kenya by reducing transaction costs associated to it. Suri and Jack (2016) confirm these positive outcome of financial inclusion through mobile banking on poverty: They estimate that the access to the Kenyan mobile money system M-Pesa lifted from poverty 2% of Kenyan households, with the impacts being more pronounced for female-headed households. These papers show that mobile banking reduces poverty and increases people welfare through financial inclusion.

Supply of banking services and financial inclusion in Kenya. Allen et al. (2020) use household surveys and bank penetration data at the district-level in 2006 and 2009 to explore the impact of Equity Bank bank branch expansion strategy in the increase of access to banking services in Kenya.[3] They find that while all banks (including Equity Bank) open more branches in urban, highly populated and English speaking areas, Equity Bank was more likely to expand to underdeveloped districts. Unlike traditional banks, including foreign and government owned banks in Kenya, Equity Bank targets less developed territories and less privileged households. Exploiting branch-level data on the profitability, credit quality, and financial structure of all branches of Equity Bank, they find that branch-level profits was

[3]Equity Bank, a pioneering institution locally founded and operated by Kenyans, was founded as Equity Building Society (EBS) in October 1984 and was originally a provider of mortgage financing for the majority of customers who fell into the low income population. Having been declared technically insolvent in 1993, Equity's transformed into a rapidly growing microfinance and then a successful commercial bank.

rising in areas with a smaller number of operating banks (i.e., less competition). Allen et al. (2020) also find that the presence of Equity Bank in a certain district is highly correlated with the likelihood of a household having access to a bank account, here again confirming the importance of distance. Its presence increased financial inclusion by 31% of the adult population between 2006 and 2015, especially for Kenyans who were less educated, did not own their own home, and lived in less-developed areas. The growth of Equity Bank suggests that financial inclusion can be achieved through profitable branching of prudentially regulated banks and service strategies.

Our study adds to the existing literature by examining theoretically the impact of the entry into the financial sector of an MNO such as M-Pesa on the traditional banking sector. We focus on the supply-side effects that mobile banking has on traditional banks' coverage decisions. To take into account the specific nature of MNO competition, we develop a model that combines vertical and horizontal differentiation with asymmetrical transport costs. To the best of our knowledge this proposal is new in the literature. From the supply-side, literature understanding the competitive dynamics triggered by mobile banking is still scant. The question of how the traditional banking sector withstands competition from innovative mobile operators, while crucial for the policy-making process, has been neglected until now. The theoretical results are illustrated using geographical banking infrastructure data at a sub-locality level in Kenya for the period 2000-2011,

3 Kenyan Banking Market: a mobile revolution

In Kenya, growth in mobile penetration has been extremely rapid (e.g. it grew from 0.42 mobile subscriptions per 100 inhabitants in the year 2000 to 121 subscriptions per 100 people in 2023, ITU, 2024). Kenya's mobile revolution has also been the driving force behind the transformation of the country's financial access landscape: Kenya is a leader, not only in Africa, but also in the developing world, for mobile banking services. Since its introduction in 2007, mobile money accounts and mobile money agent coverage have grown steadily, from basically 0 to 300,000 mobile payment agents and 68 millions of subscriptions in 2021 (see Figure 10). At the same time, the amount of transactions being transferred through mobile payment platforms has grown from 1% in 2007 to 56.8% of GDP in 2021 (see Figure 11). The driving force behind these changes was the launch of M-Pesa.

3.1 The case of M-Pesa

M-Pesa is a mobile application providing branch-less financial services. It was launched by Safaricom, the Kenyan incumbent telecommunications operator, in 2007. M-Pesa facilitates numerous services such as checking account balances, deposits and withdrawals, transferring money and phone credit to other users. It targets the unbanked and prepaid segment of the population. Customers register at a point of sale and deposit cash. The money is converted into electronic money in a virtual account managed by Safaricom. To be able to redeem electronic money via M-Pesa, the recipient must also go to a point of sale with an identification and transaction number, in order to convert the electronic money into cash. In 2009, two years after its launch, M-Pesa was already being used by 40% of the population. In particular, it reached 25% of previously unbanked households and 61% of banked households (Jack and Suri, 2011, 2014).

In addition to these bank account services, in November 2012 M-Pesa launched with success a microcredit-type loan service called M-Shwari, in cooperation with the Commercial Bank of Africa (CBA).[4] In March 2014, a mobile-based credit lending service, owned by InVentur, and named M-kopo Rahisi, was also launched on the M-Pesa platform.[5] M-Pesa also facilitates the

[4]M-Shwari employs M-Pesa users' history of bill payments to determine credit scores of clients, and, even if users don't have credit history, the mobile can be used as collateral. Almost a third of M-Pesa customers (over ten million accounts) use this banking application, and over 50,000 loans are granted every day. See http://www.cgap.org/blog/top-10-things-know-about-m-shwari

[5]The app uses social media accounts and web searches to build a customer's profile and credit score in order to determine the interest rate on micro loans. They advertise that you can apply in five minutes, be approved in seconds and receive the money in your M-Pesa account in the same time. M-Kopo, now called Tala, competes with M-Shwari, which also runs over the M-Pesa platform. See http://www.standardmedia.co.ke/business/article/2000185968/

transfer of remittances, both domestic and international.[6] Finally, in March 2017, to enhance its customers' savings options, M-Pesa launched the M-Akiba platform, which enables the sale of government bonds via the cell phone app (Quartz, 2017). With all these applications running on M-Pesa, which is not fully interoperable with other payment platforms, competition issues arise. One of the problems highlighted by Bourreau and Valletti (2015) is that M-Pesa lacks a proper API (Application Programming Interface), which makes it difficult for this payment platform to interoperate with others, as poor APIs mean high integration costs for software developers. Safaricom, the incumbent telecoms operator, has a de facto monopolistic dominant position in both the mobile telephony and mobile banking markets: M-Pesa's market share in mobile payment subscriptions was 99% in 2021.[7]

3.2 Traditional banking sector

Kenya's formal banking sector has tripled from covering around 26% of the population in 2006 to nearly 84% in 2021. Many attribute this success entirely to the deployment of mobile banking (see Figure 12). Yet traditional banks have also contributed massively to this expansion. Equity Bank devised early on a banking service strategy targeting low-income clients and underserved geographic areas. Equity Bank's business model, which is based on low margin, high-volume transactions, has been very successful at improving financial inclusion, while making profits (Allen et al., 2020). In 2006, it had 1 million customers, representing 5% of the population aged 15 years and over. By 2015, the number of customers had risen to 10 million representing 36% of the adult population. Other banks subject to prudential regulation have also extended their networks coverage since the launch of M-Pesa in 2007. As a result of this

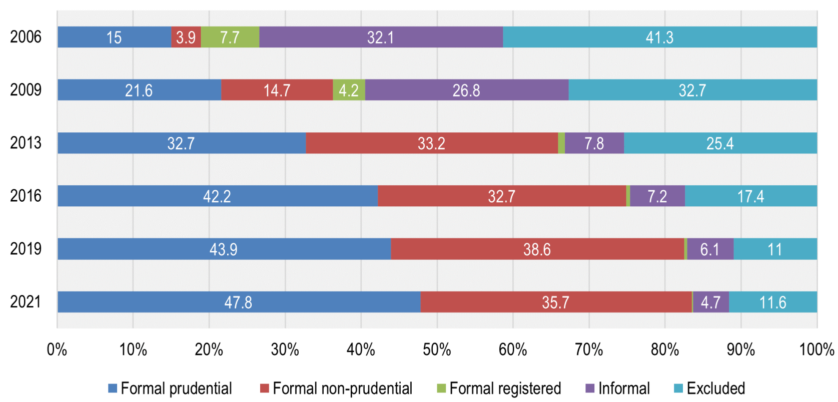
mkopo-rahisi-the-mobile-app-using-social-media-data-to-give-micro-loans

[6] In November 2014, MoneyGram, one of the largest money transfer companies in the world, and Safaricom, announced the launch of a new service that enables customers in over 90 countries outside Kenya to send money directly to M-PESA (see http://ir.moneygram.com/releasedetail.cfm?releaseid=880570).

[7] M-Pesa held a market share of almost 81% of mobile money users in June 2017, ten years after it entered the market. Furthermore, in June 2017, 79% of mobile money transactions were processed by M-Pesa, and Safaricom held a 79% share of the total number of mobile banking agents in the country (Kenya, 2017). This dominance of the incumbent is illustrated in Figure 15 in appendix 7.2.

vigorous competition of the traditional banking sector, prudentially regulated banks increased their coverage of the population from 15% in 2006 to 47.8% in 2021. As illustrated Figure 1, they are today the main providers of formal banking services in Kenya.

Figure 1: Access strand per year 2006-2021



Source: FSD Kenya, Central Bank of Kenya and Kenya National Bureau of Statistics (2021), "FinAccess Household Survey Report 2021", urlhttps://www.knbs.or.ke/wp-content/uploads/2021/12/2021-Finaccess-Household-Survey-Report.pdf

3.3 Banking Regulation in Kenya

Prudentially regulated institutions in Kenya are regulated by the Kenya's Banking Act, and the Prudential Guidelines.[8] All new bank branch applications have to be authorized by the Central Bank of Kenya (CBK). Among several conditions, it requires that bank branches should have: a fixed telephone line, custom-built strong room (Safe/Vault), security guards, alarm system installed in the premises connected to the police and security firm with a closed-circuit surveillance system (CCTV), a server room (with computers). For a bank branch license to be issued, banks must complete a form (Form CBK/IF/02) that includes as information the physical address and a fixed telephone of the branch, as well as all the list of documents and certificates asked (CBK, 2013). That is, bank headquarters and bank branches have stringent conditions to operate a premise, and at least require, fixed telecommunication infrastructure given the security and emergency systems that have to be installed. Bank branches are not

[8] For a good account of the banking sector history in Kenya see Upadhyaya and Johnson (2015).

authorized to operate on a mobile line.

Following the arrival of M-Pesa in 2007, and its rapid expansion, the Kenya Bankers Association became concerned that existing regulations prevented its members from establishing branches closer to customers, and in 2009 commissioned a report, in collaboration with the CBK, on the benefits of branch banking in Latin America. This report led to the amendment of Kenya's Banking Act in 2009. In December 2010, the CBK gave the go-ahead for five institutions to sign up to "agency banking", allowing them to offer a wide range of banking services through agents (CBK, 2010). This enabled prudentially regulated banks to contract with third-party agents, just as MNOs had been doing since 2007.

The Agency Banking regulatory framework still differs from the regulation that Mobile Money Agents are subject to. MNOs are required to follow the Payments Guidelines that were issued in 2011 (CBK, 2011b). Banks are required to seek CBK approval for the agent network, as well as approval for specific agents, and all responsibility for payments made through the agent network rests with the banks. The banking sector has been arguing that its agents are subject to stricter regulations than mobile money agents. For example, banking agents had to be interoperable and to have an 18-month track record of operation, whereas mobile money agents were only required to have a six-month track record (Mugo, 2012).

Agency banking, as a strategy to increase commercial banking coverage, has been led by Equity Bank which started its agents' operations as early as April 2011. By December 2011, there were 8 commercial banks that had contracted 9,748 active agents (CBK, 2011a). By March 2013, Equity Bank had 2.3 million agency customers (Venkata and Priyank, 2013). Furthermore, in 2014 the Communications Authority of Kenya issued Mobile Virtual Network Operator (MVNO) licenses, that allowed other players to purchase spectrum from MNO to provide communication services, such as mobile financial services (Mazer and Rowan, 2016). Equity Bank acquired its own MVNO license that year (CGAP, 2014).

Both these market developments, i.e. the roll out of agency banking in 2011 and the move of a major bank such as Equity Bank to become MVNO in 2014, can be seen as the result of the competitive pressure that the entry of mobile banking put on the financial service market after 2007. They also explain why we can't use cell towers as an instrument for cell phone penetration to assess the impact of MNO competition on prudentially regulated banks after 2011. We therefore limit our IV empirical study to the 2007-2011 period. We use the full sample for the other (non-instrumental) fixed-effect regressions. The following section presents a theoretical model for analyzing the impact of competitive pressure exerted by mobile banking services on the coverage decisions of traditional banks. It includes several important ingredients from the empirical literature reviewed above: the tyranny of distance for traditional banks, the ubiquity of coverage for MNOs, the difference in the quality of financial services between traditional banks and MNOs.

4 The model

Consider one incumbent bank (B) providing financial services and one entrant (E), a Mobile Network Operator (MNO), wishing to provide a basic financial service (i.e. of lower quality). In order to capture two dimensions of differentiation of consumers' characteristics, the model combines features of the model of vertical differentiation by Mussa and Rosen (1978) and the model of horizontal differentiation by Hotelling (1929). On the Hotelling's line, the traditional bank is located exogenously at zero. When the Entrant is allowed to compete, it faces no transportation cost as the mobile banking service is available all along the Hotelling line. In other words, it is a Hotelling model with asymmetric transportation costs and vertically differentiated quality of the service.[9]

[9]To the best of our knowledge there is no paper that analyze this type of model. The closer to it theoretically is the literature that focus on the competition between online and offline retailers (see for instance Baye and Morgan, 2001). In this literature there is generally a cost to deliver the commodity to the customer for the online provider (e.g., post office cost, delay in consuming the good, inability to assess the quality of the product before purchase, etc), different from the transportation cost that the consumer bears to visit an offline shop. Quality of the product is assumed to be uniform otherwise.

The Firms The incumbent bank, firm B, is subject to prudential regulations and offers a full range of financial services, while the entrant, firm E, has an innovative mobile banking platform and offers basic payment services. As a result firms differ in two dimensions: the quality of their financial service and their location.

The quality of the financial services is defined by the security of the product (i.e. linked to prudential regulation or other security standards) and the complexity of the bundle (e.g. payment instrument, savings, insurance, credit, etc). Quality is higher in the traditional banking sector on both accounts due to asymmetric regulation. Prudential regulations apply only to the traditional banking sector, which in exchange is allowed to offer sophisticated financial services (e.g., credits). To keep the exposition simple the quality of the financial services is encompassed in a unique dimension s_j ($j = B, E$) and is taken as given. This assumption reflects that the regulation shaping the quality of the banking services is exogenous to the firms. The incumbent bank offers the highest possible quality good and the entrant, through mobile banking, offers a lower quality financial service: $s_B > s_E > 0$.

A consumer wishing to buy a financial service from the bank B has to incur a transportation cost. The incumbent bank implies the highest transportation cost, proportional to δ, the customers distance to the bank branch. For simplicity of the exposition we consider a linear cost but the results are robust to other shapes of the transportation cost function (for instance quadratic): δt, where $t > 0$ is the marginal transportation cost. In contrast the mobile banking platform has ubiquitous coverage: the entrant E offers a service with zero transportation cost. Since the new entrant's mobile phone network already exists, it has no network rollout costs and, consequently, consumers who own a cell phone have no additional transport costs to incur to use the mobile banking network (i.e., phone unit sellers are also mobile bank representatives).

Both firms incur a fixed marginal cost per user for provision of the financial service, $c_j \geq 0$,

$j = B, E$, which is increasing in quality:[10]

$$\Delta c = c_B - c_E > 0. \tag{1}$$

Consumers, who have an inelastic demand for one unit of the financial service, are characterized by their taste for quality, $\theta \in [\underline{\theta}, \overline{\theta}]$, and their distance from the nearest traditional bank branch, $\delta \in [0, 1]$. As in Mussa and Rosen (1978) the taste parameter θ can be interpreted as the inverse of the marginal utility of income. So differences in tastes may stem from differences in income, where richer consumers have a lower marginal utility of income, and hence, a higher θ. To keep the analysis simple we assume that $\overline{\theta} - \underline{\theta} = 1$ and that the consumers with characteristics (δ, θ) are uniformly distributed over the unit-square $[0, 1] \times [\underline{\theta}, \overline{\theta}]$.[11]

Consumers care for quality. Let $v_j = v(s_j)$ denote the gross consumers' valuation of the quality offered by the financial institution $j = B, E$. The difference in quality offered by the two financial institutions yields a difference in valuation by consumers:

$$\Delta v = v_B - v_E > 0. \tag{2}$$

Consumers incur a transport cost t proportional to the distance to the bank: δt. The utility of a consumer of type $\theta \in [\underline{\theta}, \bar{\theta}]$, located at distance $\delta \in [0, 1]$ from the incumbent bank, when he/she consumes one unit of its services at price p_B is:

$$U^B(\theta, \delta) = \theta v_B - \delta t - p_B. \tag{3}$$

There is no transportation cost with the MNO. The utility that a consumer of type $\theta \in [\underline{\theta}, \bar{\theta}]$

[10] An extension of the model would be considering endogenous quality. It would allow the firms to choose quality levels while facing the cost $C(s_j)$ increasing and convex in s_j.

[11] That is, the distance parameter to the bank B, δ, is uniformly distributed over the unit interval: $\delta \sim U[0, 1]$. The willingness to pay for quality, θ, is uniformly distributed over $[\underline{\theta}, \bar{\theta}]$: $\theta \sim U[\underline{\theta}, \bar{\theta}]$ with $\overline{\theta} - \underline{\theta} = 1$. And δ and θ are independently distributed. The assumption that $\overline{\theta} - \underline{\theta} = 1$ is made for convenience as it allows to compute directly the market shares of the firm from their demand on the unit-square.

derives from purchasing one unit of the entrant's financial service at price p_{E} is:

$$U^{E}(\theta, \delta) = \theta v_{E} - p_{E}. \tag{4}$$

Finally we assume that trade is efficient and that, for the consumers who value quality most, the high quality product generates the highest surplus: $\overline{\theta} v_{B} - c_{B} > \overline{\theta} v_{E} - c_{E} > 0 \quad \Rightarrow$

$$\overline{\theta} \Delta v - \Delta c > 0 \tag{5}$$

Timing The timing is the following:

1. Bank, initially in a monopoly position, offers a high quality service s_B (determined exogenously by regulation). It chooses the price p_B^m of its services freely. Opening a new branch involves a fixed cost $K_B > 0$.
2. Financial service regulator licenses the entry of the MNO. The MNO decides to enter the financial services market with a low quality service s_E. Since it has ubiquitous coverage, there is no additional fixed cost to entry.
3. Upon entry firms compete in prices. Consumers choose provider based on their location, on prices (p_{B}, p_{E}) and on associated quality (s_B, s_E).

We solve the model backward. First consumers choose firms based on their prices/quality package. Secondly, firms maximize profits with respect to p_{B} and p_{E}.

As a first step, we compute the equilibrium with the incumbent bank monopoly. This initial scenario provides a benchmark to compare our results with the entry of innovative platform.

4.1 The case of a monopoly incumbent bank

First we suppose that the only available financial service is from the traditional banking sector. Due to prudential regulations and other costly security requirements representing barriers to entry and involving a large sunk cost, we consider the setting where the incumbent bank B is in a monopoly situation. A consumer with characteristic (θ, δ) purchases a banking service if and only if $\theta v_{_B} - \delta t - p_{_B} \geq 0$. Thus, the consumers who are indifferent between consuming a financial service from the monopolist bank and not consuming at all, are so that:

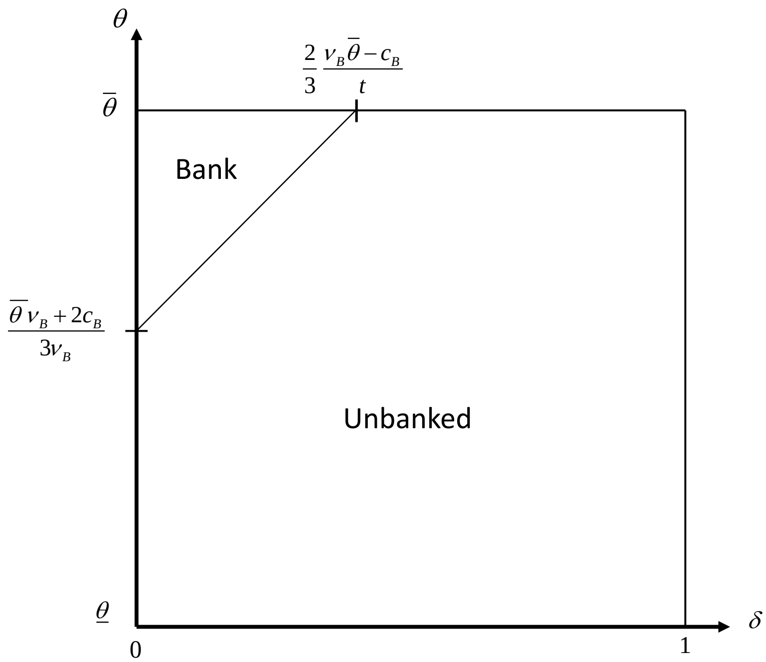
$$\theta^m_{_B}(\delta) = \frac{p_{_B} + \delta t}{v_{_B}} \tag{6}$$

Equation (6) is a linear function, which for each $\delta \in [0, 1]$ gives a value for θ. Note that this value does not necessarily belong to $[\underline{\theta}, \overline{\theta}]$. For the values that are in $[\underline{\theta}, \overline{\theta}]$, the function represents the set of consumers who are indifferent between buying from the monopoly and not buying. Depending on the value of $p_{_B}$ and of t, some consumers who are far away from the bank might not purchase its service. Since in practice transportation costs are high in Sub-Sahara Africa, due to poor infrastructure provision, in our initial situation many people are unbanked, in particular those leaving in rural areas, as illustrated in figure 2. We therefore focus on the set of parameters so that in our benchmark case only a fraction of the consumers (i.e., those who are leaving close to the bank and are wealthy enough) purchase banking services. When the transportation cost is large enough consumers living far from the bank do not purchase its services.[12] Similarly when the price of the banking services is high enough, the poor do not purchase these services even if they are close to the bank. In what follow we characterize more precisely what "high enough" means.

To do so we start by computing the demand for the bank services as it appears in figure 2. The demand is given by the triangle in the left high side corner: $D^m_{_B}(p_{_B}) =$

[12]For instance if $t > v_{_B}\overline{\theta}$, even if the banking services are free, those leaving far from the bank will not purchase its services because of the transportation cost.

Figure 2: Monopoly bank market share



$\frac{1}{2}\left(\overline{\theta}-\frac{p_B}{v_B}\right)\left(\frac{\overline{\theta}v_B-p_B}{t}\right)$. Rearranging this expression yields:

$$D_B^m(p_B)=\frac{\left(\overline{\theta}v_B-p_B\right)^2}{2tv_B} \tag{7}$$

The bank B maximizes:

$$\max_{p_B}\ \Pi(p_B)=D_B^m(p_B)\left(p_B-c_B\right) \tag{8}$$

Substituting $D_B^m(p_B)$ by its expression from (7), it is easy to check that the bank profit function $\Pi(p_B)$ is strictly concave in p_B. The first order condition (FOC) is therefore sufficient. Optimizing (8) with respect to p_B, the optimal price for the incumbent bank B in the absence of competition is:

$$p_B^m=\frac{\overline{\theta}v_B+2c_B}{3} \tag{9}$$

This price is the equilibrium price corresponding to the bank B demand (i.e., the market share measured by the triangle) shown in Figure 2 if and only if:

Assumption 1 *(only the rich and urban purchase monopoly banking services)*

(i) $\underline{\theta} \leq \overline{\theta} - \underline{\theta} = 1$

(ii) $\frac{2}{3}(\overline{\theta} v_B - c_B) < t$.

We show in appendix 7.3 that condition (i) implies that the monopoly does not serve the consumers with the lowest valuation for the service, $\underline{\theta}$, even if they are geographically very close to the bank. Condition (ii) implies that it does not serve consumers that are far away, even if they value the service highly.

With a Gini index of 40, Kenya is an unequal country and due to poor road infrastructure in rural areas, transportation costs are quite high (see section 2), so condition (21) is warranted. It explains that in 2006, before mobile banking was introduced, less than 15% of the population had an account in a prudentially regulated bank. As illustrated in Figure 12, a large fraction of the population was still unbanked.

To sum up, the incumbent bank's network coverage is determined by its location on the Hotelling line, in addition to the price of its services. High transportation costs and poverty explain why the monopoly bank initially serves only part of the population. Under assumption 1 the monopolistic bank's market share is measured by the right-angled triangle marked "Bank" in Figure 12:

$$x_B^m = \frac{2}{9} \frac{\left(\overline{\theta} v_B - c_B\right)^2}{t v_B} \in (0, 1) \tag{10}$$

Consumers can only access the high quality financial service if the banking network is near to where they live and if they are wealthy enough to pay for it. As a result, without entry, a large fraction of the consumers in the country remain unbanked.

4.2 Entry of the Mobile Network Operator

We assume that upon entry of the MNO the market is covered (i.e., $\underline{\theta}$ is sufficiently large so that in equilibrium $\underline{\theta}v_{_E} - p_E > 0$).[13] The marginal consumers are now those who are indifferent between buying the financial service from the incumbent bank or from the entrant mobile network operator. A consumer with characteristic (θ, δ) is indifferent between the incumbent bank and the entrant if $\theta v_B - p_B - \delta t = \theta v_E - p_E$. Let

$$\Delta p = p_B - p_E. \tag{11}$$

We deduce that the threshold value of the indifferent consumers upon entry of the MNO in the duopoly setting is defined by the function:

$$\theta^E(\delta) = \frac{\Delta p + \delta t}{\Delta v} \tag{12}$$

Any consumer with characteristic (θ, δ) so that $\theta\Delta v - \Delta p \geq \delta t$, will buy from the incumbent bank B. We deduce that the demand for the incumbent bank in the duopolistic competition setting is $D_B(p_B, p_E) = \frac{1}{2}\left(\overline{\theta} - \frac{\Delta p}{\Delta v}\right)\left(\frac{\overline{\theta}\Delta v - \Delta p}{t}\right)$, which is equivalent to:

$$D_B(p_B, p_E) = \frac{\left(\overline{\theta}\Delta v - \Delta p\right)^2}{2t\Delta v} \tag{13}$$

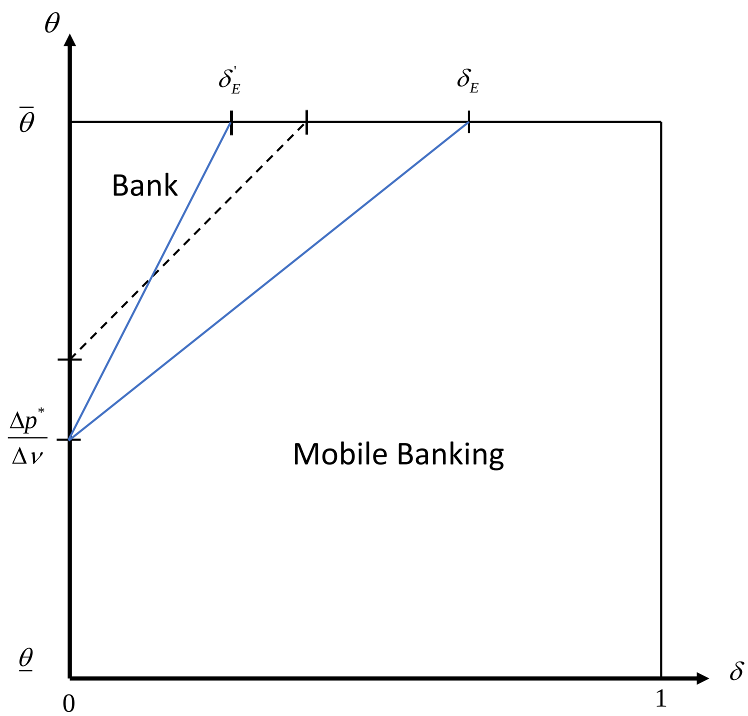
The demand faced by the entrant E is:

$$D_{_E}(p_{_B}, p_{_E}) = 1 - \frac{\left(\overline{\theta}\Delta v - \Delta p\right)^2}{2t\Delta v} \tag{14}$$

[13] This assumption simplifies the computations of the equilibrium prices in the duopoly case. In particular it allows us to obtain closed form solutions. If the market is not covered then $D_E(p_B, p_E) = 1 - \frac{\left(\overline{\theta}\Delta v - \Delta p\right)^2}{2t\Delta v} - \frac{p_E}{v_E}$, where the last term is the proportion of consumers who purchase nothing (i.e., so that $\theta v_{_E} - p_{_E} \leq 0$). This last term makes the computations for the entrant reaction function more tedious (the reaction function of the bank is unchanged). The main economic results are not affected, but the calculations are more complex and the equilibria are only implicitly defined.

There are several cases to consider for the comparison with the monopoly benchmark case. As in section 4.1, the bank may continue to focus on the high-end of the demand and apply high prices so that its market share decreases upon entry. Alternatively, because of competitive pressure from the entrant, the bank may be enticed to price more aggressively and expand as a result its market share. Note that, although mobile banking is available everywhere and its consumers bare no transportation cost, the quality of the service provided by the entrant is lower. Therefore, in the region where both the bank B and the entrant E are present, consumers with high preference for quality will purchase the financial service from the bank, while those with low preference for quality will buy from the entrant. In addition, consumers that are far away from the bank will all purchase from the entrant given their high transportation costs.

Figure 3: Bank and MNO market shares



Figures 3 illustrates the two possible cases of the demand faced in equilibrium by the bank and the entrant. The dash line represents the market share of the formal bank before the entry of the MNO. The solid lines represent the market share after the entry of the MNO, which covers the latent demand. In the first case, materialized by the line $[\frac{\Delta p^*}{\Delta v}, \delta'_E]$, the market share covered by the bank decreases upon entry of the MNO, compared to the monopoly situation. In the second case, materialized by the line $[\frac{\Delta p^*}{\Delta v}, \delta_E]$, the bank market share increases upon entry.

In what follow we compute the different possible equilibria and study under which conditions each cases might prevail. It turns out that expansion of the formal banking sector is more likely than contraction when transport costs and the quality gap between incumbent and entrant services are high.

Firms' profit functions

First, lets consider the situation of the bank B. Its profit upon entry writes:

$$\Pi_B(p_B, p_E) = \frac{\left(\overline{\theta}\Delta v - \Delta p\right)^2}{2t\Delta v}(p_B - c_B) \tag{15}$$

where $\Delta p = p_B - p_E$. It is easy to check that this function is strictly concave in p_B. The FOC, which is sufficient, yields the reaction function of the bank:

$$p_B(p_E) = \frac{\overline{\theta}\Delta v + 2c_B + p_E}{3} \tag{16}$$

Second we compute the reaction function of the MNO entrant E. The profit function of the entrant, under the condition that it covers the latent demand, maximizes:

$$\Pi_E(p_B, p_E) = \left(1 - \frac{\left(\overline{\theta}\Delta v - \Delta p\right)^2}{2t\Delta v}\right)(p_E - c_E) \tag{17}$$

This function is strictly concave in p_E. The FOC, which is sufficient, yields after some computations the reaction function of the entrant (see appendix 7.4 for a proof):

$$p_E(p_B) = \frac{c_E - 2\left(\overline{\theta}\Delta v - p_B\right) + \sqrt{\left(\overline{\theta}\Delta v - p_B + c_E\right)^2 + 6\Delta v t}}{3} \tag{18}$$

As one can see by the two reaction functions (16) and (18), the prices are strategic complements. That is, an increase in p_E leads to an increase in p_B and vice versa. Moreover, the entrant's price increases if the transport cost increases as high transportation costs reduce traditional bank coverage, and decreases with the quality difference offered by the bank relative to the entrant's service (i.e., the larger the quality differential the lower the entrant's price is). Conversely, for the bank, the larger the quality differential, the higher the price it can charge for its services. Substituting p_B by $p_B(p_E)$ from (16) in equation (18) yields a second degree equation in p_E. We show in the appendix 7.4 that only one root of this equation is the solution to our problem.

Given that, in practice, traditional banks and mobile network operators are simultaneously active in the banking sector in Kenya, we are focusing on interior solutions.

Assumption 2 $\frac{2\left(\overline{\theta}\Delta v - \Delta c\right)^2}{9\Delta v} < t < \overline{\theta}\left(\overline{\theta}\Delta v + \Delta c\right).$

Assumption 2 garantees that (i) t is large enough that the MNO E has a positive market share (LHS of the inequality), and (ii) wealthy consumers value quality enough so that the bank B market share is strictly positive (RHS of the inequality).

The next proposition collect our results on equilibrium prices.

Proposition 1 ***(Equilibrium prices upon entry)***

Let assumption 2 holds. The prices of the bank and of the entrant are:

$$p_B^* = c_B + \frac{\sqrt{\left(\overline{\theta}\Delta v - \Delta c\right)^2 + 8\Delta v t} + \left(\overline{\theta}\Delta v - \Delta c\right)}{8} \tag{19}$$

$$p_E^* = c_E + \frac{3\sqrt{\left(\overline{\theta}\Delta v - \Delta c\right)^2 + 8\Delta v t} - 5\left(\overline{\theta}\Delta v - \Delta c\right)}{8} \tag{20}$$

Proof: See appendix 7.4 □

As can be seen from the equations (19) and (20) these prices increase with the transport cost t, as it reduces the competitive pressure between the two firms. The price of the traditional bank increases with $\overline{\theta}\Delta v - \Delta c$, the net surplus differential created by it service compared to the entrant basic service for the wealthiest consumers. The price of the entrant on the contrary decreases with this net surplus differential.

4.2.1 Comparing bank coverage before and after entry

Depending on the transportation cost t and the difference in quality valuation offered by the bank versus the entrant, Δv, the bank will choose to cut its price and expand its market share or, on the contrary, will keep its high margin and focus on the high end customers, as illustrated in Figure 3. Comparing its market shares before the MNO entry and after we are able to establish the following proposition.

Proposition 2 *Under assumption 2, the Bank increases its market share upon entry of the MNO if and only if:*

$$\frac{\overline{\theta}\Delta v - \Delta c}{\sqrt{\Delta v}} \geq \frac{\overline{\theta} v_B - c_B}{\sqrt{v_B}} \tag{21}$$

Proof: See appendix 7.5 □

When assumption 2 holds, so that both B and E are active in equilibrium, the bank increases its market share upon the entry of the MNO if condition (21) holds. We show in appendix 7.6 that this will typically be the case when $\frac{v_B}{v_E} > \frac{c_B}{c_E}$ and when v_B and Δv are not very different. In other words, when the quality of service offered by the new entrant is low, so that the difference in the quality of financial services provided by the bank and the MNO is significant, as was typically the case in Kenya before 2011 with a rudimentary mobile money account compared to an ordinary bank account offering a standard range of financial services, the bank increases its market share when the MNO enters. The competitive pressure pushes the traditional banking sector to react aggressively by cutting prices and expanding its coverage. We want to bring this prediction to the data.

4.3 Fostering competition through interoperability

In this section, we explore the consequences of interoperability first between MNOs and then between the prudentially regulated bank and MNOs. The latter case corresponds to the evolution of legislation in Kenya which, after 2011, allowed prudentially-regulated banks to implement agent-based banking services, on the same model as mobile banking agents. Moreover, as an attempt to increase competition in the mobile payments market, the Kenyan Competition Authority put an end to agent exclusivity clauses in 2014. That is, this new provision allowed mobile money agents to serve more than one Mobile Financial Service provider (Mazer and Rowan, 2016). However, the Competition Authority did not rule on interoperability *per se*, given that they view this regulatory issue as being part of the realm of the Central Bank of Kenya (CBK) and the Communications Authority (Ochieng, 2014). Nevertheless, the roll out of agency banking in 2011 and the end of exclusivity clauses in 2014, can be seen as a move toward interoperability of the network of banking agents.

4.3.1 Full interoperability in the mobile banking segment

Interoperable mobile money platforms would allow telecommunications companies to compete more effectively in delivering improved financial solutions for the poor in Kenya (Bourreau and Valletti, 2015; Heyer and King, 2015).[14] Even if, in practice, the lack of a real API (Application Programming Interface) makes it difficult for the M-Pesa platform to be interoperable, which explains its quasi-monopolistic position in Kenya, it is nevertheless useful to study what would happen if MNO platforms were totally interoperable at zero cost to users. This exercise allows us to assess the gains that could be generated by full interoperability of MNOs.

[14] See World Bank blog on financial inclusion of June 2016 by King and Heyer http://blogs.worldbank.org/allaboutfinance/kenyan-financial-transformation-2000-2015

In the context of our model, this corresponds to a competitive fringe in the MNO segment. That is, instead of enjoying market power and pricing its service at price p_E^* as defined equation (20), now the competition between the MNOs drives mobile banking prices to their marginal cost c_E. It implies that the bank maximizes $\Pi_B(p_B, c_E)$ defined equation (15). Optimizing $\Pi_{_B}(p_{_B}, c_{_E}) = \frac{\left(\overline{\theta}\Delta v - (p_B - c_E)\right)^2}{2t\Delta v}(p_{_B} - c_{_B})$ with respect to $p_{_B}$ yields:

$$p_B^{**} = c_B + \frac{\overline{\theta}\Delta v - \Delta c}{3}. \tag{22}$$

Comparing the price p_B^* defined equation (19) with the price p_B^{**} defined equation (22) we show in appendix 7.7 that under assumption 2, the price of the bank services decrease when interoperability between MNOs increase: $p_B^{**} \leq p_B^*$. By substituting the price p_B^{**} into the demand function, we obtain the market share of the bank under pressure from a competitive fringe of MNOs:

$$x_B^{**} = \frac{2}{9}\frac{\left(\overline{\theta}\Delta v - \Delta c\right)^2}{t\Delta v}. \tag{23}$$

Comparing equations (10) and (23), it is straightforward to check that the market share of the incumbent bank decreases compared to the monopoly situation, while its price decreases: $p_B^{**} = p_B^m - \frac{\overline{\theta}v_E - c_E}{3} < p_B^m$ defined in (9). Despite its reduction in price, the traditional banking sector's market share is shrinking due to fierce competition from MNOs. Since all the prices are lower, consumers surplus increases as a result of full interoperability of MNOs mobile banking platforms. It increases first because the price of MNOs' service goes down, and second because the prudentially regulated banking sector reacts by lowering its price further.

4.3.2 Interoperability in the traditional banking segment: setting $t = 0$

After 2011, banks subject to prudential regulation were allowed to implement agent-based banking services, on the same model as mobile banking agents. This development broke the tyranny of distance for traditional banks. It corresponds in the context of our model to a drop in t the transportation cost that bank's customers had to incur to access the service. We therefore compute the demand and profit for the monopoly bank in the absence of transportation cost with and without the competition of MNOs.

Bank in a monopoly position when $t = 0$: When there is no transportation cost, the distance to the bank is irrelevant (δ does not influence demand). The bank's marginal customer, $\tilde{\theta}$, is indifferent to whether or not he buys the bank's service: $\tilde{\theta} v_B - p_B = 0$. We deduce that when $t = 0$, demand of the bank's service is $D_{B0}(v_B, p_B) = \left(\bar{\theta} - \frac{p_B}{v_B}\right) \times 1$ if $\frac{p_B}{v_B} \in [\underline{\theta}, \bar{\theta}]$. The bank maximizes with respect to p_B: $\Pi_{B0}(v_B, p_B) = \left(\bar{\theta} - \frac{p_B}{v_B}\right)(p_B - c_B)$, which yields $p_{B0} = \frac{c_B + \bar{\theta} v_B}{2}$. It is easy to check that under condition (i) of assumption 1, $\frac{p_{B0}}{v_B} \in [\underline{\theta}, \bar{\theta}]$. The percentage of the population that is covered by the monopolist bank is $D_{B0} = \frac{\bar{\theta} v_B - c_B}{2 v_B}$.

Entry of the MNO when $t = 0$: If the consumers have the choice between the service of the MNO (v_E, p_E) and the service of the bank (v_B, p_B), the marginal consumer is defined equation (12) for $t = 0$: $\theta^E(0) = \frac{\Delta p}{\Delta v}$. Assuming that $\frac{\Delta p}{\Delta v} \in [\underline{\theta}, \bar{\theta}]$, the demand of the bank is then $D_{B0}(p_B, p_E) = \bar{\theta} - \frac{\Delta p}{\Delta v}$, while the demand faced by the MNO is $D_{E0}(p_B, p_E) = 1 - \bar{\theta} + \frac{\Delta p}{\Delta v}$. The bank maximizes $\Pi_{B0}(p_B, p_E) = \left(\bar{\theta} - \frac{\Delta p}{\Delta v}\right)(p_B - c_B)$, which yields the reaction function $p_{B0}(p_E) = \frac{c_B + p_E + \bar{\theta} \Delta v}{2}$. We distinguish two cases.

First, if, as in section 4.2, the MNO has market power it will choose its price p_{E0} so as to maximize its monopolist profit. This situation corresponds to the equilibrium in Kenya where Safaricom is de facto in a monopoly position (see Figure 14). We show in appendix 7.8 the following result.

Proposition 3 ***(Equilibrium prices upon entry of monopolist MNO when $t = 0$)***
When $t = 0$ the prices of the bank and of the entrant are:

$$p_{B0} = c_B + \frac{(\bar{\theta} + 1)\Delta v - \Delta c}{3} \tag{24}$$

$$p_{E0} = c_E + \frac{(2 - \bar{\theta})\Delta v + \Delta c}{3} \tag{25}$$

Proof: See appendix 7.8. □

Substituting this equilibrium price in $D_{B0}(p_B, p_E) = \bar{\theta} - \frac{\Delta p}{\Delta v}$, the market share of the bank is $x_{B0} = \frac{(\bar{\theta}+1)\Delta v + \Delta c}{3\Delta v}$, while the MNO market share is $x_{E0} = 1 - x_{B0} = \frac{(2-\bar{\theta})\Delta v - \Delta c}{3\Delta v}$.

Second we study the case of perfect competition between the MNOs (e.g. due to full interoperability) so that $p_{E0} = c_E$. It implies that $p_{B0} = c_B + \frac{\bar{\theta}\Delta v - \Delta c}{2} > c_B$ since we assume that $\bar{\theta}\Delta v - \Delta c > 0$. Comparing the price p_{B0} with the price p_B^{**} defined in (22) it is easy to see that $p_B^{**} < p_{B0}$. This result may seem surprising since, with $t = 0$, competitive pressure should be stronger. However, the bank faces the same competition from MNOs in both cases. The difference is that, with zero transport costs, it can reach distant customers and raise the price of its services without losing too many of them. In other words, access to the same distribution network as MNOs enables the bank to charge higher prices as it has the effect of expanding its market share. It loses some of its close customers, but gains many distant ones.

5 Empirical illustration in the Kenyan case

The aim of this section is to assess the relevance of the theory by studying in the Kenyan context the competitive effect that the entry of MNOs mobile money has been exerting on traditional banks. We distinguish two periods: before the change in legislation that allowed traditional banks to compete with MNOs with a network of local agents (that is before 2011), which corresponds to section 4.2, and after the change in regulation, which correspond to section 4.3. To assess the effect of the entrance of Mobile Banking in 2007 on traditional banks' coverage decisions we rely on geographically referenced (GPS) data of banking infrastructure (i.e. number of prudentially regulated bank branches and agents, as well as mobile banking agents) per sub-locality, made available by the FSD Kenya in their supply side survey.

In addition, mobile GSM cellular coverage per sub-locality in Kenya is used as an instrument. Our identification strategy for measuring the impact of MNO competition on prudentially regulated banks takes advantage of the fact that cellular coverage that predates the introduction of mobile money can only influence bank branching decision through the deployment of mobile money agents and no other channels. Indeed, for mobile banking services to exist, there must first be a mobile network (i.e., the mobile voice network must pre-exist). We document that before 2007 (i.e., before the introduction of mobile banking), such a network roll-out is independent from the deployment of bank branches. Before 2011, traditional banks had to have, among other things, a fixed line to be authorized to operate a new branch. Using the mobile network as an instrument for mobile agents network, we are able to assess how traditional banks reacted to the competition of MNO. The antenna that pre-existed the introduction of mobile banking in 2007 have only an indirect impact on bank branches, through the competitive pressure exerted by mobile banking agents.

5.1 Supply Side Data: Financial Infrastructure in Kenya years 2000-2016

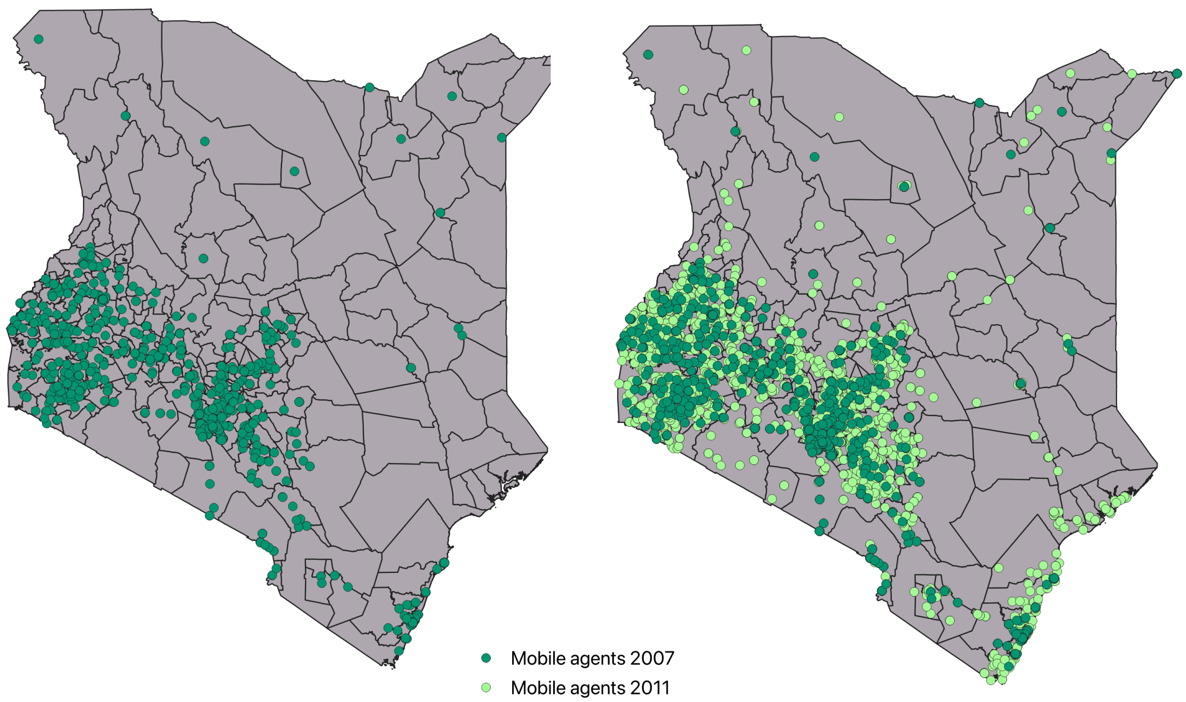
To examine the competitive effect of the entry of M-Pesa in Kenya, with respect to traditional banks' coverage decisions, we used data provided by the FSD Kenya, namely the "2016 FinAccess geospatial mapping dataset."[15] This dataset has the coordinates of financial institutions in Kenya, and in addition, it provides the date when each branch or agency was established. This information allowed us to recover the existing infrastructure of financial institutions in a retrospective way. Thus, we were able to trace back and map the formal prudential banking infrastructure as well as the location of mobile banking agents in Kenya for the period 2000 to 2016.

Using the Geographic Information System (GIS) software "QGIS" we were able to map the location of these mobile banking agents, ATMs, bank branches and bank agents. As an example of the prudential bank coverage in Kenya, the two maps below compare the mobile

[15] See https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/SG589T

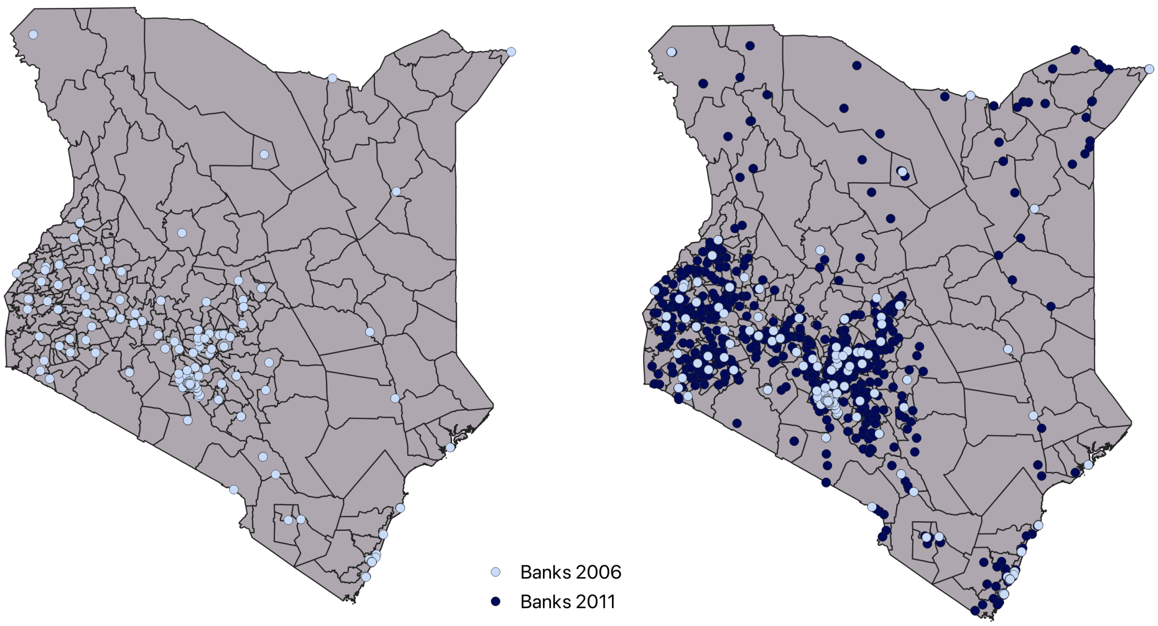
banking agents coverage in 2007 and 2011, and the banking coverage in 2006 and 2011.

Figure 4: Mobile Banking Agents, comparison 2007 vs. 2011



Source: Own elaboration using Data on Financial Providers FSD Kenya 2016

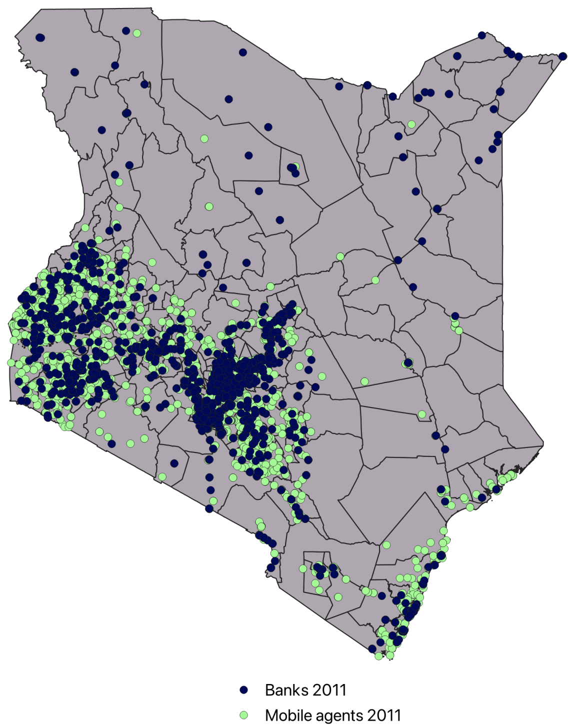
Figure 5: Prudential bank coverage branches, comparison 2006 vs. 2011



Source: Own elaboration using Data on Financial Providers FSD Kenya 2016

In addition, by transposing a map of sub-localities in Kenya, and performing an algorithm called "spatial join", we were able to find out the features that intersect in these two map layers. This allowed us to calculate the amount of banks and mobile banking agents per year, and per sub-locality in Kenya. As an example, the map in figure 6 portrays the number of banks branches and the number of mobile banking agents per sub-locality in Kenya for the year 2011.

Figure 6: Prudential bank coverage branches and mobile banking agents in Kenya, 2011

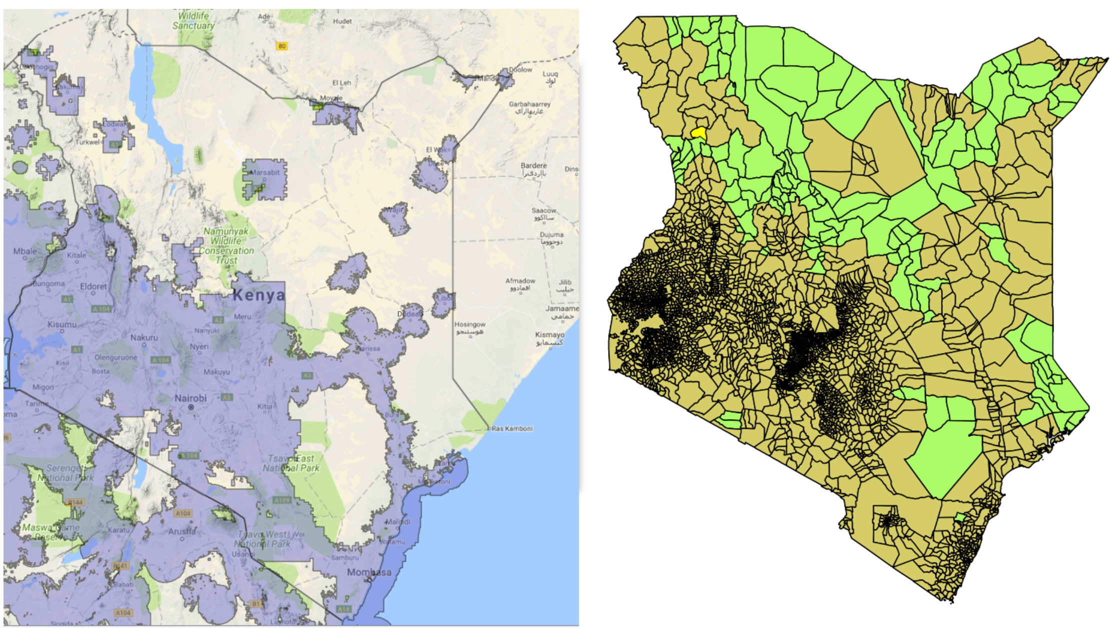


Source:
Own elaboration using Data on Financial Providers FSD Kenya 2016

Finally, as an instrument that is correlated to determinants of mobile money agents expansion, we used cellular coverage per-sub-locality in Kenya. We purchased a historical dataset of Global GSM mobile coverage for the available years called the "Collins Bartholomew network coverage." The historical coverage dataset covers the years 2000-2015, (excluding 2010 which was a year where no coverage maps are available). This company, Collins Bartholomew, is in charge of mapping the coverage of mobile cell tower data provided by mobile operators worldwide to the GSM Association (known as GSMA). The data does not disclose the exact location of the mobile towers which is considered business-sensitive information, but instead, the coverage polygons of the different mobile operators. In this sense, it makes it easier for us, as it already provides the exact coverage taking into account ruggedness of the territory. As an example of the coverage data, the map below shows the number of mobile banking agents for the year 2011 and the GSM cellular coverage per sub-locality in Kenya.

The historical GSM Mobile coverage dataset is global, so, once again, to find out the coverage of cellular towers per sub-locality in Kenya, we intersected the map layer of sub-localities with the global coverage data through an algorithm intersecting both layers. An example of what this intersection looks like for the year 2011 can be found below. This procedure was done for all the years we had data on banking infrastructure and mobile coverage data (i.e. 2000-2009, and 2011-2015).

Figure 7: Mobile GSM coverage (left) and intersection of cellular coverage with Kenyan sub-localities (right), year 2011



Source: Own elaboration using Data on Financial Providers FSD Kenya 2016, and world mobile coverage data by GSMA

5.2 Econometric specification

Fixed Effects. Looking at supply-side data on banking infrastructure, we focus on the competition effect of mobile banking deployment on bank branches opening by sub-locality. In this preliminary results we do not instrument MNOs and therefore cover the period 2000-2016. The variable "banks" in our regressions includes both bank branches and bank agents.

Before 2011 it reflects only branches, and after that agents and banks. Exploiting the panel dimension of our data set, we first conduct the following Fixed-Effects regression by sub-locality j including time fixed effects:

$$Bank_{j,t} = \alpha_j + \gamma_t + \beta_1(MobileAgent_{j,t}) + \epsilon_{j,t}. \tag{26}$$

Table 1: Number of banks per sub-locality (FE regression 2000-2016)

	Regression Coefficients		
	Reg (1)	Reg (2)	Reg (3)
Number of mobile agents	0.160***	0.159***	0.160***
	(0.000)	(0.000)	(0.000)
Intercept	0.114***	0.084***	0.083**
	(0.009)	(0.030)	(0.040)
Time FE (dummies)	No	Yes	Yes
Sub-locality FE	Yes	Yes	No
Random Effects	No	No	Yes
N	40205	40205	40205
R-squared	0.873	0.874	0.874

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

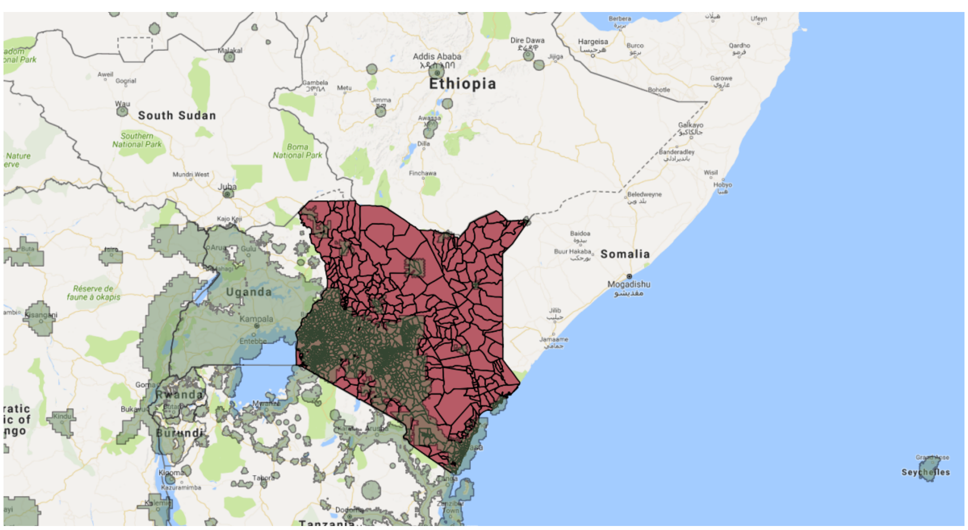
The results in Table 1 for the different econometric specifications (i.e. regressions (1)-(3)), show a stable regression coefficient of around 0.16 for the number of mobile agents per sub-locality significant at the 1% level. The interpretation is that for each additional mobile agent in Kenyan sub-localities, increases on average by 0.16 the number of bank branches in that sub-locality. In other words, for each 6 new mobile agents in that sub-locality, one bank branch on average opens.

Similar regressions controlling for demand-side factors are displayed in Appendix 8.2. We used demand-side information of FinAccess Household surveys (2006, 2009 and 2013) aggregated at a sub-locality level to control for demand side covariates. The coefficient for the number of mobile agents per sub-locality in this set of regressions is still significant at the 1% level. The coefficient is a bit lower at around 0.13, which suggests that for each 8 new mobile agents in that sub-locality, one bank branch on average opens.

5.3 Instrumenting Mobile Agents by GSM Mobile Network Coverage

There may be endogeneity arising from the fact that the coverage decisions by banks (i.e., number of branches) may be driven by unobserved factors that would also influence the number of mobile agents per sub-locality. Therefore, we instrument the number of mobile agents per sub-locality by the mobile network coverage. A priori, mobile network coverage is exogenous to these unobserved factors. The decision to deploy mobile towers is arguably a technological decision (depending on amount of spectrum), geographical decision (depending on the ruggedness of the terrain), and primarily depends on the pre-existing, latent demand for mobile communication services. Thus, the claim is that GSM mobile network coverage impacts directly the amount of mobile banking agents per sub-locality, and influences the amount of bank branched only through this variable (and is exogenous to other unobserved factors in our regression). Figure 8 shows the GSM Coverage in Kenya in 2007.

Figure 8: GSM Coverage in Kenya in 2007

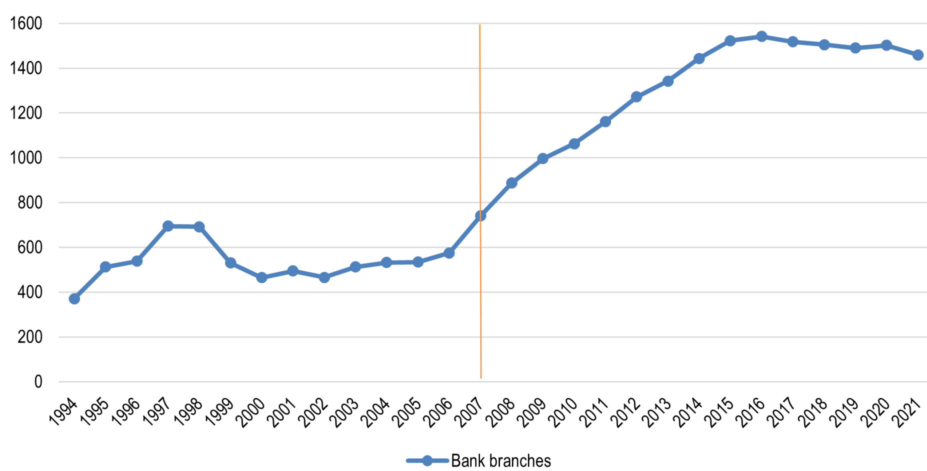


Source: Own elaboration using Data on GSM World Mobile coverage, data collected by Collins Bartholomew for the GSMA

To validate the instrument, we need to check the exogeneity restriction, or orthogonality of the instrument with unobserved characteristics of the number of banking branches. That is, mobile 2G coverage should only influence number of banking branches in a sub-locality through its effect on the number of mobile agents. It is reasonable to assume that where mobile towers are placed has little to do with banking agencies prior to 2007 for two reasons. First, since mobile banking did not exist prior to 2007, these two markets were unrelated so it would be far-fetched to believe that mobile operators, when deciding where to place a mobile tower, would think about banking infrastructure. Secondly, where towers are placed obeys the topographical characteristics of the country, and where mobile operators are allowed to place sites, depends on permits and negotiations with the local authorities.

Bank branches time series: To confirm that before the introduction of mobile banking in 2007 the mobile network deployment had no discernible effect on bank branches creation we look at the aggregate time series of the number of bank branches per year. Figure 9 shows the growth of the number of commercial bank branches based on data of the Central Bank of Kenya for the period 1994-2021. Our sample run from 2000 to 2016.

Figure 9: Number of commercial bank branches 1994-2021



Source: Own elaboration using CBK Bank Supervision and Banking Sector Annual Reports, https://www.centralbank.go.ke/reports/bank-supervision-and-banking-sector-reports/

It seems clear from the figure 9 that over this period there is a structural breaks in the year 2007, which coincides with the year M-Pesa entered the market. To confirm this visual result and test for the existence of structural break in the time series in 2007, we perform in table 2 a simple time series regression of the number of bank branches as a function of the number of lagged bank branches. Table 3 shows that the null hypothesis of no structural break is rejected: there is a break in the year 2007.

Table 2: Estimation results: Bank branches vs. lagged bank branches (t-1)

Variable	**Coefficient** (SE)
L.bankbranches	1.037***
	(0.034)
Intercept	23.961
	(38.529)
Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$	

Table 3: Wald test for structural break in 2007

Ho:	**No structural break in 2007**	**p-value**	**Sample years**
Wald	$\chi^2(2) = 24.6081$	0.000	1995-2016
N= 22			

In other words, traditional bank penetration is pretty stable before 2007, and after the entry of M-Pesa, as predicted by the theory, a structural break is observed. Thus, unless there is a large reshuffling occurring among sub-localities that is not observed in the aggregate data, when regressing banking branches with mobile coverage prior to 2007, one expect the coefficient to be close to zero given the very small variation of the dependent variable, as confirmed by the results in the appendix 8.4.

We focus on the period 2000-2011. Prior to 2011 banks had to open official branches, which was quite costly because of the nature of the regulation they are subject to. Among several conditions established in the Prudential Guidelines (which exempt MNOs), bank branches should have alarm system installed in the premises connected to the police and security firm with a closed-circuit surveillance system (CCTV) and a server room (with computers), among other conditions. In addition, for the branch license to be issued by the Central bank, Banks have to complete a form which includes the fixed telephone of the branch (CBK, 2013). That is, bank headquarters and bank branches have more stringent conditions to operate a premise, and in particular, they needed fixed telecommunication network infrastructure (fixed telephone line, DSL connection, or other).

The mobile towers and antennas infrastructure do not depend on the legacy of fixed network infrastructure.[16] Thus, if banks had the requirement of a fixed line or fixed network prior to 2011, this has little to do with where MNOs decided to place their mobile network antennas. Therefore, we instrument the number of mobile banking agents with the coverage of 2G networks per sublocality up until 2011.[17] After 2011, with the rise of agency banking, our instrument is invalid.

Instrumenting the number of mobile agents by mobile network coverage: This section displays panel regressions instrumenting the presence of mobile money agents by the mobile network geographic coverage per locality. Results of the first stage regression of this estimation can be found Table 8 in Appendix 8.3. We conduct both a sub-locality fixed-effect regression, and a random-effects regression, using time dummy variables.

The results of the panel fixed-effects regression, without instrumenting, show that each additional mobile agent in Kenyan sub-localities is associated with a 0.16 increase in the number of bank branches in that sub-locality (at a 1% significance level). In other words,

[16] Although mobile deployment requires fibre backhaul (fibre links that are intercity), the location and number of antennas (i.e. towers or sites) depends on topology and the amount of spectrum that the operator has. In other words, although the core network (i.e. backbone) of both fixed and mobile networks is fibre, the last mile, or the link that goes to the end user, which constitutes 70% of the cost of network deployment, is entirely different. The last mile connection in mobile networks is through spectrum and towers, whereas for fixed networks it requires cable, copper or fibre connected to end user.

[17] The agency banking model initiated in Kenya by the end of 2010, when the CBK issued guidelines allowing banks to offer a broad range of banking services through third parties (CBK, 2010). However, agency banking as a strategy to increase commercial banking coverage really took-off in 2011, which was led by Equity Bank which started its agents' operations in April 2011. Indeed bank agents only started in Kenya in 2011 (after new regulation was passed). This was a result of the lobbying by the banking association to change regulation to allow agency banking.

Table 4: Instrumental Variable (IV) Fixed Effects (FE) regressions: Number of banks per sub-locality

	Period 2000-2011	
	FE (4)	**FE-IV (5)**
Number of mobile agents	0.124***	0.141***
	(0.00)	(0.01)
Time fixed effects	Yes	
Sub-locality fixed effects	Yes	
N	36550	

Notes: Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Columns (4) and (5) represent regressions with fixed effects (FE) only and fixed effects with instrumental variables (FE-IV), respectively.

roughly for each 6 new mobile agents in a sub-locality in Kenya, we find that one average there is one new bank branch. When we use demand side controls for the years where this is possible (i.e., 2006, 2009 and 2013), the coefficient decreases to 0.125. The results are robust to different regression specifications, and different set of controls.

Due to rise of agency banking in 2011, to make use of our instrument we need to restrict the sample to the years 2000-2011. For the period 2000-2011, when instrumenting the presence of mobile money agents by the mobile network geographic coverage per locality we find that this regression coefficient increases to roughly 0.141 (whereas the OLS result for this period is 0.124). That is, for each 7 mobile banking agents in a certain sub-locality, one new bank branch may appear in such sub-locality.

In the appendix 8.4 we run several robustness check. In particular, given that we only have one instrument (i.e. mobile coverage) to instrument for mobile bank agents, the model is just-identified (i.e. no over-identifying restrictions). The Anderson-Rubin (AR) test allows us to test for weak instrument for just-identified models. Since the results of the test displayed in table 11 do not allow us to reject the null, it suggests that the exogeneity conditions are generally satisfied and that our instrument is not weak.

6 Conclusion

Financial inclusion is a cornerstone of development, and the mobile banking revolution in sub-Saharan Africa has the potential to help many countries take a quantum leap forward. Kenya, with the introduction of M-Pesa in 2007, has been seen as the most compelling example of how mobile banking can radically change the financial landscape of a developing country in less than a decade. However, Kenyan success has not often been replicated elsewhere. The paper argues that one of the reasons for the rapid roll-out of banking services in Kenya is the competitive effect that mobile banking has had on the traditional banking sector. The latter's aggressive response has led to a rapid expansion of financial services, to the extent that today the bulk of Kenyans have an account with a prudentially regulated financial institution. Yet the reaction of this sector is usually overlooked by the studies on mobile banking. While previous literature has studied many of M-Pesa's positive impacts on development outcomes, this paper focused on the effects it has had from a supply-side perspective. It developed a theoretical model, combining vertical and horizontal differentiation with asymmetric transportation costs to analyze this issue and, in the case of Kenya, has empirically documented and explored the impact on the coverage decision of prudentially regulated banks (i.e. traditional banks) upon the arrival of mobile banking in 2007.

For the empirical application, we mapped the coordinates of bank branches and mobile banking agents over the years (2000-2016) in Kenya to understand the coverage of both these players per sub-locality and per year. We then used a panel of Kenyan sub-localities to get a sense empirically of the impact of the number of mobile banking agents on the number of bank branches per sub-locality. Due to potential endogeneity concerns, we instrument the number of mobile money agents per sub-locality by mobile network coverage for the period 2000-2011. The OLS results for the period 2000-2016 show that each additional mobile agent in Kenyan sub-localities impacts around 0.16 the number of bank branches per sub-locality (at a 1% significance level). The IV results for the period 2000-2011 show that each additional mobile agent in Kenyan sub-localities impacts around 0.141 the number of bank branches per sub-locality (at a 1% significance level). In other words, roughly for each 7 new mobile agents, we find that a Kenyan sub-locality is likely to have one new bank branch. This result is pretty stable and robust.

A closer look at the factors that have influenced the success of mobile payments in Kenya may also prove useful to other developing countries that are wishing to implement regulation that fosters adoptions of mobile payments (e.g. Pakistan, Myanmar, Mexico, among others). In developed regions of the world, where mobile banking is considered rather a complementary service offered with other traditional banking services, MNOs operating as banks have to comply with banking regulation (e.g. in France MNOs have to ask for national supervision). In developing countries, however, due to the transformative impact of this application, there is uncertainty with regards to regulation. Such uncertainty could slow down adoption. Much of the success in Kenya is due to regulatory decisions that enabled the expansion of financial coverage to previously undeserved population (e.g., not applying prudential regulation to MNOs). In turn, this allowed an innovation in the telecommunication sector (i.e. M-Pesa) to exert sufficient competitive pressure on a previously unrelated market: the prudentially regulated financial market.

In the light of Kenya's experience, one of the questions a regulator may face when deciding how to regulate mobile banking in developing countries is whether to ease regulatory requirements (thereby reducing the cost of entry) in order to increase the coverage of financial services. In doing so, the added benefit of financial inclusion may come with a cost (for example, the additional risk of a bank holding large deposit accounts). The regulator must assess this trade-off and design a contract for the new entrant that internalizes the social costs of its activity. Another question is whether competitive pressure can increase the bank's coverage decision but decrease the quality of the financial service it wishes to provide, "quality" being understood as the prudential rules requiring the bank to set certain security standards. In this sense, competitive pressure can increase coverage, but also reduce the quality of the financial service offered by the bank if new sources of risk are introduced. Since the current model does not endogenize the bank's quality decision, this question is left for future research.

References

Allen, F., Carletti, E., Cull, R., Qian, J. Q., Senbet, L., and Valenzuela, P. (2020). Improving access to banking: Evidence from kenya*. *Review of Finance*, 25(2):403–447.

Banerjee, A. and Duflo, E. (2012). *Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty*. PublicAffairs.

Baye, M. R. and Morgan, J. (2001). Information gatekeepers on the internet and the competitiveness of homogeneous product markets. *American Economic Review*, 91(3):454ÔÇô474.

Bourreau, M. and Valletti, T. (2015). Enabling digital financial inclusion through improvements in competition and interoperability: What works and what doesn't? *Center for Global Development*, CGD Policy Paper 065.

Burgess, R. and Pande, R. (2005). Do rural banks matter? evidence from the indian social banking experiment. *American Economic Review*, 95(3):780–795.

CBK (2010). Guidelines on agent banking–cbk/pg/15.

CBK (2011a). Bank supervision annual report 2011.

CBK (2011b). The national payment system act.

CBK (2013). Prudential guidelines 2013.

CGAP (2014). Is Kenya ready for an MVNO?

Demirguc-Kunt, A., Klapper, L., Singer, D., and Ansar, S. (2022). The global findex database 2021.

Dupas, P., Green, S., Keats, A., and Robinson, J. (2012). Challenges in banking the rural poor: Evidence from kenya's western province. Working Paper 17851, National Bureau of Economic Research.

Eijkman, F., Kendall, J., and Mas, I. (2010). Bridges to cash: The retail end of m-pesa. *Savings and development*, pages 219–252.

Heyer, A. and King, M. e. (2015). *Kenya's Financial Transformation in the 21st Century*. FSD Kenya.

Hotelling, H. (1929). Stability in competition. *The Economic Journal*, 39(153):41–57.

ITU (2024). World telecommunication/ict indicators database.

Jack, W. and Suri, T. (2011). Mobile money: the economics of m-pesa. Technical report, National Bureau of Economic Research.

Jack, W. and Suri, T. (2014). Risk sharing and transactions costs: Evidence from kenya's mobile money revolution. *The American Economic Review*, 104(1):183–223.

Kenya, C. A. (2017). Sector statistics report communications authority kenya, 4q 2017.

King, M. (2012). Is mobile banking breaking the tyranny of distance to bank infrastructure? evidence from kenya. *The Institute for International Integration Studies Discussion Paper Series iiisdp412, IIIS.*

Levine, R. (2005). Finance and growth: Theory and evidence (chapter 12). In Aghion, P. and Durlauf, S. N., editors, *Handbook of Economic Growth*, volume 1, pages 865–934. Elsevier.

Mazer, R. and Rowan, P. (2016). Competition in mobile financial services: Lessons from kenya and tanzania. *The African Journal of Information and Communication*, 2016(17):39–59.

Mbiti, I. and Weil, D. N. (2016). 7. mobile banking: The impact of m- pesa in kenya. In Edwards, S., Johnson, S., and Weil, D. N., editors, *African Successes, Volume III, Modernization and Development*, pages 247–294. University of Chicago Press, Chicago.

Morawczynski, O. and Miscione, G. (2008). Examining trust in mobile banking transactions: The case of m-pesa in kenya. In *Social dimensions of information and communication technology policy*, pages 287–298. Springer.

Mugo, M. (2012). Regulation of banking and payment agents in kenya. *MIT Press*, 6(4).

Munyegera, G. K. and Matsumoto, T. (2016). Mobile money, remittances, and household welfare: Panel evidence from rural uganda. *World Development*, 79:127–137.

Mussa, M. and Rosen, S. (1978). Monopoly and product quality. *Journal of Economic Theory*, 18(2):301–317.

Ochieng, L. (2014). CAK orders Safaricom to open up M-PESA.

Quartz (2017). Kenya is launching the world's first mobile–only government bond.

Rajan, R. G. and Zingales, L. (2001). The influence of the financial revolution on the nature of firms. *American Economic Review*, 91(2):206–211.

Subramaniam, G. (2013). Mobile money: A theoretical study of alternative media of exchange, and an empirical study with respect to m-pesa in kenya. *Available at SSRN 2278679*.

Suri, T. and Jack, W. (2016). The long-run poverty and gender impacts of mobile money. *Science*, 354(6317):1288–1292.

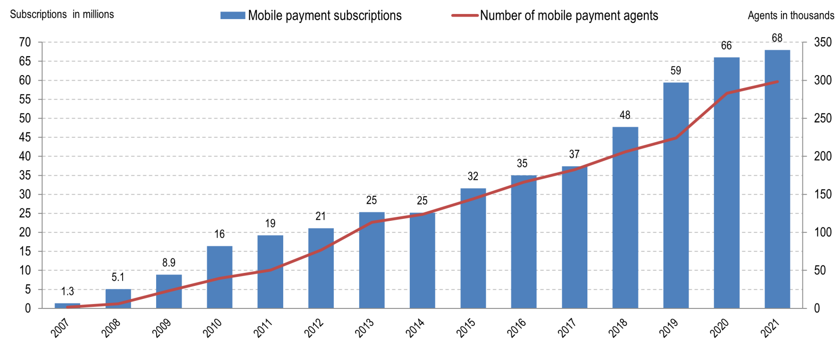
Upadhyaya, R. and Johnson, S. (2015). Transformation of kenya's banking sector, 2000–2012. In Heyer, A. and King, M., editors, *Kenya's Financial Transformation in the 21st Century*, chapter 1, pages 1–61. FSD Kenya, Nairobi, Kenya.

Venkata, N. and Priyank, M. (2013). Success factors of equity bank's agency banking. *MicroSave Briefing Note*, (140).

7 Appendix

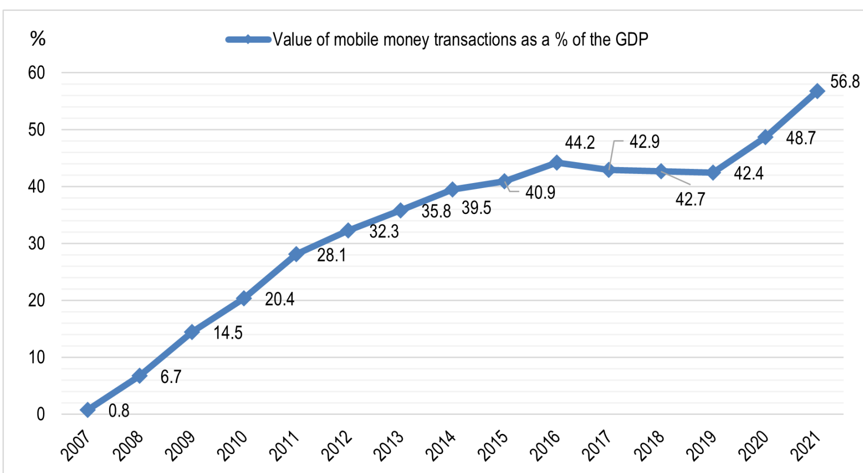
7.1 Kenya is a world leader in mobile money

Figure 10: Mobile money accounts in Kenya and Mobile Agents, 2007-2021



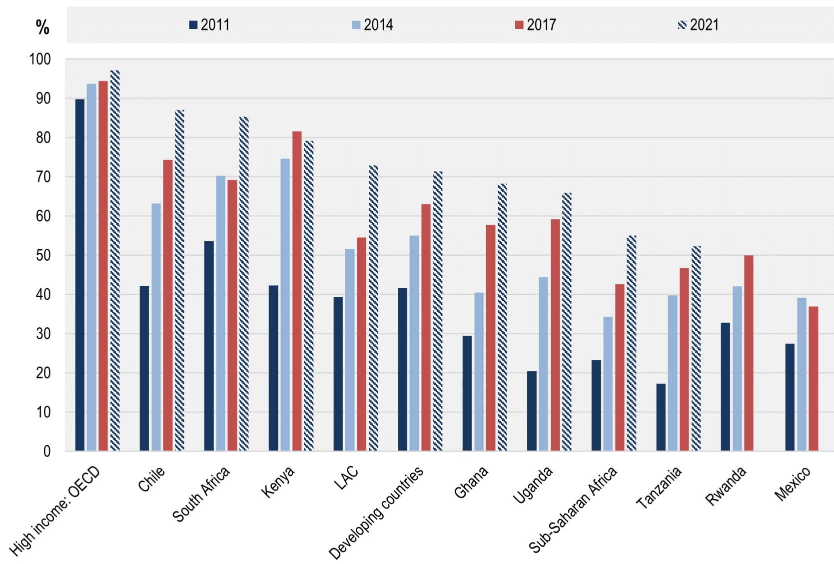
Source: Own elaboration with data from the IMF Financial Access Survey 2021

Figure 11: Value of mobile money transactions as a percentage of the Kenyan GDP, 2007-2021



Source: Own elaboration with data from the IMF Financial Access Survey 2021

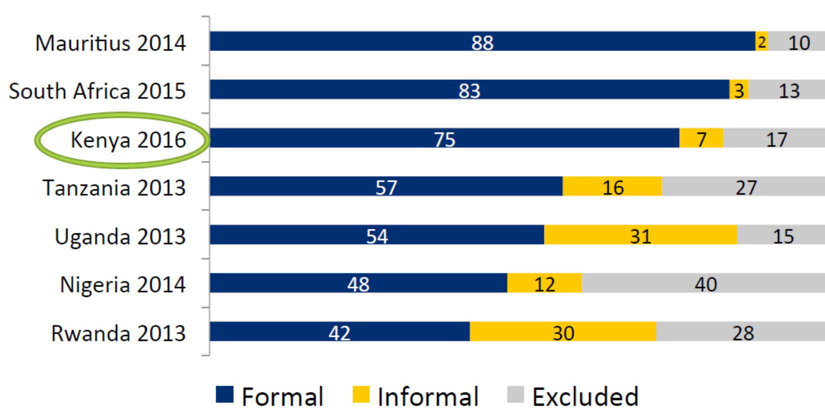
Figure 12: Adults with an account at a financial institution (as a % of total population in 2011, 2014, 2017 and 2021)



Source: Own elaboration with data from the World Bank's Global Findex Report 2021

Note: Denotes the percentage of respondents who report having an account. For 2011, this can be an account at a bank or another type of financial institution, and for 2014 on-wards this can be a mobile account as well.

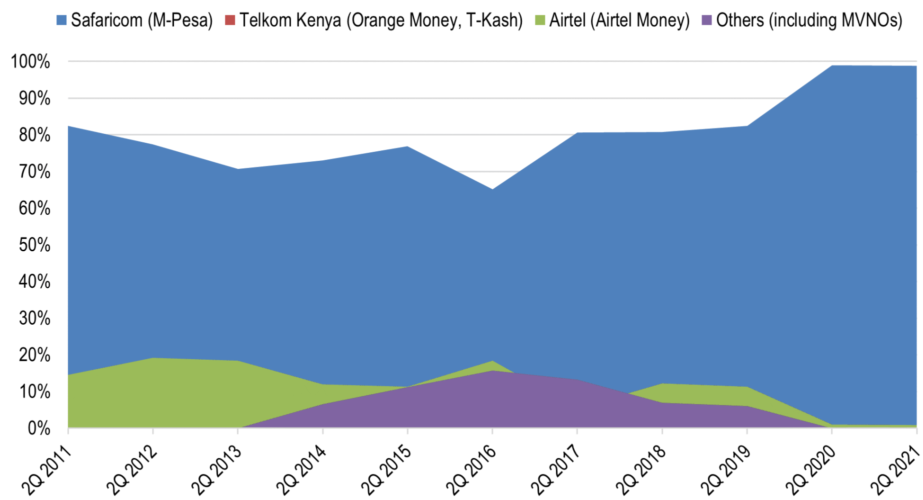
Figure 13: Financial inclusion in the region



Source: FinAccess Report 2016

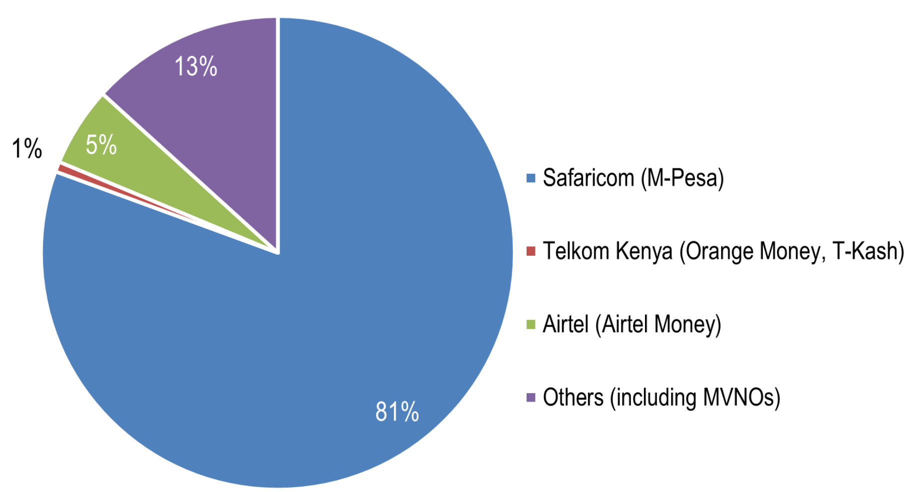
7.2 M-Pesa market share

Figure 14: Evolution of the share of mobile money subscriptions (2011-2021)



Source: Own elaboration with data from the Annual reports of the Communications Authority of Kenya https://www.ca.go.ke/downloads/publications/annual-reports/

Figure 15: Mobile money market shares in terms of subscribers, June 2017



Source: Own elaboration with data from the Annual reports of the Communications Authority of Kenya https://www.ca.go.ke/downloads/publications/annual-reports/

7.3 Deriving Assumption 1

- Condition (i): For low-type consumers to be excluded from the market, the resulting equilibrium price has to be such that $p_B^m > \underline{\theta} v_B$, that is, substituting (9), yields $\frac{\overline{\theta} v_B + 2c_B}{3} > \underline{\theta} v_B$. This is equivalent to $(\underline{\theta} - \Delta\theta) v_B < c_B$, which is true under condition (i) as $\underline{\theta} - \Delta\theta = \underline{\theta} - 1 \leq 0$.
- Condition (ii): For trade to occur it must be the case that $c_B < \overline{\theta} v_B$. For those who live far away, none of them will purchase the service if replacing δ by 1 in (6) and p_B by p_B^m from (9) yields $\tilde{\theta}_{Bm}(1) > \overline{\theta}$. This is equivalent to $\frac{\overline{\theta} v_B + 2c_B}{3} + t > \overline{\theta} v_B$, which yields condition (ii).QED

7.4 Proof of Proposition 1

7.4.1 Reaction function of the entrant

We rewrite (17) as follows:

$$\Pi_E(\Delta p, p_B) = \left(1 - \frac{\left(\overline{\theta}\Delta v - \Delta p\right)^2}{2t\Delta v}\right)(p_B - \Delta p - c_E) \tag{27}$$

We derive (27) with respect to Δp:

$$\frac{\partial \Pi_E}{\partial \Delta p} = -\left(1 - \frac{\left(\overline{\theta}\Delta v - \Delta p\right)^2}{2t\Delta v}\right) + \frac{2\left(\overline{\theta}\Delta v - \Delta p\right)}{2t\Delta v}(p_B - \Delta p - c_E) = 0 \tag{28}$$

Multiplying left and right by $2t\Delta v$ and simplifying yields:

$$3\Delta p^2 - 2\Delta p\Big(2\overline{\theta}\Delta v + p_B - c_E\Big) - 2t\Delta v + (\overline{\theta}\Delta v)^2 + 2\overline{\theta}\Delta v(p_B - c_E) = 0. \tag{29}$$

This second degree equation admits two roots:

$$\Delta p^{\pm} = \frac{2\overline{\theta}\Delta v + p_{B} - c_{E} \pm \sqrt{\left(\overline{\theta}\Delta v - p_{B} + c_{E}\right)^{2} + 6\Delta vt}}{3} \tag{30}$$

We deduce that $p_{E}(p_{B}) = p_{B} - \Delta p$ can possibly takes 2 values: $p_{E}^{+} = p_{B} - \Delta p^{-}$ or $p_{E}^{-} = p_{B} - \Delta p^{+}$. It turns out that, since we focus on equilibrium where both firms are active (i.e., $\overline{\theta}\Delta v > \Delta p$), $p_{E}^{-} - c_{E}$ is negative:

$$p_{E}^{-} = \frac{-2\left(\overline{\theta}\Delta v - p_{B}\right) + c_{E} - \sqrt{\left(\overline{\theta}\Delta v - p_{B} + c_{E}\right)^{2} + 6\Delta vt}}{3}$$

This is equivalent to:

$$p_{E}^{-} - c_{E} = -2\left(\overline{\theta}\Delta v - \Delta p\right) - \sqrt{\left(\overline{\theta}\Delta v - p_{B} + c_{E}\right)^{2} + 6\Delta vt} < 0$$

Only the solution p_{E}^{+} is admissible, which implies that only the root Δp^{-} is solution to our optimization problem. We obtain (18) and

$$\Delta p = \frac{2\overline{\theta}\Delta v + p_{B} - c_{E} - \sqrt{\left(\overline{\theta}\Delta v - p_{B} + c_{E}\right)^{2} + 6\Delta vt}}{3}$$

7.4.2 Finding the equilibrium prices

We next rewrite (18) as

$$\left(3p_{E} - c_{E} + 2\left(\overline{\theta}\Delta v - p_{B}\right)\right)^{2} = \left(\overline{\theta}\Delta v - p_{B} + c_{E}\right)^{2} + 6\Delta vt \tag{31}$$

Substituting (16) into (31) yields after simplification:

$$8(p_{E} - c_{E})^{2} + 10(p_{E} - c_{E})(\overline{\theta}\Delta v - \Delta c) + 2(\overline{\theta}\Delta v - \Delta c)^{2} - 9\Delta vt = 0 \tag{32}$$

This defines a second degree equation in $p_{_E} - c_{_E}$. It admits two roots:

$$(p_{_E} - c_{_E})^{\pm} = \frac{-5(\overline{\theta}\Delta v - \Delta c) \pm 3\sqrt{(\overline{\theta}\Delta v - \Delta c)^2 + 8\Delta v t}}{8} \tag{33}$$

Since $(p_{_E} - c_{_E})^-$ is negative, the only admissible solution is $(p_{_E} - c_{_E})^+$. We still need to check that $(p_{_E} - c_{_E})^+$ is strictly positive. This requires that $3\sqrt{(\overline{\theta}\Delta v - \Delta c)^2 + 8\Delta v t} > 5(\overline{\theta}\Delta v - \Delta c)$, which is equivalent to

$$t > \frac{2(\overline{\theta}\Delta v - \Delta c)^2}{9\Delta v}. \tag{34}$$

We deduce that under condition (34) the optimal price of the entrant is (20). Substituting the price (20) in the bank reaction function (16) yields the optimal price of the bank (19). Finally we need to find the conditions so that $\Delta p^* = p^*_{_B} - p^*_{_E}$ is strictly positive. Substituting $p^*_{_B}$ and $p^*_{_E}$ we find that:

$$\Delta p^* = \frac{3\overline{\theta}\Delta v + \Delta c - \sqrt{\left(\overline{\theta}\Delta v - \Delta c\right)^2 + 8\Delta v t}}{4}. \tag{35}$$

It is easy to check that Δp^* is strictly positive if and only if

$$t < \overline{\theta}\left(\overline{\theta}\Delta v + \Delta c\right). \tag{36}$$

We conclude that if $\frac{2\left(\overline{\theta}\Delta v - \Delta c\right)^2}{9\Delta v} < t < \overline{\theta}\left(\overline{\theta}\Delta v + \Delta c\right)$, which is a non empty set as $\frac{2\left(\overline{\theta}\Delta v - \Delta c\right)^2}{9\Delta v} < \overline{\theta}\left(\overline{\theta}\Delta v + \Delta c\right)$ is always true (i.e., it is equivalent to $3.5\overline{\theta}\Delta v > -\Delta c$), then (19) and (20) are the equilibrium prices. QED

7.5 Proof of Proposition 2

Let $W_B = \overline{\theta} v_B - c_B$ and $W_E = \overline{\theta} v_E - c_E$ so that $\overline{\theta}\Delta v - \Delta c = W_B - W_E$. Under assumption 2 the market is covered and both firms are active.

By virtue of (10) the monopoly bank market share (i.e. before the MNO entry) is

$$x_B^m = \frac{2W_B^2}{9tv_B}. \tag{37}$$

By virtue of equation (13) the bank market share after the MNO entry is:

$$x_B^e = \frac{\left(\overline{\theta}\Delta v - \Delta p^*\right)^2}{2t\Delta v} \tag{38}$$

where $\Delta p^* = p_{_B}^* - p_{_E}^*$. Substituting $p_{_B}^*$ and $p_{_E}^*$ as defined in (19) and (20) and simplifying yields: $\Delta p^* = \Delta c + \frac{3(W_B - W_E) - \sqrt{(W_B - W_E)^2 + 8\Delta vt}}{4}$. Substituting this expression in (38) yields after some simplification:

$$x_B^e = \frac{\left(\overline{\theta}\Delta v - \Delta c + \sqrt{(\overline{\theta}\Delta v - \Delta c)^2 + 8\Delta vt}\right)^2}{32t\Delta v}. \tag{39}$$

Comparing (37) and (39) we deduce that $x_B^m \leq x_B^e$ if and only if:

$$\left(\frac{8}{3}\right)^2 \frac{\Delta v}{v_B} W_B^2 \leq \left(W_B - W_E + \sqrt{(W_B - W_E)^2 + 8\Delta vt}\right)^2 \tag{40}$$

This is equivalent to

$$\frac{8}{3}\sqrt{\frac{\Delta v}{v_B}} W_B \leq W_B - W_E + \sqrt{(W_B - W_E)^2 + 8\Delta vt}. \tag{41}$$

If $\left(\frac{8}{3}\sqrt{\frac{\Delta v}{v_B}} - 1\right) W_B \leq -W_E$, which is equivalent to

$$3\frac{\overline{\theta}\Delta v - \Delta c}{\sqrt{\Delta v}} \geq 8\frac{\overline{\theta}v_{_B} - c_{_B}}{\sqrt{v_B}} \tag{42}$$

then (41) is always true. Now if $\left(\frac{8}{3}\sqrt{\frac{\Delta v}{v_B}} - 1\right) W_B > -W_E$, rearranging and elevating to the square yields:

$$\left(\frac{8}{3}\sqrt{\frac{\Delta v}{v_B}}W_B-(W_B-W_E)\right)^2\leq(W_B-W_E)^2+8\Delta vt. \tag{43}$$

Developing the square and simplifying yields:

$$\frac{8}{9}\frac{\Delta v}{v_B}W_B^2-\frac{2}{3}\sqrt{\frac{\Delta v}{v_B}}W_B(W_B-W_E)\leq\Delta vt. \tag{44}$$

Dividing left and right by Δv yields:

$$\underline{t}=\frac{1}{\Delta v}\left\{\frac{8}{9}\frac{\Delta v}{v_B}W_B^2-\frac{2}{3}\sqrt{\frac{\Delta v}{v_B}}W_B(W_B-W_E)\right\}. \tag{45}$$

We deduce that $x_B^m\leq x_B^e$ if and only if $t\geq\underline{t}$, which is equivalent to:

$$t\geq\frac{2}{9}\frac{(\overline{\theta}v_B-c_B)^2}{v_B}\left(4-3\frac{\overline{\theta}\Delta v-\Delta c}{\sqrt{\Delta v}}\frac{\sqrt{v_B}}{\overline{\theta}v_B-c_B}\right) \tag{46}$$

We next aim to find the necessary and sufficient condition for (46) to hold when assumption 2 holds. Under assumption 2 the transport cost is so that $t>\frac{2\left(\overline{\theta}\Delta v-\Delta c\right)^2}{9\Delta v}$. We deduce that if

$$\frac{2\left(\overline{\theta}\Delta v-\Delta c\right)^2}{9\Delta v}\geq\frac{2}{9}\frac{(\overline{\theta}v_B-c_B)^2}{v_B}\left(4-3\frac{\overline{\theta}\Delta v-\Delta c}{\sqrt{\Delta v}}\frac{\sqrt{v_B}}{\overline{\theta}v_B-c_B}\right) \tag{47}$$

then the Bank always increases its market share upon entry of the MNO. Equation (48) is equivalent to:

$$\left(\frac{\overline{\theta}\Delta v-\Delta c}{\sqrt{\Delta v}}\right)^2\left(\frac{\sqrt{v_B}}{\overline{\theta}v_B-c_B}\right)^2\geq4-3\frac{\overline{\theta}\Delta v-\Delta c}{\sqrt{\Delta v}}\frac{\sqrt{v_B}}{\overline{\theta}v_B-c_B} \tag{48}$$

which can be rewritten as:

$$\left(\frac{\overline{\theta}\Delta v-\Delta c}{\sqrt{\Delta v}}\frac{\sqrt{v_B}}{\overline{\theta}v_B-c_B}\right)\left(\frac{\overline{\theta}\Delta v-\Delta c}{\sqrt{\Delta v}}\frac{\sqrt{v_B}}{\overline{\theta}v_B-c_B}-1\right)\geq4\left(1-\frac{\overline{\theta}\Delta v-\Delta c}{\sqrt{\Delta v}}\frac{\sqrt{v_B}}{\overline{\theta}v_B-c_B}\right) \tag{49}$$

We deduce that a necessary and sufficient condition for equation (49) to be true is

$$\frac{\overline{\theta}\Delta v - \Delta c}{\sqrt{\Delta v}} \frac{\sqrt{v_B}}{\overline{\theta} v_{_B} - c_{_B}} \geq 1 \tag{50}$$

This yields condition (21). QED

7.6 The set of conditions so that Assumption 2 and condition (21) hold is not empty

Condition (50) is equivalent to:

$$\overline{\theta} \leq \frac{\frac{c_B}{\sqrt{v_B}} - \frac{\Delta c}{\sqrt{\Delta v}}}{\sqrt{v_B} - \sqrt{\Delta v}} \tag{51}$$

A necessary condition for condition (51) to hold is that $\frac{c_B}{\sqrt{v_B}} - \frac{\Delta c}{\sqrt{\Delta v}} > 0$, which is always true if $\frac{v_B}{v_E} > \frac{c_B}{c_E}$. It is then easy to check that condition (51) always holds when Δv is large enough. Indeed

$$\lim_{\Delta v \to v_B} \left(\frac{\frac{c_B}{\sqrt{v_B}} - \frac{\Delta c}{\sqrt{\Delta v}}}{\sqrt{v_B} - \sqrt{\Delta v}} \right) \to +\infty.$$

That is if Δv is large (i.e., if v_E is small compared to v_B) then condition (51) holds. We deduce that there are a whole range of the model parameters so that both Assumption 1, Assumption 2 and condition (21) hold. QED

7.7 Proof of $p_B^{**} \leq p_B^*$

Substituting p_B^* defined equation (19) and p_B^{**} defined equation (22) yields:

$$p_B^{**} \leq p_B^* \;\Leftrightarrow\; \frac{\overline{\theta}\Delta v - \Delta c}{3} \leq \frac{\sqrt{\left(\overline{\theta}\Delta v - \Delta c\right)^2 + 8\Delta v t} + \left(\overline{\theta}\Delta v - \Delta c\right)}{8}.$$

Simplifying, this is equivalent to $t \geq \frac{2\left(\bar{\theta}\Delta v - \Delta c\right)^2}{9\Delta v}$, which is true by virtue of assumption 2. QED

7.8 Proof of proposition 3

When the consumers have the choice between the service of the MNO (v_E, p_E) and the service of the bank (v_B, p_B), the marginal consumer is defined equation (12) for $t = 0$: $\tilde{\theta}^0 = \frac{\Delta p}{\Delta v}$. Assuming that $\frac{\Delta p}{\Delta v} \in [\underline{\theta}, \bar{\theta}]$, the demand of the bank is then $D_{B0}(p_B, p_E) = \bar{\theta} - \frac{\Delta p}{\Delta v}$, while the demand faced by the MNO is $D_{E0}(p_B, p_E) = 1 - \bar{\theta} + \frac{\Delta p}{\Delta v}$. The bank maximizes $\Pi_{B0}(p_B, p_E) = \left(\bar{\theta} - \frac{\Delta p}{\Delta v}\right)(p_B - c_B)$, which yields the reaction function $p_{B0}(p_E) = \frac{c_B + p_E + \bar{\theta}\Delta v}{2}$. If, as in section 4.2, the MNO has market power it will choose its price p_{E0} so as to maximize $\Pi_{E0}(p_B, p_E) = \left(1 - \bar{\theta} + \frac{\Delta p}{\Delta v}\right)(p_E - c_E)$. It yields the reaction function $p_{E0}(p_B) = \frac{c_E + p_B + (1-\bar{\theta})\Delta v}{2}$. Solving for the equilibrium we find that: $p_{B0} = c_B + \frac{(\bar{\theta}+1)\Delta v - \Delta c}{3}$ and $p_{E0} = c_E + \frac{(2-\bar{\theta})\Delta v + \Delta c}{3}$. We next compute $\Delta p^0 = p_{B0} - p_{E0}$:

$$\Delta p^0 = \frac{(2\overline{\theta} - 1)\Delta v + \Delta c}{3}. \tag{52}$$

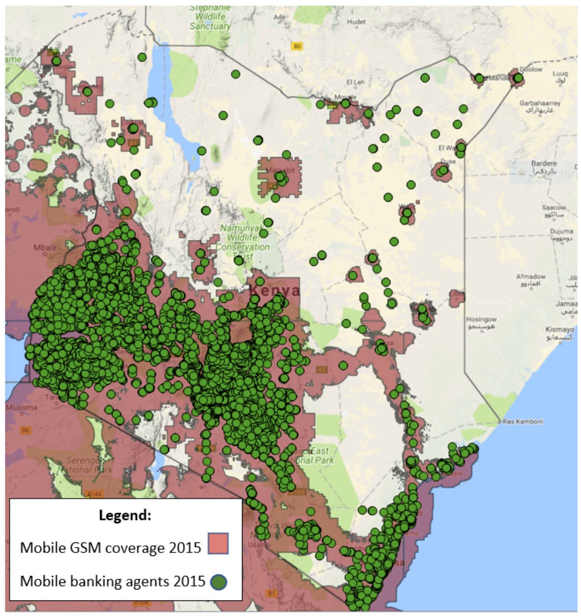
Substituting this equilibrium price in $D_{B0}(p_B, p_E) = \bar{\theta} - \frac{\Delta p}{\Delta v}$, the market share of the bank is $x_{B0} = \frac{(\bar{\theta}+1)\Delta v + \Delta c}{3\Delta v}$, while the MNO market share is $x_{E0} = 1 - x_{B0} = \frac{(2-\bar{\theta})\Delta v - \Delta c}{3\Delta v}$.

QED

8 Supply-side econometric analysis

8.1 GSMA Global Cellular Coverage data

Figure 16: Mobile GSM coverage and Mobile Banking agents in Kenya, year 2015



Source: Own elaboration using Data on Financial Providers FSD Kenya 2016, and world mobile coverage data by GSMA

8.2 Demand side controls of the FinAccess Household Surveys

It is useful to control for demand side factors to improve our preliminary regressions and check their robustness. The Financial Access Partnership (FAP) in Kenya, a partnership by the Financial Sector Deepening organization (FSD) and the Central Bank of Kenya (CBK), was kind enough to share with us four waves of the FinAccess National Household Survey (2006, 2009, 2013, and 2016), which is representative at the national level. These household surveys profile the developments of financial access and usage in Kenya. Several papers have used the FinAccess data for the years 2006 and 2009 (King, 2012; Subramaniam, 2013), and some have used the 2013 wave (Heyer and King, 2015).

The dataset used in this paper comprises three rounds of the FinAccess household survey

Table 5: FE Banks vs Mobile Agent with demand-side covariates, 2006, 2009, and 2013

Variable	**Coefficient**	**(Std. Err.)**
Number of mobile agents	0.126***	(0.002)
lndistbank	-0.241**	(0.128)
mobile	-0.007	(0.387)
asset_index	0.213***	(0.110)
married	-0.171*	(0.388)
education	-0.197***	(0.137)
age	0.005	(0.013)
female	0.059	(0.421)
rural	-0.407	(0.396)
Intercept	1.142	(0.781)
Significance levels: ***: 1%, **: 5%, *: 10%		
N	2414	
R^2	0.886	
$F_{(1732,681)}$	586.122	

which is representative at a national level, and was conducted in 2006, 2009, and 2013. The unit of observation is adults (above 18 years old), and the sampling method in these surveys is stratified clusters, where clusters are selected in three stages: first, clusters are chosen to ensure a national representative sample of provinces and urbanization levels, then households were selected, and, finally, individuals were randomly chosen in each household. The FinAccess 2013 dataset covered 6449 individuals (1140 variables), the 2009 survey 6598 observations (1292 variables), and the 2006 baseline survey had 4418 observations (1179 variables).

We use some of the demand side information of the Finaccess Survey aggregated at a sub-locality level to control for demand side covariates. In the following regression, data for the years 2006, 2009 and 2013 has been used. We conduct the following Fixed Effects regression by sub-locality j:

$$Bank_{j,t} = \alpha_j + \beta_1(MobileAgent_{j,t}) + \eta X_{d,t} + \epsilon_{j,t}$$

The estimation results are presented in table 5. A similar FE-Regression is done using time fixed effects as well as the demand-side covariates in table 6. Both tables confirm that the number of bank branches increases with the number of mobile agents, and the coefficient in

Table 6: FE Banks Vs Mobile Agents with Demand-side covariates and time dummies

Variable	**Coefficient**	**(Std. Err.)**
Number of mobile agents	0.125***	(0.002)
2006b.year	0.000	(0.000)
2009.year	0.261	(0.288)
2013.year	0.498	(0.434)
lndistbank	-0.158	(0.152)
mobile	-0.315	(0.465)
asset_index	0.255*	(0.129)
married	-0.150	(0.390)
education	-0.124	(0.165)
age	0.007	(0.013)
female	0.087	(0.428)
rural	-0.430	(0.398)
Intercept	0.522	(0.942)
Significance levels: ***: 1%, *: 5%, †: 10%		
N	2414	
R^2	0.886	
$F_{(1734,679)}$	479.295	

both cases is relatively stable.

8.3 Instrumenting by Mobile Coverage

First stage regression of IV FE regression, 2000-2011 The table 8 presents the first stage regression results of the IV-FE regression for the period 2000-11.

Table 7: First stage regression of IV (Fixed Effects), 2000-2011

Variable	**Coefficient**	**(Std. Err.)**
Mobile coverage	-1.190**	(0.116)
2000b.year	0.000	(0.000)
2001.year	0.654**	(0.136)
2002.year	0.783**	(0.142)
2003.year	0.828**	(0.145)
2004.year	0.851**	(0.146)
2006.year	1.213**	(0.152)
2007.year	1.463**	(0.153)
2008.year	1.837**	(0.154)
2009.year	2.445**	(0.157)
2011.year	4.706**	(0.157)
Intercept	0.098	(0.085)
Sub-locality FE	Yes	
N	36550	
R^2	0.051	
$F_{(3664,32885)}$	177.171	

Significance levels: ***: 1%, **: 5%, *: 10%

Table 8: First stage regression of IV (Fixed Effects), 2000-2011

Variable	**Coefficient**
Mobile coverage	-1.190**
	(0.116)
Intercept	0.098
	(0.085)
Year FE	Yes
Sub-locality FE	Yes
N	36550
R^2	0.051
$F_{(3664,32885)}$	177.171

Significance levels: ***: 1%, **: 5%, *: 10%

IV-FE Regression with demand side controls In this section we conduct regressions using time dummy variables, demand-side covariates, and instrumenting the presence of mobile money agents by the mobile network geographic coverage per locality for the years 2006, 2009 and 2013.

Table 9: Estimation results: FE with time dummies

Variable	**Coefficient**	**(Std. Err.)**
mobagents	0.154*	(0.084)
lndistbank	-0.329	(0.536)
mobile	-0.220	(0.601)
asset_index	0.138	(0.377)
married	0.051	(0.743)
education	0.093	(0.671)
age	0.005	(0.016)
female	0.175	(0.553)
rural	-0.635	(0.760)
2006b.year	0.000	(0.000)
2009.year	-0.179	(1.345)
2013.year	-1.019*	(4.527)
Intercept	0.868	(1.485)
Significance levels: ***: 1%, **: 5%, *: 10%		
N	2414	
Log-likelihood	.	
$\chi^2_{(1735)}$	1807.282	

IV-RE Regression with demand side controls Random effects estimation may be more useful when instrumenting the presence of mobile agents with Network coverage as this instrument does not exhibit much variation within these years at a sub-locality level.

Table 10: Estimation results: RE with time dummies

Variable	Coefficient	(Std. Err.)
mobagents	0.205***	(0.058)
lndistbank	0.174	(0.421)
mobile	-0.209	(0.391)
asset_index	0.069	(0.152)
married	-0.156	(0.289)
education	0.120	(0.214)
age	0.007	(0.012)
female	0.119	(0.304)
rural	0.811	(0.998)
2006b.year	0.000	(0.000)
2009.year	-0.293	(0.354)
2013.year	-1.272*	(0.655)
Intercept	-1.318	(2.218)
Significance levels: ***: 1%, **: 5%, *: 10%		
N	2414	
Log-likelihood	.	
$\chi^2_{(11)}$	1114.788	

8.4 Robustness

Testing for weak instruments. Given that we only have one instrument (i.e. mobile coverage) to instrument for mobile bank agents, the model is just-identified (i.e. no over-identifying restrictions). The Anderson-Rubin (AR) test allows us to test for weak instrument for just-identified models. The AR test is a joint test of the structural parameter and the exogeneity of the instruments (i.e. $E(Zu) = 0$, where Z are the instruments and u is the error term in the structural equation). The null hypothesis in this test is whether the structural parameter (in our case the parameter of the number of mobile agents per sub-locality) is equal to the parameter of the instrument variable (i.e. mobile coverage).Since the results of the test displayed in table 11 do not allow us to reject the null, it suggests that the exogeneity conditions are generally satisfied and that our instrument is not weak.

Table 11: The Anderson-Rubin (AR) for weak instruments, IV regression for period 2000-2011

Weak instrument robust test for linear IV (Fixed Effects)			
Test	Statistic	p-value	Conf. Interval
AR	Chi2 (1)= 41.12	0.000	95% [.1297209, .1820334]
Wald	Chi2 (1)=148.59	0.000	95% [.128051, .177118]
N= 36550			

Testing the exclusion restriction of our instrument. In just-identified models, there are no over-identifying restrictions, and as such, we cannot test for the validity of the over-identifying restrictions. Therefore, the justification of the validity of the instrument relies on the arguments of justifying the exclusion restriction. We thus ran some additional regressions to confirm the validity of our instrument.

We want to test the exclusion restriction of our instrument, mobile coverage. If the instrument is valid, it should only affect the number of banks per sublocality through its effect on mobile banks/agents after the introduction of mobile agents in Kenya. Therefore, if we run the regression with the number of banks per sublocality as dependent variable and mobile coverage as independent variable (controlling for covariates), we should not expect any effect prior to 2007. However, this regression should yield a significant coefficient for mobile coverage after 2007 (i.e. once mobile agents were introduced in the market). Through the FinAccess Survey data, which is a demand side data, we only have covariates available for the years 2006, 2009, 2013 and 2016. The period that concerns to test the exclusion restriction is prior to 2011, when then instrument would still be valid. Running these two regressions, we find that the instrument behaves as expected between years 2006 and 2009. The table 12 shows that the instrument was not significant prior to 2007, and then, the instrument became significant after the introduction of mobile banking.

Table 12: Testing for exclusion restriction: Number of banks per sub-locality in 2006 and 2009

	2006	2009
Mobile Coverage	-0.717	-1.272**
	(0.447)	(0.589)
Distance to bank (ln)	-0.468***	-0.788***
	(0.095)	(0.097)
Asset Index	-0.004	0.553***
	(0.093)	(0.115)
Married	-0.235	0.309
	(0.348)	(0.320)
Education	0.098	-0.312***
	(0.113)	(0.101)
Age	-0.001	-0.015
	(0.011)	(0.012)
Female	0.377	0.329
	(0.357)	(0.366)
Rural	-0.7***	-1.304***
	(0.277)	(0.317)
Intercept	2.48***	5.075***
	(0.730)	(0.778)
N	546	806
R-Squared	0.149	0.247

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$