Impact of Mobile Phone-Based Money Transfer Services in Agriculture: Evidence from Kenya

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Abstract

This study contributes to pioneering literature on the impact of mobile phone-based money transfer, especially in agriculture. It provides information regarding financial intermediation to the excluded through the use of new generation Information Communication Technology (ICT) tools, especially the mobile phone. The study employs propensity score matching technique to examine the impact of MMT services on household agricultural input use, agricultural commercialization and farm incomes among farm households in Kenya. It uses cross-sectional data collected from 379 multi-stage randomly selected households in three provinces of Kenya. The study found that use of mobile phone-based money transfer services significantly increased level of annual household input use by $42, household agricultural commercialization by 37% and household annual income by $224. We conclude that mobile phone-based money transfer services in rural areas help to resolve a market failure that farmers face; access to financial services. We discuss implications for policy and practice.

Keywords: mobile phones, money transfer, M-PESA, impact, smallholder farmers, Kenya
JEL: Q01, Q16, O30, Q18

1 Introduction

Sending or receiving money for either payment of salaries, settlement of business transactions, payment of school fees, or for family support is a common phenomenon for both businesses and individuals. It requires efficient, reliable and affordable money transfer services whereby money can be deposited in one location and withdrawn in another in both urban and rural areas (KIM et al., 2010, and CONTINI et al., 2011).

Structural weaknesses in the formal financial industry in Kenya, however, limit the access to money transfer services, especially in rural areas and for low-income people (HUGHES and LONIE, 2007). This is because banks are concentrated mainly in urban centers and have conditions that constitute barriers to the use of their services (BILJON and KOTZÉ, 2008). The cost of transfer, usually charged as a percent of the amount sent, is considered expensive for small amounts for both local and international transfers (AU and KAUFFMAN, 2008).

The informal systems of money transfer such as individuals carrying money on themselves or sending drivers and conductors are susceptible to highway robberies and thefts (KIM et al., 2010, and HUGHES and LONIE, 2007). SANDER (2003) also noted that money sent through friends and relatives is sometimes misused and at times never reaches its destination while money sent through letters and parcels of the courier companies may be stolen. Other challenges associated with the formal and semi-formal systems, include delays and long queues, network limitations, insolvency of branches, unreliable communication and misdirected parcels (AU and KAUFFMAN, 2008).

This situation has changed dramatically in the last few years with the introduction of mobile phone-based money transfer (MMT) services. The introduction of prepaid cards of low denominations and the fallen prices of mobile handsets have led to a rapid spread of mobile phones in the developing countries (OROZCO et al., 2003). This has opened up diverse opportunities for it to be used beyond voice communication. At the center of this experience is money transfer. MMT service is an aspect of a broader concept emerging in the electronic payment and banking industry referred to as Mobile banking (OROZCO et al., 2003). Even though MMT has not been well defined in literature it can be said to include all the various activities (long-distance remittance, micro-payments, and informal air-time battering schemes) that bring financial services to the unbanked using mobile technology. JENKINS (2008) simply defined MMT as money that can be accessed and used via mobile phone.

The primary function of MMT services is to reduce the costs of making payments from one individual to another, especially across large distances (WORLD BANK, 2009). Because individuals do not need to withdraw or send balances immediately, they are also able to accumulate savings on their MMT accounts over time. Thus, MMT has become a savings instrument, as well as a means to send money. Sometimes money is stored in an MMT account simply to save a person from carrying too much cash, especially for example on long and potentially dangerous bus trips. With a large network of MMT agents in the rural areas, it can especially make it easy for agricultural households to reduce the time and cash expense in accessing the funds they need to invest in agriculture. The aim of this study is to assess the impact of the recently introduced mobile phone–based money transfer (MMT) services among farm

households in Kenya. Specifically, the objective is to ascertain the impact of using these services on household input use, level of household agricultural commercialization and level of household farm incomes. There is growing interest in mobile money transfer services in Kenya driven by relatively high rural mobile phone penetration rates and the historical exclusion of majority smallholder farmers from formal financial markets.

2 Mobile Phone-Based Money Transfer (MMT) in Kenya

Four companies provide mobile phone services in Kenya. These include Safaricom, Airtel (formally Zain), YU and Orange (formally Telkom Kenya). Safaricom was the first company to provide mobile services and MMT services in Kenya. In partnership with the Commercial Bank of Africa and a micro-finance company, Faulu Kenya, Safaricom designed and tested a micro-payment platform called M-PESA in 2004. 'Pesa' means 'money' in Kiswahili and the prefix 'M' refers to the use of a mobile phone to facilitate banking transactions. M-PESA began by using Safaricom's airtime retailers (agents) to issue microloans that borrowers would repay at an interest rate reduced by eliminating the overhead conventional microloans carried. However, the skilled worker in Kenya soon began using the facility to transfer cash from working relatives in the city to their families in the rural areas (HUGHES and LONIE, 2007). Consequently, M-PESA money transfer service was officially launched in March 2007 as a MMT service. MMT service in Kenya is almost synonymous with M-PESA. Meanwhile, Airtel – the second largest mobile phone company launched its MMT service called Airtel-Money (formally ZAP) in February 2009 while YU mobile phone company introduced its services named and YU-CASH in December 2009. Orange (formally Telcom and Posta) is the fourth and latest entrant to introduce its MMT service called Orange Money in November 2010.

MMT operates in a very easy and simple way. MMT services allow customers to use their phone like a bank account and a debit card. These customers credit their accounts at a local authorized agent and can then transfer the money to another person's phone or use for different transactions such as making loan repayment, paying bills or redeeming it as cash. MMT is still at an early stage of development in Kenya but ahead of the world: it is designed to bring the economic advantages of having a savings and money transfer facility to those with small, irregular or cyclical incomes (PULVER, 2009).

Recent evidence suggests that there is an increase in penetration and use of MMT services in Kenya (MASON, 2007; KIRUI et al., 2010). In early 2011, Safaricom had an M-PESA subscription base of about 16 million and about 17,000 agents (outlets)

countrywide (CENTRAL BANK OF KENYA, 2010). Figures for the other MMT service players were not immediately available. This represents substantially more points of service than the combined number of bank branches (1,063) and Automated Teller Machines (ATMs) (1,979) (CENTRAL BANK OF KENYA, 2010). Statistics from the CENTRAL BANK OF KENYA indicate that Safaricom's M-PESA users moved more than Ksh. 728 Billion (approximately $8 Billion) in 2010 as compared to only Ksh. 50 Million by Orange-money (CENTRAL BANK OF KENYA, 2010). This amount was moved in the more than 306 Million transactions conducted in the service. The report further puts daily movement of cash to more than Ksh 2.3 Billion. Revenue from M-PESA in 2010 stood at Ksh 12 Billion, up from Ksh 8 Billion in 2009 (CENTRAL BANK OF KENYA, 2010). M-PESA remains the most widely used method of mobile money transfer as evidenced by the number and value of transactions effected.

MMT has a clear edge over banks especially because it is fast and cost-effective. For instance, to send KSh. 35,000 ($ 350) within the country using a classic money transfer company such as Western Union would cost KSh. 1,200 ($ 12), but using MMT method, such as M-PESA, to send the same amount would cost only Ksh. 75 ($ 0.75) which is 13 times cheaper (CENTRAL BANK OF KENYA, 2010). Classic money transfer methods requires that one must visit a given post office or bank (which could be a long distance away) to receive the payments. Most banks and post offices are associated with long queues and fixed times of operation hence the opportunity cost of time spent while waiting to obtain the cash and other transaction costs are usually high (MASON, 2007). Successes in Africa (and particularly in Kenya's M-PESA) are being tried out elsewhere in the world. A recent inventory by the social venture credit SMS suggests that that there are at least 23 distinct MMT, operating or pending in 20 countries following the success of MPESA (MAS and MORAWCZYNSKI, 2009). Some, like MTN's Mobile Money, and Zain's Zap operate across multiple countries; others are country-specific. Some of these applications include: a Greenefield deployment in Indonesia launched in 2009 and the SMART Communications' Island Activations Program in the Philippines (PULVER, 2009). The leading Afghan mobile network operator, Roshan, anticipate building an M-PESA-like infrastructure in Afghanistan by end of 2010 (ZYCK, 2011).

3 Study Methods

3.1 Conceptual Framework

The desire to spur progress in smallholder agriculture has historically led to search for new models of agricultural financing that address the constraints faced by farmers. Among these models are interventions that provide agricultural finance to farmers in

groups and attempts to use the Grameen lending model (ZELLER and SHARMA, 2000). Other models link farmers to formal agricultural finance markets through flexible lending systems that allow recovery of loan from sales (such as interlinked credit schemes) (GINÉ, 2009). Other efforts include establishment of credit and microfinance platforms based on collateralized lending (BESLEY, 1998; ZELLER and SHARMA, 2000). Indeed, the emergence of rural micro-finance organizations and Savings and Credit Cooperative Societies (SACCOs) has been based on the premise that small-holder farmers need unique services that are close to them. These models have had limited success due to factors such as high transaction costs of delivering the services to small and widely dispersed farmers, high covariate risks, missing markets for managing weather and market risks and the lack of suitable collateral (POULTON et al., 2006; OKELLO et al., 2010). These factors limit the ability of smallholder farmers to save, borrow as well as access payments. In this paper we specifically focus on the later – access to payments.

Money transfer services in Kenya are provided by a variety of institutions and individuals. At one end of the spectrum are individuals using the very informal and basic systems of transfer such as physical transport of cash themselves and friends and/or relatives and at the other end are the modern commercial banks using state-of-the-art technology of electronic fund transfer systems. Along the spectrum there are a range of services of varying degrees of sophistication, including semi-formal providers.

Generally, commercial banks have been the major players in money transfer business in Kenya, servicing mainly large users and, to a smaller extent, low-income users (WORLD BANK, 2003). Among the commercial bank instruments, telegraphic transfers, cheques, electronic funds transfers and bank drafts are typically used for large value transfers, as they offer the cheapest service for the transfer of large amounts (WRIGHT, 2001). Western Union and MoneyGram, which operate through commercial banks, are used almost exclusively to receive money rather than send it. Despite the network of these formal providers throughout the country, rural areas and client segments such as low-income earners tend to be excluded (UN, 2006). Indeed, the financial exclusion (people without access to any form of financial services stands at 38% of the Kenyan population (FSD, 2009).

The availability of financial services in the rural areas has suffered a setback since the mid-nineties when commercial banks closed down less-profitable branches especially in rural areas. The post offices, with the single largest network of offices and often the only choice for much needed basic financial services, withdrew their telegraphic money transfer service. This left many rural and low-income people with few if any formal service alternatives, especially for domestic money transfers (UN, 2005; WORLD BANK, 2003). Such gaps left by formal providers have typically been bridged

by informal means and services. These include transporting the money oneself or sending it with a friend or through an unlicensed service (RAVALLION et al., 2007).

The frequencies and volumes of money transferred vary depending on seasonal needs. For instance, transfers for school fee payments follow the school term calendar with payments at the beginning of every term. Remittances from family members working in urban areas and abroad for purposes of family support are regular and often small. The costs of transfers also vary depending on the amounts sent, the instruments used and also the destination. Fees range from less than 1% to 35% of the amount being transferred (WORLD BANK, 2006; OWENS, 2007). It is cheaper to transfer large amounts than small amounts for both local and international transfers. For small amounts, the fee as percentage of amount sent can be higher than 35% due to the high minimum fees charged for every transfer while for very large amounts the percentage can be lower than 1% of the value (OWENS, 2007). This often discourages and rations out clients with small payments.

The WORLD BANK (2006) finds that there have been an increasing number of agencies (both public and private) involved in raising the reach and efficiency of financial intermediation targeting the poorest clientele/households. Their task of providing financial services at reasonable costs to poor smallholder farmers has not been easy. The poor economic conditions in rural communities make running of such organizations unprofitable. Consequently, most financial organizations tend to be located in commercial centers where there is enough clientele to make their operations profitable. Such centers, however, tend to be inaccessible to the remotely located smallholder farmers. The lack of access to a broader set of financial options represents a potential constraint to entrepreneurship and the ability to undertake socially and privately profitable investment projects (HAGGBLADE et al., 2007).

Rural financial intermediation is expensive because participants are geographically scattered, financial transactions are small and rural incomes tend to be unstable (LARIVIERE and MARTIN, 1999, and SCHRIEDER, 2000). However, the arrival of MMT service in Africa (Kenya in particular) has significantly altered the status quo. It can, theoretically, resolve the constraints smallholder farmers face in accessing finances by reducing the transaction costs associated with access to financial services. First, it can make money transfer into farming communities easy and instant. Consequently, farmers do not have to incur high time and travel costs to travel to banking facilities. Second, it can include the hitherto excluded farmers into the banking services by reducing the costs of accessing remitted funds or depositing small savings. The latter is especially important because unlike the commercial banks and savings organizations, MMT services attract no ledger fees and minimum balances. At the same time, it attracts a very modest withdrawal fee that is affordable to farmers. By facilitating

cheap and timely transfer of small amounts of money across large distances, MMT can improve the investment in, and allocation of, human capital as well as physical capital. One element of banking not offered by MMT services is lending. It is, however, acknowledged that producers could improve their productivity by reorganizing their resources, not by necessarily borrowing (NYIKAL, 2003).

3.2 Econometric Model: Examining the Impact of an Intervention

The effect of use of MMT is examined by assessing its impact on household share of agricultural sales (i.e., agricultural commercialization), level of input use and agricultural income. The level of household agricultural commercialization in this study is computed as a ratio of the value of sales to the value of total production. Input use and agricultural income were measured as value of purchased inputs and agricultural revenue respectively. The inputs considered in this study included fertilizer, improved seed varieties, pesticides, and hired labor.

The dependent variable in the first case (commercialization index) is bound variable with a range of 0 to 1, therefore a Tobit model can potentially be used to estimate the model relating to level of household commercialization index to a set of right-hand side variables (TOBIN, 1985). However, in the second and the third case, the dependent variables (input use and agricultural income) are continuous, therefore, OLS can potentially be used to estimate the model relating to input use or agricultural income to a set of right-hand side variables (GREENE, 2003). The Tobit or OLS model can be expressed as:

$$(1) \qquad Y_i = X'\beta + \alpha_m P_m + u_i \qquad \text{i, m =1, 2, 3,… n}$$

where, Y_i , the dependent variable, measures the outcome (i.e., commercialization index (Tobit equation) or input use or income (for the OLS equation)), β is a vector of parameters to be estimated, X is a matrix of the explanatory variables that include farmer-specific, farm-specific, asset endowment and location (regional) characteristics. P_i is a dummy variable indicating use of MMT services (1=user, 0=otherwise), and u_i is the error term.

In the above formulation, α_m which is a constant coefficient of the dummy P_m gives the average effect (Average Treatment Effect on Treated - ATT) of use of MMT services on users (HECKMAN et al., 1999). If the explanatory variables X perfectly captured impact of MMT on the user then α_m would be an unbiased estimator of use of MMT on users. In other words, the formulation in Equation (1) assumes absence of selection bias, which is unlikely to be the case. Ideally, the ATT is likely to be affected by other confounding factors not captured in X.

In presence of selection biases, OLS regression techniques tend to yield biased estimates. Previous authors have employed different models to counter this problem. These include the Heckman two-step (HS) method, the Instrumental Variable (IV) method and the difference-in-indifference method (PUHANI, 2000; WOOLDRIDGE, 2002; VANDENBERGHE and ROBIN, 2004). However, HS and IV have inherent weakness and assumptions that are overly restrictive (ALI and ABDULAI, 2010). Both of these procedures are completely dependent on the strong assumption that unobserved variables are normally distributed. Another limitation of these approaches is that it requires/uses at least one variable in the treatment equation to serve as instrument in specifying the outcome equation. Finding such instruments has remained a setback in empirical application of these methods. Difference-in-differences method is appropriate when panel data are available. This method differs from cross-sectional matching in that it allows for temporally invariant differences in outcomes between users and non-users (SMITH and TODD, 2005). Recent studies have employed the use of propensity score matching technique in the evaluation of the impact of a program/intervention in the presence of selection bias using cross-sectional data. This study applies the propensity score matching technique.

Propensity score matching consists of matching treatment with controls/comparison units (i.e., users of MMT with non-users) that are similar in terms of their observable characteristics. The difference in outcome variables between the matches and then computing and averaged to obtain the ATT. It follows that the expected treatment effect (ATT) for the treated population is of primary significance.

Let Y_i^1 = outcome after treatment (i.e., use of MMT), and Y_i^0= outcome without treatment. Then the causal effect on an individual *i* is given by:

(2) $$Y_i = Y_i^1 - Y_i^0$$

The estimated causal effect is thus given by:

(3) $$E(Y_i) = E(Y_i^1 - Y_i^0) = E(Y_i^1) - E(Y_i^0)$$

When using cross-section data, for impact evaluation, it is impossible to *observe* individual treatment effect since we do not know the outcomes for untreated observations when it is under treatment (Y_i^1) and for treated when it is not under treatment (Y_i^0). Propensity score matching, therefore, takes a treated individual and matches with a control of similar pre-participation characteristics. Any difference in the outcome (household level of commercialization, household income or input use) will then be attributed to the treatment (use of MMT service).

Propensity score matching technique begins with an estimation of a probit of a logit that assigns every individual a score (propensity score) that shows the probability of being included in the matching process. Mathematically, the probability that an individual is treated, given the observable variables, can be expressed as:

(4) $Prob(x) = Prob\ [P=1|X=x]$

Where P=1 is the observable treatment (user of MMT) and 0 otherwise; X is a vector of pre-participation characteristics including farmer-specific, farm-specific, asset endowment and regional/location variables. The implicit functional form of estimated use equation in this study is given by:

(5) $Y_i = f(X) + e$

Where, e is the random error term.

The estimated scores are then used for matching the users and non-users. The four techniques that have been used in the matching process are: Nearest Neighbor Matching (NNM), Radius Matching (RM), Kernel Based Matching (KBM) and Mahalanobis Metric Matching (MMM) techniques. The NNM consists of matching each treated individual with the control individual that has the closest propensity score. It allows for replacement of the matches which increases the average quality of matching, but reduces the number of distinct nonparticipant observations used to construct the counterfactual mean, thereby increasing the variance of the estimator (SMITH and TODD, 2005).

In Radius Matching (RM) approach, an individual from the control group is chosen as a matching partner for a participant that lies within the specified radius in terms of propensity score. Usually a smaller radius results in better quality matching. Following DEHEJIA and WAHBA (2002) and SMITH and TODD (2005), this study uses a radius and a calliper of $1xE^{-3}$. The Kernel Based Matching (KBM) on the other hand involves matching each participant with a weighted average of all controls. The weights used are inversely proportional to the distance between the propensity scores of participants and controls. Mahalanobis Metric Matching (MMM) technique randomly orders subjects and then calculates the distance between the first treated subject and all controls. The minimum distance between the treated subject and the controls is used as a match and the procedure is repeated for all the covariates. This technique is usually appropriate for panel data hence not applied in this study. All these matching algorithms compute the difference between the matched treatment and control which is then averaged to obtain the average treatment effect on the treated (ATT). The ATT is measure of the impact of a program/intervention.

The credibility of the results of the propensity score matching technique crucially depends on two key assumptions; namely the balancing assumption and the absence of hidden bias. Since we do not condition on all covariates but on the propensity score, it has to be checked if the matching procedure is able to balance the distribution of the relevant variables in both the control and treatment group. The basic idea of checking the matching quality is to compare the situation before and after matching and check if there remain any differences after conditioning on the propensity score. Additionally, SIANESI (2004) suggests to re-estimate the propensity score on the matched sample (that is, only on participants and matched non-participants) and compare the pseudo-R^2 before and after matching. The pseudo-R^2 indicates how well the regressors, *X,* explain the participation probability. After matching there should be no systematic differences in the distribution of covariates between both groups and therefore, the pseudo-R^2 should be fairly low. Furthermore, one can also perform an F-test on the joint significance of all regressors. The test should not be rejected before, and should be rejected after matching (ALI and ABDULAI, 2010).

To test the sensitivity of estimated treatment effects with respect to unobserved covariates we calculate Rosenbaum-bounds. Rosenbaum bounds take the difference in the response variable between treatment and control cases. This is reported in percentages; it shows the critical levels of gamma, Γ, at which the causal inference of significant impact of treatment may be questioned. Gamma measures difference in the response variable between treatment and control cases. By considering the lowest critical value of sensitivity analysis, we can concluded the level at which unobserved heterogeneity would alter the inference about the estimated effects of treatment.

3.3 Sampling Procedure and Data

This study was part of a wider project implemented by Electronic Agricultural Research Network in Africa (eARN-Africa). The aim of the project was to evaluate the effectiveness of ICTs in helping smallholder farmers commercialize. The project had been implemented in three different districts each in a separate province. These include Kirinyaga (central province), Bungoma (western province) and Migori (Nyanza province). These districts were characterized by poor access to markets by small farmers and reliance on agriculture. The study districts were selected to represent diverse agro-ecological zones, socio-economic environment, cultural diversity and varying production systems. For example, Kirinyaga district is considered a high potential area with export oriented export crops (French beans, baby-corn and Asian vegetables). Bungoma district on the other hand grew mainly maize with sugarcane while Migori is considered low potential area with main crops grown being maize and tobacco. Thus the choice of the districts presents differing levels of commercialization. Kirinyaga district is mainly

inhabited by people of Kikuyu ethnic group while Bungoma and Migori districts are mainly inhabited by Luhya and Luo ethnic groups respectively.

Sampling procedure was done in three stages. First, the three districts (project districts) were purposely selected. Second, in each of the district, a location was randomly identified. A list of all farm households within the selected location was then drawn with the help of local administration (village elders and area agricultural extension officers). Third, the respondents were sampled from the lists using probability proportionate to size sampling method. That is, more respondents were sampled from the district with more inhabitants. This procedure resulted in a total of 379 farmers – 121, 132 and 126 respondents from Kirinyaga, Bungoma and Migori districts, respectively – interviewed in this study. These comprised of 198 (52%) users of MMT and 181 (48%) non-users of MMT. We compare and contrast these respondents in the next section. The data was collected through personal interviews using pre-tested questionnaire and data entered and analyzed using SPSS and STATA packages. The data collected included household characteristics, socio-economic indicators, household assets, information sources, ownership and use of mobile phones, sources and uses of income, among others. The household survey was conducted during March and April of 2010.

3.4 Variables Used in the Empirical Models

Three outcome variables are considered in this study: agricultural commercialization index, level of agricultural input use and household agricultural income. We measure commercialization index as a ratio of total value of sales to the value of total agricultural production. While level of input use is the total value of agricultural inputs. Agricultural income was computed as the sum total of income from agricultural activities. A summary of the variables use in modeling as described in Equation 5 are shown in Table 1.

Table1. Variables used in the econometric models

Variable name	Variable definition
Dependent variables	
mtransfer	1 If a farmer uses mobile phone-based money transfer services, 0 otherwise
Outcome variables	
commindex	Household agricultural commercialization index
inputindex	Household agricultural input use index
farmincome	Income from farming activities
Independent variables	
age	Age of household head (years)
gender	1 if household head is male, 0 otherwise
occupation	1 if main occupation of the farmer is farming, 0 otherwise
household size	Size of the household (number of household members)
mmtdist	Distance to the nearest mobile phone-based money transfer agent (km)
bankdist	Distance to the nearest electricity hook-up (km)
cropenteprises	Number of crop enterprises within the farm (count)
edu	Education level of the household head (years of formal schooling)
landsize	Total land area (acres) cultivated during 2009
farmexperience	Years of farming (years)
assets	Value of household production assets measured in Kenya Shillings*
nonfarmincome	Income from non-farm activities measured in Kenya Shillings*
grpmember	1 if farmer is member of a farmer organization, 0 otherwise
Kirinyaga	1 if the farmer is located in Kirinyaga district, 0 otherwise
Migori	1 if the farmer is located in Migori district, 0 otherwise
Bungoma	1 if the farmer is located in Bungoma district, 0 otherwise

* The exchange rate was Ksh.78 = 1 US dollar at the time of survey.

Source: survey results (2010)

4 Results

4.1 Characteristics of Users and Non-Users of MMT Services

We present differences in the characteristics of users and non-users of MMT services with test of significance in their differences in Table 2. We carried out t-tests for continuous variables and chi-square test for categorical variables. Results suggest that there were differences between users and non-users of MMT with respect to farmer-

specific, farm-level and asset endowment characteristics. Specifically, results show that users of MMT services are more educated than their counterparts. Interestingly, non-users of MMT services are more experienced in farming. There are also significant differences among the farm-specific characteristics namely, distance to the bank, distance to the money transfer agent and distance to the agricultural extension agent's office. Users of MMT services have a closer proximity to the MMT agent. Asset endowment (value of current assets) characteristics show no significant difference between the groups.

Table 2. Differences in characteristics of users and non-users of MMT services (sample mean)

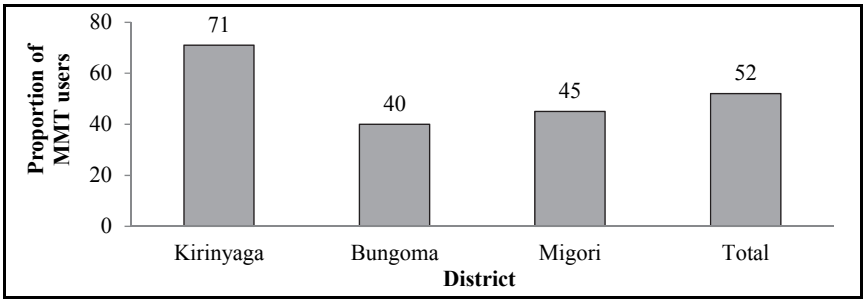
Characteristic	Users (n=198)	Non-Users (n=181)	Difference	t -values
Farmer-specific characteristics				
Age of the household	40.85	41.68	-0.83	-0.62
Gender (Male=1)	0.57	0.44	0.13***	2.58
Occupation (Farming =1)	0.72	0.31	0.41	0.28
Awareness of MMT services (Aware=1)	1.00	0.92	0.08	1.28
Farm-level characteristics				
Distance to bank (km)	8.61	11.75	-3.14***	-4.17
Distance to agric extension agent (km)	6.66	8.59	-1.93	-1.41
Distance to MMT agent (km)	2.17	4.29	-2.12***	3.54
Number of enterprises	6.31	3.20	3.11***	1.92
Household size (adult equivalent)	5.64	5.85	-0.21	0.93
Asset endowment characteristics				
Education (years)	9.78	6.99	2.79***	7.95
Farming experience (years)	16.49	20.25	-3.76***	-2.82
Group membership (member =1)	0.69	0.34	0.35***	2.84
Agricultural income (KSh.)	8,866.19	2,706.27	6,159.92***	6.02
Non-agricultural income (KSh.)	17,854.31	12,955.29	4,899.02**	1.97
Assets value (KSh.)	39,735.49	29,436.77	10,298.72	1.32
Location characteristics				
Kirinyaga	63	58	5	0.62
Bungoma	69	63	6	0.56
Migori	66	60	6	0.61
Total number of farmers (N)	**198**	**181**		

Note: significance level: *10%, **5% and ***1% levels
Source: survey results (2010), STATA: ttest

4.2 Use of MMT Services among Respondents

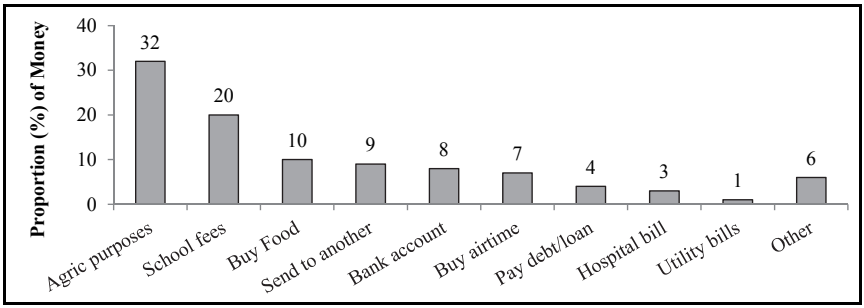
Overall, 96% of the respondents were aware of the existence of MMT services. Meanwhile 198 (52%) had used these services. However, as expected, the usage differed for different regions (Figure 1). More farmers in Kirinyaga district have used MMT services before than in the other two districts. Two factors may explain this finding. First, the overall market access to agricultural output market is better in this district than in the other two. Second, ownership of mobile phones was higher in Kirinyaga than in Migori and Bungoma districts. Farm households interviewed in this study use the money they received through MMT for various purposes. Figure 2 presents the various uses to which monies received via mobile phones are used. Interestingly, agricultural related purposes (purchase of seed, fertilizer, farm equipment/implements, leasing of land for farming, paying of farm workers) accounts for the largest proportion (32%) of use of the monies received via mobile phone transfer. School fees payment accounted for 20% while purchase of food yielded 10%.

Figure 1. Use of MMT services by district



Source: survey results (2010)

Figure 2. Uses of money received via mobile phone transfer



Source: survey results (2010)

4.3 Determinants of Use of MMT Services

Several factors determine the use (adoption) of MMT services by farm households (Table 3). Among the farmer specific characteristics, only gender affected the likelihood of using MMT services. Male farmers were better able to use MMT services than their female counterparts. On the other hand, distance to the nearest MMT agent has a negative influence on the likelihood of using MMT services. The further away the farmers were from MMT agent the less likely was the use of the service. Interestingly, distance to the nearest bank was positively and significantly related to the likelihood of use of MMT services. That is, the further away the farmer was from the nearest commercial bank, the more likely that they would use MMT services. These findings indicated that MMT, therefore, had great potential to reduce the exclusion of farmers from banking services caused by lack of access resulting from distance to the service.

Table 3. Propensity score for use of MMT services

Variable category	Variable definition	Coefficient	p-value
Farmer-specific variables	Gender	0.68	0.073
	Age	0.15	0.132
Farm-specific variables	Distance to nearest MMT agent	-0.12	0.017
	Distance to nearest bank	0.40	0.062
	Household size	-0.06	0.329
Asset endowment variables	Household non-farm income	0.31	0.015
	Current value of assets	0.28	0.031
	Land size	0.01	0.142
	Education	0.05	0.000
	Group membership	0.09	0.042
Regional variables	Bungoma	1.02	0.346
	Migori	0.93	0.554
Constant	Constant	0.68	0.001
Model characteristics	No. of observations: 379	Log Likelihood: -200.74	
	Pseudo R^2: 0.32	p-value: 0.000	

Source: survey results (2010), STATA: psmatch2

Human capital proxied by years of formal education also positively influenced the likelihood of using MMT services. More educated farmers were more likely to use used MMT services. Similarly, social capital, proxied by membership in farmer organizations, also affected the likelihood of using MMT services. This finding corroborated with those of previous studies that indicate that collective action affects adoption of

new techniques (SALASYA et al., 1996). The other capital endowment variable that affects the likelihood of using MMT services includes possession of physical assets. Analysis showed that the likelihood of usage of MMT is higher among the more asset-endowed farmers than their counterparts.

4.4 Impact of MMT on Input Use, Commercialization Index and Income

Results from all matching approaches indicated that use of MMT services had a positive and significant effect on level of household commercialization, household agricultural income and household input use (Table 4). The results from all matching approaches (Nearest Neighbour Matching (NNM), Kernel-based matching and Radius Matching (RM)) indicated that MMT services had a positive and significant effect on level of household commercialization, household agricultural income and household input use. Specifically, the results show that the level of commercialization is higher among users of MMT by 37%. The value of household annual input use was KSh. 3,300 ($42) more for MMT users than their counterparts while total income from farming activities was more by KSh. 17700 ($224) for MMT users.

Table 4. Impact of MMT on household commercialization and household input use and income

Matching Algorithm	Outcome variables	Treated (N=198)	Control (N=181)	ATT	t-values
Nearest Neighbor Matching (NNM)	Commercialization	0.83	0.46	0.37**	2.27
	Household input use	6,366	3,186	3,079*	1.83
	Household income	34,727	16,970	17,757***	3.36
Kernel Based Matching (KBM)	Commercialization	0.84	0.46	0.37***	2.91
	Household input use	6,303	3,279	3,023**	1.99
	Household income	34,720	16,990	17,730***	3.19
Radius Matching (RM)	Commercialization	0.84	0.46	0.37***	3.24
	Household input use	6,377	3,322	3,055*	1.88
	Household income	34,724	17,010	17,714***	3.03

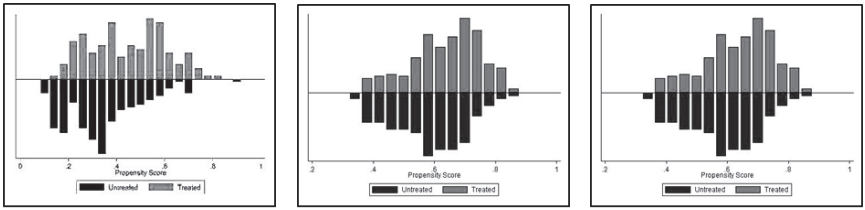
Note: significance level at ***1%, **5% and *10%

Source: survey results (2010), STATA: psmatch2

4.5 Balancing Test for Conditional Independence Assumption (CIA) and Sensitivity Analysis

Propensity score estimation balances the distribution of independent variables in the groups of users and non-users of MMT. Figure 3 shows the distribution and common support for the propensity score estimation. From the graphs, all the treated and the untreated individuals were within the region of common support indicating that all treated individuals have corresponding untreated individuals. Results (Table 5) indicate that there was a substantial reduction in bias as a result of matching. The estimates showed that reductions in the median absolute bias were all greater than 20% and hence were considered 'large' (ROSENBAUM and RUBIN, 1985; ALI and ABDULAI, 2010). Results of the pseudo-R2 after matching were all lower than before matching for all matching algorithm. This implies that after matching there were no systematic differences in the distribution of covariates between both users and non-users of MMT. The joint significances of the regressors were rejected after matching, whereas we failed to reject at any significance level before matching. This suggests that there was no systematic difference in the distribution of covariates between users and non-users of MMT after matching.

Figure 3. Propensity score distribution and common support for propensity score estimation



Effect on commercialization | Effect on input use | Effect on agric. income

Source: survey results (2010), STATA: psgraph bin, (25)

Results from the sensitivity analysis on hidden bias, which show the critical levels of gamma, Γ, at which the causal inference of significant impact of use of MMT may be questioned are also presented in the last column of Table 5. Gamma measures difference in the response variable between treatment and control cases. For example, the value of 1.80-1.85 for impact of MMT on commercialization implies that if the individuals that had the same characteristics were to differ in their odds of use MMT by a factor of 80 to 85%, the significance of the impact on level of household commercialization would be questionable. The lowest critical value of sensitivity analysis was 1.30-1.35 whereas the largest critical value was 1.80-1.85. We, therefore, concluded that even,

Table 5. Indicators of covariate balancing before and after matching

Matching algorithm	Outcome	Median bias before matching	Median bias after matching	% bias reduction	Pseudo R^2 (unmatched)	Pseudo R^2 (matched)	p-value of LR (unmatched)	p-value of LR (matched)	Critical level of Hidden bias (Γ)
Nearest Neighbour Matching	Commercialization Index	32.4	16.5	73.6	0.167	0.091	0.000	0.607	1.80-1.85
	Household annual input use	27.2	15.5	35.9	0.188	0.111	0.024	0.884	1.45-1.50
	Household annual farm income	28.5	6.5	36.2	0.171	0.124	0.000	0.636	1.30-1.35
Kernel Based Matching	Commercialization Index	26.3	9.8	30.8	0.108	0.015	0.000	0.343	1.75-1.85
	Household annual input use	20.5	12.1	45.6	0.117	0.026	0.000	0.763	1.40-1.50
	Household annual farm income	38.9	10.4	21.0	0.126	0.019	0.000	0.873	1.35-1.40
Radius Matching	Commercialization Index	32.4	12.8	44.8	0.203	0.122	0.000	0.440	1.60-1.75
	Household annual input use	24.2	11.9	29.8	0.191	0.116	0.004	0.911	1.45-1.55
	Household annual farm income	48.8	16.4	40.8	0.222	0.127	0.001	0.719	1.35-1.45

Source: survey results (2010), STATA: pstest, rbounds

large amounts of unobserved heterogeneity would not alter the inference about the estimated impact of MMT on level of household commercialization, household input use and household agricultural income.

5 Summary, Conclusions and Policy Implications

This study assessed the impact of the recently introduced MMT services on smallholder agriculture in Kenya. It finds that the level of awareness of MMT is quite high (96%). However, this has not translated into usage. Only 52% of the farmers were found to be users. The study specifically found that the largest proportion of money received (32%) via MMT was used on agricultural related purposes (purchase of seed, fertilizer for planting and topdressing, farm equipment/implements, leasing of land for farming, and paying farm workers). The study found that use of MMT services significantly increase household annual input use by KSh. 3,300 ($42), household agricultural commercialization by 37% and household farm incomes by KSh. 17,700 ($224.)

The implication of these findings is that use of MMT services especially in rural areas resolves some market failures that farmers face; no or constrained access to financial services. The success of MMT services can be attributed to a host of factors: the service is simple to operate; the registration process has been made simple and can be completed within few minutes. Ideally, all one needs to use MMT service today is as simple as an active mobile phone number. Additionally, there are large numbers of access points (agents) all over the country. The companies operating MMT services in Kenya (Safaricom, Airtel, Orange and YU) together with the government of Kenya through the Communication Commission of Kenya have made it easy for individuals to access licenses to operate as access points (agents). The amount of capital (float) needed to operate as an agent has also been reduced (from $2,000 to $1,000). Ongoing support from government through liberalization of the mobile market, investment in infrastructure, facilitation of the initial pilot – combined with strong consumer demand across all strata of society has made it possible for MMT to thrive in Kenya unlike in any other country. We recommend that other countries should consider these factors which are imperative to entry and survival of MMT initiatives.

In addition, attention should be given to infrastructural constraints facing rural areas like lack of electricity (needed to charge mobile phones). Security in handling cash flows is also an important factor to successful implementation of MMT services. Currently, all mobile phone providers in Kenya offer MMT services. As such, competition for clients has resulted to a significant reduction in the cost of sending/receiving money via mobile phones. Countries with more mobile phone service providers and huge subscriber base can leverage on them.

The ICT sector is on a fast revolution. Some of the notable mobile money related innovations launched recently after MMT include m-banking solutions such as M-Kesho, Mobicash, Elma, Pesa-Pap and Pesa-Connect. Future studies should consider examining the effect of using such services on the welfare of smallholder farmers. The Kenyan MMT service is currently exploring the options of sending money across networks just like making phone calls across networks. This implementation and its impact are also worth studying in future.

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