# Determinants of Awareness and Use ICT-based Market Information Services in Developing-Country Agriculture: The Case of Smallholder Farmers in Kenya

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**Abstract**

Access by smallholder farmers to markets has traditionally been constrained by lack of market information. Yet progress in smallholder agriculture is inconceivable without greater market participation. The desire to strengthen farmer access to market has thus resulted in the emergence of many agricultural projects that use Information and Communication Technologies (ICT) in developing countries over the last decade. These technologies focus on providing market information services (MIS) to farmers. This study uses regression techniques and data collected from 379 smallholder farmers in Kenya to examine the conditioners of awareness and use of ICT-based MIS. The study finds that transaction costs, the characteristics of the area in which ICT-based projects are implemented and farmer endowments with human and financial capital play an important role in smallholder farmers' awareness, use and/or extent of use of ICT-based MIS projects. It concludes that awareness and the use of ICT-based MIS is driven by farmer, farm and location-specific characteristics as well as various capital endowment factors. The study discusses the implications of these findings for policy and practice.

**Keywords:** smallholder farmers, ICT-based MIS, awareness and use, Kenya
**JEL:** Q13, Q16

# 1 Introduction

Market access is one of the most critical factors influencing the performance of agriculture in developing countries and plays a major role in enhancing and diversifying the livelihoods of poor smallholder farmers (BARRETT, 2009). Smallholder producers form the majority of both the total and rural poor in many developing countries, especially in Africa. Most are engaged in subsistence or semi-subsistence agriculture, often characterized by low productivity, low marketable surplus (hence low returns) and low investment - a situation described as low equilibrium poverty trap (BARRETT, 2008; BARRETT and SWALLOW, 2006). Increasing returns from agricultural production through improved access to markets can, therefore, be a vital element of poverty alleviation strategy and livelihood improvement. Improved market access results in commercialization of agriculture, which can in turn result in increased marketable surplus, increased agricultural income, savings and hence investment in productivity enhancing technologies.

Despite its importance, market participation in many developing countries remains severely constrained by poor access to agricultural/market information (SHEPHARD, 1997; BARRETT and Carter, 2013). Poor access to market information results in information-related problems such as moral hazard and adverse selection which increase transaction costs and subsequently impede participation in markets by some farmers (OMAMO, 1998; FAFCHAMPS and HILL, 2005; SHIFERAW et al., 2008). High transaction costs curtail the exchange process and prevent market actors from investing in complementary services, leading to organizational failure (DOWARD et al., 2005). This is especially the case with the provision of essential business development services (BDS) (including provision of information on prices, trends, quality, volumes, buyers and sellers (SHIFERAW et al., 2011). Consequently recent attempts to strengthen smallholder farmers' access to market have focused on facilitating their access to agricultural information. These interventions are increasingly using ICT-based technologies as the medium for transferring information to farmers (TOLLENS, 2006; OKELLO et al., 2010). The ICT tools being used include mobile phones, internet/web-based platforms, and interactive video, CD-ROM, radio and television (MUNYUA, 2007).

Unlike the traditional agricultural information transfer methods, ICT tools have the advantage of offering a cheaper way of: i) communicating knowledge and information to rural farmers, ii) delivering education and training modules to farmers, iii) improving smallholder farmers' access to markets and agricultural credit, iv) empowering farmers to negotiate better prices, and v) facilitating and strengthening networking among smallholder farmers. These advantages have given rise to several market information service projects that use ICT tools (OKELLO et al., 2010). Notable examples include Center Songhai in Benin, MISTOWA in Ghana and Benin (and other west African countries), DrumNet and Kenya Agricultural Commodity Exchange in Kenya, Last Mile Initiative in Madagascar, Malawi Agricultural Commodity Exchange in Malawi and BRODSI and WOUGNET in Uganda. Despite the increase in the number projects using ICT tools to provide agricultural information services in African countries, factors that determine awareness of such projects and the usage of their services are still not clearly understood. This is because the existing studies have mainly focused on the effect of such projects on market performance (DE SILVA and RATNADIWAKARA, 2010; AKER, 2008, AKER, 2011; OKELLO, 2011; ABEL-RATOVO et al., 2012). For instance, OKELLO (2011) examines the effect of ICT-based MIS projects on rural traders in Kenya. ABEL-RATOVO et al. (2012) assess the use of mobile phones and computer-based MIS platform by rural traders in Madagascar. DE SILVA and RATNADIWAKARA (2010) investigate the effect of ICT use on transaction costs of accessing high value non-traditional export markets. To our knowledge only LWASA et al. (2011) have attempted to access awareness of ICT-based market information sources. However, their study examined whether farmers were aware of ICT projects that target smallholder farmers with market information. It also does not examine the usage of services such ICT-based projects provide and drivers of use of such services by smallholder farmers. This study differs from most of the past studies by focusing on the conditioners of i) awareness of ICT-based MIS and, ii) usage of such services. It thus builds on the work of LWASA et al. (2010) by specifically examining the awareness of the different types of services ICT projects provide and their usage by smallholder farmers.

This paper uses data primary collected from three regions (i.e., Bungoma, Migori and Kirinyaga) where ICT-based MIS projects were implemented. It focuses on Kenyan smallholder farmers growing both food and cash crops for both local and export markets, respectively. Smallholder farmers comprise more than 70% of farming in Kenya (KIRIMI et al., 2011). At the same time, MUNYUA (2007) found more than 39 projects that were using ICT tools to provide different kinds MIS to farmers in Kenya, with the locus of intervention being the smallholder farmer. Kenya, therefore, provides a suitable case to study. The rest of this paper is organized as follows: Section 2 presents the study context while Section 3 discusses the conceptual framework of the study and the empirical methods employed. Section 4 presents the study results while Section 5 concludes and discusses the policy implications of the study findings.

## 2 Study Context

The debate on how best to provide smallholder farmers with market information has occupied development literature for many years (SHEPHERD, 1997; EICHER and STAATZ, 1998: 17). It has over the years led to perpetual search for the best model for reaching farmers with MIS. An early example of models used in providing MIS to farmers involved public extension service which were based on the personal contact between a trained extension agent and the farmer. Several variants of this approach existed in Kenya, including the progressive farmer approach in which the better-performing farmers were targeted with production and market information services. The messages passed on to these farmers were then expected to trickle down to the rest of the farmers through demonstration effect. However, this model had the shortcoming that the messages were not always relevant and appropriate, besides the approach being perceived as being top down.

In the 1980s, the training and visit (T&V) model of personal contacts with farmers was adopted. The model entailed regular training of agricultural staff on production, post-harvest handling and marketing (NAMBIRO et al., 2005). The trained staff was then expected to pass the acquired knowledge to farmers through fortnightly visits. This model turned out to be too costly with messages sometimes becoming repetitive (KIBETT et al., 2005). It was later modified, and the training component removed. At the same time, the fortnightly visits were later replaced with non-scheduled visits to reduce costs. The approach was later abandoned altogether when the financial support from the World Bank, the major donor, lapsed (NAMBIRO et al., 2005). Other models of providing MIS have also been used in Kenya. These include the field day approach, on-farm trials and demonstrations, and the residential training through farmer/agricultural training schools/centers. Some of these latter models focused on farmer and community based organizations and entailed training the organizations' members, and the organizations being used, subsequently, as information hubs for the rest of the community (EVENSON and MWABU, 1998; MUYANGA and JAYNE, 2006).

In some cases, agricultural extension models such as the Training and Visit (T&V) have been traditionally complemented with traditional mass media channels such as the radio and television. These tools have been used to broadcast agricultural information at certain times of the day. However, the messages transmitted through these channels have tended to be dated because of the time it takes to gather, process and disseminate information. The timing of delivery of information through radio and television is also a problem as most of the programs tend to be aired when farmers are out in the field or busy with other domestic chores (MUNYUA, 2000). Thus, new generation ICT tools, notably mobile phones, are being used by some projects to reduce the time lag between market information gathering and its dissemination. These tools allow farmers to obtain real-time prices and other services within hours of their collection (DE SILVA and RATNADIWAKARA, 2010; AKER, 2011).

Unlike radio programming, mobile phone based information system works through a platform that can be queried by sending a text message any time, and hence provides information on commodity demand and supply anywhere and anytime (DE SILVA and RATNADIWAKARA, 2010). At the same time, web-based applications that upload daily market information enables subscribers to get access to information anytime and anywhere.

In addition to the normal public extension service system, three ICT-based initiatives operated in the study areas. These were DrumNet project, Kenya Agricultural Commodity Exchange (KACE) and Bungoma Farmer Field School (FFS) initiatives. The Bungoma FFS and KACE initiatives operated in Bungoma district while DrumNet covered all the three study districts. These initiatives targeted smallholder farmers with a portfolio of market information services whose aim was to link smallholder farmers to better paying markets. All the three initiatives used mobile phones and a computer-based platform as well as commodity trading boards. The trading boards were located within some of the major market centers. In addition, KACE provided its MIS via web-based and radio auction platforms. OKELLO et al. (2010) discuss the services offered by these projects.

# 3 Conceptual Framework and Empirical Methods

## 3.1 Conceptual Framework

This study is based on the Transaction Cost (TC) theory, which is part of the new institutional economics (HUBBARD, 1997; CLAGUE, 1997; POULTON et al., 1998), and the theory of the firm. The concept of transaction costs was first introduced by COASE (1937) and has been widely used to analyze a variety of problems facing agriculture in developing countries (JAFFEE, 2005; FAFCHAMPS and HILL, 2005; OKELLO and SWINTON, 2007, DE SILVA and RATNANDIWAKA, 2010).

Transaction cost is loosely defined as cost of doing business or cost of exchange between two trading partners, in our case farmers and buyers. The transaction cost theory posits that difficulties in economic exchange between two partners arise because of exchange related problems that include asymmetric information. In a small farm environment, asymmetric information arises when either the farmer or buyer lacks essential information relating to the exchange. The more informed party, therefore, takes advantage of the exclusively available information to benefit him/ herself, a situation referred to as opportunism and has been defined by WILLIAMSON (1985: 45) as “self-interest seeking with guile”. In agriculture, where smallholder farmers tend to be less informed than traders/buyers, the latter can use the exclusively available information (about price, supply condition, or quality) to benefit themselves. One way to deal with this problem is to agree on the terms of exchange beforehand.

However, while the terms of exchange can be specified *a priori* through a contract, such contracts often tend to be incomplete due to the uncertain nature of future undertakings (WILLIAMSON, 2000; MENARD, 2005). Hence, the buyer, even with a priori agreement on terms of exchange, can take advantage of the farmer by engaging in opportunistic behavior. For instance, the more informed party can undertake actions that are contrary to the specifications of the agreement or renege on certain obligations due to changes in the market environment. These conditions are widespread in many farming environments (including Kenya's) where agricultural information is generally unavailable.

Lack of information between the farmer and the buyer makes the exchange of goods (i.e., trade) more costly (WILLIAMSON, 2004). COASE (1937) categorized these exchange-related costs into search and screening, negotiation, monitoring, enforcement and mal-adaptation costs. Farmers who need to sell some produce must search for buyers and screen-off unreliable or opportunistic ones thus incurring search and screening costs. Once the buyer is identified, the farmer has to negotiate the terms of sale (i.e., price, quantity, quality, time of sale, frequency of sale, etc.). The farmer thus incurs costs relating to time spent and financial outlays in negotiating the terms of exchange. A farmer may then have to engage in follow up activities (i.e., monitor) the buyer to ensure that the latter meets the terms of exchange and hence incurs monitoring costs. The farmer may also have to spend time and resources getting the buyer to honor the terms of agreement thus incur enforcement costs. Lastly, in the longer term agreements, changes in market condition may necessitate making adjustments to the terms of exchange such as the sales volume, quality, price, and frequency or time of sale. The farmer may thus incur monetary or time costs (i.e., mal-adaptation costs) during the renegotiation of the terms of exchange. These four categories of transaction costs are prevalent in both input and output markets in Africa. POULTON et al. (2006), and FAFCHAMPS and GABRE-MADHIN (2006) for instance highlight some of these costs in relation to African farmers and traders.

In sum, lack of market information increases the costs of exchange between the farmer and buyer. Smallholder farmers are especially disadvantaged because they often face thin, fragmented and geographically dispersed markets that increase the transaction costs (POULTON et al., 2006; SHIFERAW et al., 2011). Theoretically, households that are aware of and use market information services provided by ICT-based projects are expected to face lower transaction costs. Awareness of ICT-based MIS projects is expected to influence the likelihood of using the services they provide and the degree to which such services are used. The use of MIS has the advantage of reducing the costs of production and exchange. It reduces the costs of production by reducing the cost of input acquisition.

In this study, we assume that the farmer minimizes the total cost of production and exchange which includes both conventional and transaction costs subject to conventional constraints. The farmer chooses agricultural information service, **I,** alongside other inputs to minimize the combined conventional and transaction costs. That is, the farmer minimizes,

$$C(\mathbf{WX}) \tag{1}$$

Subject to a production function specified as:

$$q(\mathbf{X}) = q(\mathbf{V}, \mathbf{I}, \mathbf{L}, \mathbf{K}, \mathbf{z}); \tag{2}$$

where C is the total input cost including transaction costs (**TC**), assumed to be a function of information **I** obtained through ICT-based agricultural projects; W is a vector of input prices; **X** is vector of all production inputs comprised of **V,** a vector of conventional variable inputs such as, fertilizer, seed, and pesticides used by the farmer and **L,** the total labor requirement which includes both family (*l*) and hired labor (*h*). The variable **q** is the output produced using, among others, agricultural information. Lastly, **K** and **z** are the fixed and quasi-fixed capital inputs and institutional factors, respectively.

The farmer's optimization problem, therefore, is to choose **I** to minimize the total cost of production and marketing subject to labor availability and a specified quantity of output $\mathbf{q^o}$. That is, the farmer chooses I to;

$$\text{Min } C(.) = W_V V + W_I I + W_L L + TC(I) \tag{3}$$

Subject to:

$$q \geq q^0 \tag{4}$$

$$L \leq l + h \tag{5}$$

Equation (4) shows that the output constraint need not hold exactly, whereas equation (5) indicates that total effective labor is comprised of the family labor and the hired labor.

Solving the Lagrangean expression associated with the cost minimization problem above, and assuming that the second order sufficient condition is satisfied yields, among others,

$$I^* = I^*(W, q, K, z). \tag{6}$$

Where $I^*$ is the conditional input demand equation (associated with ICT tools) and is a function of output **q**, input prices **W**, fixed and quasi-fixed factors **K,** and a vector of institutional factors, **z**.

Equation (6) above also gives the adoption function related to the use of market information services.

## 3.2 Empirical Methods

In this study, a 3-stage analytical framework was used to assess awareness and then the use of ICT-based MIS. The first stage examines whether a farmer is aware of ICT-based MIS or not using logit analysis. The second stage assesses whether the farmer decides to use ICT-based MIS or not, given that he/she is aware of ICT-based MIS. Lastly, the last stage assesses the extent of usage of the ICT-based MIS by a farmer, conditional on the decision to use ICT-based MIS.

The first two models namely *awareness* and *use* of ICT-based MIS by farmers are estimated using a binary dependent variable. The dependent variable *awareness* assumes a value of 1 if a farmer is *aware* of (i.e., has heard of and hence knows of the existence of) any of the market information services provided by ICT-based projects and 0 otherwise. Similarly, the dependent variable *use* assumes a value of 1 if a farmer decides to *use* any of the services provided by the ICT-based projects in the study area, and 0 otherwise. Such binary choice models are usually analyzed using Logit or Probit regression models. LIAO (1994) and GUJARATI (2004) indicate that the Probit and Logit models generate similar predicted probabilities although differing in terms of the distribution. Following MADDALA (2001), the probability, *P*, that a household is aware of (uses) an ICT-based MIS is given by:

$$P = e^{z}/1+e^{I} \tag{7}$$

Central to the use of logistic regression is the logit transformation of *p* given by *I*

$$I= ln(p/1-p) \tag{8}$$

Where;

$$I= I(F, R, K, D)+ \varepsilon \tag{9}$$

I in (9) is a latent variable that takes the value of 1 if the farmer is aware of any market information service provided by ICT-based projects, and 0 otherwise, F is a vector of farmer characteristics, R is a vector of farm level variables, K is a vector of capital endowments, D is a vector of location dummies and ε is the stochastic term, assumed to have a logistic distribution. Similarly, I in (9) would take the value 1 if a farmer decides to use ICT-based MIS, 0 otherwise, in the second model estimated.

The factors likely to influence the *awareness* of and the *use* of ICT-based MIS include farmer, farm, capital endowment and location-specific variables. The variables included under each of these categories of factors were selected based on past literature and *a priori* expectations and include:

1. Farmer specific variables (F): *lnage* is natural logarithm of age in years, *gender* is a dummy variable equal to 1 if farmer is male, 0 otherwise),

2. Farm specific variables (R): *lntransptcost* is the natural log of transport cost to the nearest output market.

3. Capital endowment variables (*K*): *lnassets* is natural log of assets; *landsize* is size of land in acres; *mobilephone* is dummy variable equal to 1 if farmer owns mobile phone, 0 otherwise; *literacy* is education in years; *group member* is a dummy variable equal to 1 if a farmer belongs to a farmer group, 0 otherwise; *lnincome* is given by natural log of crop income in Kenya Shillings.

4. Location variables (D): are given by dummies, *kirinyaga* (1 if study district is Kirinyaga, 0 otherwise), *bungoma* (1 if study district *is Bungoma*, 0 otherwise), *migori (1 if stu*dy district is Migori, 0 otherwise).

The intensity of use of MIS provided by ICT-based projects is proxied in this study by the number of ICT-based market information services used by a farmer. The ICT-based market information services considered included information on input price, output price, market where to buy, market where to sell, quality of produce, and quantity (volumes) of produce. These were the main market information services provided by the ICT-based projects in the study areas. A detailed discussion of these services can be found in OKELLO et al. (2010). The number of services used by a farmer assumes integer values of discrete nature and is therefore a nonnegative count variable. The study therefore used a count data model to analyze the intensity of use of MIS provide by ICT-based projects.

The most common regression techniques used to analyze count data models include the Poisson Regression Model (PRM) and the Negative Binomial Regression Model (NBRM) (WINKELMANN and ZIMMERMANN, 1995; GREENE, 2008). The NBRM is used where PRM fails due under-dispersion or over-dispersion of variance. The PRM is used in this study because the tests for over-dispersion and under-dispersion ruled out these problems. Indeed, a test of under/overdispersion yielded p-values greater than of 0.624, indicating the absence of these problems.

Following WOOLDRIDGE (2002) and GREENE (2008), the density function of the Poisson regression model is specified as:

$$f(y_i|x_i) = \frac{e^{-\lambda(x)}\lambda_i(x)^y}{\Gamma(1+y_i)} \tag{10}$$

Where $\lambda_i = \exp(\alpha + X'\beta)$ and $y_i = 0,1,...,i$ is the number/count of market information services used (in our case); X = a vector of predictor variables and α and β are the parameters to be estimated. The estimated empirical model has the count of ICT-based MIS used by a farmer as the dependent variable and similar explanatory variables as those of the first two models.

### 3.3 Sampling Procedure and Data

This study uses survey data collected from smallholder farmers in Kirinyaga, Bungoma and Migori districts in Kenya. The districts were selected because they hosted ICT-based MIS projects and also due to the diverse social-economic and cultural backgrounds in each. Kirinyaga district has export-oriented agriculture and exports several high value crops (e.g., French beans, various Asian vegetables and baby corn). Smallholder farmers in Bungoma district grow mainly maize and sugarcane, in addition to sunflower. In Migori, the main crops are maize, sunflower and tobacco.

The study targeted villages where an ICT-based project whose aim was to link smallholder farmers to markets by providing MIS operated. The respondents in this study were stratified by participation in the ICT-based agricultural projects.

A three-stage sampling procedure was used to identify 379 farmers across the three districts. First, in each district, an area with an ICT-based project was identified. Second, for each district, a list of all farmers who participated in ICT-based projects was drawn with the help of project leaders and farmer leaders. A second list of farmers that did not participate in the ICT-based projects was also obtained with the help of local leaders and administrators (namely, village headmen and area agricultural extension officers, respectively). Third, the respondents were sampled from the two lists using probability proportionate to size sampling method. This procedure resulted in 162 ICT-based project participants and 216 non-participants. A total of 379 farmers were, therefore, interviewed comprising of 127, 130 and 122 respondents from Kirinyaga, Bungoma and Migori districts, respectively. The data were collected in April 2010 through personal interviews using a pre-tested questionnaire. The information collected included farmer-specific characteristics, farm-specific characteristics, household capital/asset endowments, and location-specific characteristics. Table 1 and 2 presents variable definitions and their summary statistics, respectively.

**Table 1. Definitions of variables used in the empirical estimations**

| Variable name | Variable Definition |
|---|---|
| **Dependent variables** | |
| Awareness | 1 If a farmer is aware of an MIS , 0 otherwise |
| Decision to use MIS | 1 if a farmer uses MIS, 0 otherwise |
| Number of MIS used | Total number of MIS used by a farmer |
| **Independent variables** | |
| *Farmer/household specific variables* | |
| lnage | Natural log of age of household head (years) |
| Gender | 1 if household head is male, 0 otherwise |
| Literacy | 1 if a member can read and write, 0 otherwise |
| *Farm-specific variables* | |
| lntransport cost | Natural log of transport cost to a produce market |
| *Capital endowment variables* | |
| Mobilephone | If a farmer has a working mobile phone or simcard |
| Lnlandsize | Natural log of size of and in acres |
| Lnassets | Natural log of value of assets measured in Kenya Shillings |
| Lnincome | Natural log of income measured in Kenya Shillings |
| Group member | 1 if farmer is member of a farmer organization, 0 otherwise |
| *Location variables* | |
| 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 Kshs 78 = 1 US dollar at the time of survey.
Source: own survey (2010)

The results of the t-tests of difference in means show that participants differ from nonparticipants in terms of decision to use ICT-based MIS and the number of such services used. The average number of ICT-based MIS used by participants is significantly higher than nonparticipants. The results also show differences between participants and non-participants with respect to farmer-specific, farm-level and capital endowment characteristics. Specifically, household sizes differ significantly between participants and nonparticipants.

**Table 2. Characteristics of ICT-based MIS project participants and non-participants (means)**

| Variable definition | Participant (N-164) | Non participant (N=215) | Mean difference | T-values |
|---|---|---|---|---|
| **Dependent variables** | | | | |
| Awareness (1,0) | 0.74 | 0.58 | 0.16*** | 3.19 |
| Use of MIS (1,0) | 0.81Ω | 0.34 | 4.70*** | 4.10 |
| Number of MIS used (count) | 3.20 | 1.11 | 2.09*** | 3.98 |
| **Independent variables** | | | | |
| *Farmer specific variables* | | | | |
| Age | 44.32 | 42.88 | 1.44 | 1.00 |
| Literacy | 0.88 | 0.82 | 0.08* | -1.37 |
| Household size | 5.41 | 6.00 | -0.60*** | -2.68 |
| Gender | 0.52 | 0.49 | 0.03 | 0.60 |
| Occupation | 0.92 | 0.87 | 0.05 | 1.45 |
| *Farm-specific variables* | | | | |
| lntransptcost | 3.04 | 2.81 | 0.23 | 1.49 |
| *Capital endowment variables* | | | | |
| landsize | 2.58 | 2.21 | 0.37 | 1.54 |
| Experience | 18.63 | 17.22 | 1.40 | 1.16 |
| Mobilephone | 0.285 | 0.372 | -0.09** | 1.64 |
| ln assets | 10.65 | 10.51 | 0.13 | 0.89 |
| ln income | 8.43 | 7.41 | 1.02** | 2.36 |
| Group membership | 0.68 | 0.57 | 0.11** | 2.09 |
| *Location variables* | | | | |
| Kirinyaga | 0.31 | 0.35 | -0.05 | -0.95 |
| Bungoma | 0.49 | 0.25 | 0.24*** | 4.96 |
| Migori | 0.20 | 0.40 | -0.19*** | -4.00 |

Ω = the **n** for this is 121, i.e., 81% of the farmers that were aware of MIS decided to use it;
* , **, and *** = significant at 10%, 5% and 1%, respectively.

Source: authors` computation (2014)

# 4 Results and Discussion

The results of the 3-stage analysis are presented in Table 3. The first stage (logistic regression) examines the conditioners of awareness of ICT-based MIS; the second stage (also a logistic regression) examines the drivers of decision to use ICT-based MIS given that a farmer is aware of them; and the third stage (Poisson regression) examines the drivers of intensity of use of ICT-based MIS given that the farmer has decided to use ICT-based MIS. We discuss the results of each of the stages in the proceeding sections.

## 4.1 Drivers of Awareness of ICT-based MIS

The coefficient estimates and marginal effects of the factors influencing awareness of ICT-based MIS along with their p-values are presented in the first 5 columns of Table 3. Results show that literacy, household asset endowment and farm level characteristics (proxied by transport cost to the main market) positively influence the likelihood that a farmer is aware of ICT-based market information service. Regional characteristics affect the likelihood a farmer being aware of the market information services provided by any of the ICT-based projects in the area.

The marginal effects show that a unit increase in the natural log of assets increases the likelihood of a farmer being aware of ICT-based market information services by 0.07, holding other things constant, suggesting that farmers with more asset endowments are more likely to learn/know about the existence of ICT-based market information services than their counterparts. Results further show that a unit increase in transport cost increases the likelihood of awareness of ICT-based MIS by 0.02, holding other factors constant. This finding suggests that farmers who live far away from the main markets are more likely to be aware of ICT-based market information services. The results also indicate that the literate farmers are more likely to be aware of ICT-based projects than their counterparts.

The results of the awareness model further show that farmers from Bungoma district are more likely to be aware of ICT-based MIS, holding other factors constant, contrary to those in Kirinyaga. The finding can be attributed to the popular radio auction program known as *Soko Hewani* (or market-on-air) that was aired by Kenya Agricultural Commodity Exchange (KACE) every Tuesday night in Bungoma and the surrounding districts.

**Table 3. Drivers of use and intensity of use of ICT-based market information services (MIS): 3-stage analysis**

| Variable definition | 1st stage (awareness of ICT-based MIS) Dep. variable: Awareness of ICT-based MIS | | | | 2nd stage (decision to use ICT-based MIS) Dep. variable: Decision to use ICT-based MIS | | | | 3rd stage (Intensity of ICT-based MIS use) Dep. variable: Count of ICT-based MIS used | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Logit regression | | Marginal effects | | Logit regression | | Marginal effects | | Poisson regression | | Marginal effects | |
| | Coeff | p-value | Coeff | p-value | Coeff | p-value | Coeff | p-value | Coeff | p-value | Coeff | p-value |
| *Farmer-specific variables* | | | | | | | | | | | | |
| Log age | 0.235 | 0.587 | 0.058 | 0.587 | -0.320 | 0.245 | -0.087 | 0.243 | -0.045 | 0.801 | -0.052 | 0.801 |
| Gender | -0.191 | 0.457 | -0.047 | 0.457 | 0.223 | 0.174 | 0.060 | 0.174 | 0.104 | 0.285 | 0.122 | 0.285 |
| Literacy | 1.032 | 0.007 | 0.232 | 0.002 | 0.414 | 0.063 | 0.126 | 0.093 | 0.563 | 0.002 | 0.549 | 0.000 |
| *Farm-specific variables* | | | | | | | | | | | | |
| Log transptcost | 0.009 | 0.004 | 0.002 | 0.004 | 0.006 | 0.009 | 0.002 | 0.007 | 0.309 | 0.006 | 0.004 | 0.005 |
| *Capital endowment variables* | | | | | | | | | | | | |
| Mobilephone | -0.065 | 0.812 | -0.016 | 0.812 | 0.323 | 0.058 | 0.091 | 0.066 | -0.060 | 0.330 | 0.349 | 0.004 |
| Log landsize | -0.004 | 0.841 | -0.001 | 0.841 | -0.013 | 0.885 | -0.004 | 0.885 | 0.024 | 0.494 | -0.070 | 0.329 |
| Log income | 0.051 | 0.105 | 0.013 | 0.105 | 0.038 | 0.044 | 0.010 | 0.043 | 0.003 | 0.006 | 0.031 | 0.047 |
| Log assets | 0.264 | 0.005 | 0.065 | 0.005 | 0.023 | 0.688 | -0.006 | 0.688 | 0.027 | 0.048 | 0.028 | 0.049 |
| Group member | 0.208 | 0.432 | 0.051 | 0.429 | 0.373 | 0.022 | 0.105 | 0.025 | 0.169 | 0.105 | 0.195 | 0.098 |
| *Location characteristics* | | | | | | | | | | | | |
| Bungoma | 1.708 | 0.000 | 0.403 | 0.000 | 0.596 | 0.003 | 0.148 | 0.001 | 0.281 | 0.036 | 0.345 | 0.045 |
| Kirinyaga | -0.830 | 0.010 | -0.198 | 0.007 | 0.367 | 0.082 | 0.094 | 0.064 | 0.328 | 0.013 | 0.408 | 0.019 |
| Constant | -0.348 | 0.831 | | | 0.467 | 0.649 | | | -1.318 | 0.055 | | |
| Model characteristics | Number of obs = 379<br>Prob > $chi^2$ = 0.000<br>Pseudo $R^2$ = 0.201<br>Log likelihood = -208.36 | | | | Number of obs = 296<br>Prob > $chi^2$ = 0.000<br>Pseudo $R^2$ = 0.138<br>Log likelihood = -171.64 | | | | Number of obs = 296<br>Prob > $chi^2$ = 0.000<br>Pseudo $R^2$ = 0.207<br>Log likelihood = -386.89 | | | |

Source: authors` estimations (2014)

### 4.2 Factors Affecting the Decision to Use of ICT-based Market Information Services

Results of the logit model estimated to assess the drivers of the decision to use ICT-based MIS are presented in columns 6-9 of Table 3. They show that human capital (literacy level), farm specific variable (i.e., transport cost to the nearest output market), physical and financial capital endowments (i.e., owning a mobile phone, log of income from farming activities) and social capital (proxied by membership to a farmer organization) positively influence the decision to use of the ICT-based market information services among the smallholder farmers. Results further show that location variables, namely, Bungoma and Kirinyaga, positively influence the decision to use of ICT-based MIS.

Results of the marginal effects show that a unit increase in farmer's level of education increases the likelihood of a decision to use ICT-based MIS by 0.13, holding other factors constant. It suggests that more educated farmers are more likely to use of ICT-based MIS and corroborates the findings of OKELLO et al. (2010). Similarly, other things equal, owning a mobile phone increases the likelihood of deciding to use ICT-based MIS by 0.09, while a unit increase in farm income increases the chance of deciding to use ICT-based MIS by the 0.09, other things equal. Results also indicate that belonging to a farmer organization increases the likelihood of using ICT-based MIS used by 0.1, other factors being constant. This finding suggests that farmer organizations play a significant role in facilitating farmers' decision in the use ICT-based services. The finding can be attributed to the fact that most rural interventions tend to target farmers that are organized into producer organizations (WAMBUGU et al., 2010; SHIFERAW et al., 2011).The producer organizations considered in this study were specifically involved in production and marketing of crops. Such groups act as effective channels of new interventions relating to agricultural production and marketing (WAMBUGU et al., 2009).

Results further show that a unit increase in the cost of transport to the local output market increases the likelihood of using ICT-based MIS by 0.02, other things constant, indicating that farmers that face higher transaction costs are more likely to use MIS than their counterparts. In addition, the results show that farmers from Bungoma and Kirinyaga are more likely to use ICT-based MIS than their counterparts in Migori district. Compared to Migori district, Bungoma and Kirinyaga (especially the latter) have higher agricultural potential and grow higher value crops. In Kirinyaga, for instance, majority of smallholder farmers grow green beans and baby corn for export to Europe. Indeed, the ownership and use of mobile phones for agricultural transactions is much higher in Kirinyaga district than in Migori and Bungoma. These findings therefore indicate that the decision to use of ICT-based MIS may be affected by the agricultural potential of the area in which they are implemented.

### 4.3 Drivers of Intensity of Use of ICT-based MIS

Results of the Poisson regression model fitted to assess drivers of the intensity of use of ICT-based MIS are presented in the last 4 columns of Table 3. They show that literacy level, transport cost to the nearest output market, crop income, and endowment with financial assets positively influence the intensity of use of ICT-based market information services. Results further show that location variables also affect the intensity of use of ICT-based MIS. The marginal effects show that a unit increase in farmer's literacy level increases the expected number of ICT-based market information services used by a farmer by 0.55, holding other factors constant. Similarly, a unit increase in transport cost increases the expected number of ICT-based MIS used by 0.004, other things being constant. Results also show that, other things constant, the expected number of ICT-based MIS used increases by 0.03 and 0.03, respectively, when the natural log of household income and financial assets is increased by 1 unit. At the same time the expected number of ICT-based MIS used increases by 0.35 and 0.41 if a farmer originates from Bungoma and Kirinyaga, respectively, holding all other factors constant.

## 5 Summary, Conclusions and Policy Implications

This study examined the conditioners of awareness of market information services provided by ICT-based projects and of the use of such services by smallholder farmers in Kenya. The study finds that awareness of the ICT-based market information services is driven by literacy level, transport cost (a proxy for transaction costs), asset endowments and the location of a farmer. These findings indicate that awareness of services can benefit from programs that promote literacy, reduce transaction costs farmers face, and improve wealth of farm households.

The study also finds that, among others literacy, ownership of a mobile phone, log of income, and membership to farmer organizations/groups explain the decision to use of ICT-based MIS, while literacy, distance to output market, the natural log of income and assets explain the intensity of use of ICT services. The study concludes that awareness of ICT-based MIS and their usage are affected by a wide range of farmer and farm specific factors as well as capital endowments and location characteristics.

Results further indicate that human capital (represented by literacy level) plays an important role in smallholder farmers' awareness, decision to use, and the intensity of their use of ICT-based MIS. While not entirely new, this finding implies that ICT projects designed to provide market information should employ strategies that do not require high literacy levels. These findings also suggest that high transaction costs drive the awareness, use, and the intensity of use of ICT-based MIS. This finding implies the need for infrastructural developments (especially improvement in quality of roads) to ease access to information. The finding that involvement by the farmer in farmer groups affects the decision to use ICT based MIS suggests the need to continue using such groups as conduits of ICT-based MIS. Indeed, most rural projects use producer organizations as the locus of intervention. Farmer groups do play a significant role in reducing transaction costs. They also act as channels of information to members. However, as recent studies suggest, the success of such groups can be undermined by many internal and external factors (MERKELOVA et al., 2009; MERKELOVA and MWANGI, 2010). Thus the success of ICT-based projects that are implemented through groups will greatly depend on the interplay of such factors.

The finding that the area in which ICT-based projects are implemented determines the use MIS implies that projects that target areas with higher agricultural potential are more likely to succeed in reaching farmers with agricultural information. It also suggests that ICT-based MIS projects implemented in areas with low agricultural potential have lower odds of succeeding since farmers in such areas are much less likely to pay for such services. This finding therefore has major implications for sustainability of ICT-based MIS projects in areas that produce low value crops.

The overall implication of the findings of this study is that strategies that seek to promote the provision of market information services to smallholder farmers through expansion of the coverage of ICT-based MIS projects in rural areas should take into account the incentives provided by such projects and capacity of the smallholder farmers to use them. For instance, the finding that literacy conditions awareness, use and the intensity of use of ICT-based MIS highlights the need to design tools that can be more easily used by the usually less educated smallholder farmers. In addition, attention should be given to the other farmer, farm, and location-specific characteristics of the targeted farmers.

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