A Triple Hurdle Analysis of the Use of Electronic-Based Agricultural Market Information Services: The Case of Smallholder Farmers in Kenya

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Abstract

Smallholder farmers' access to markets has traditionally been constrained by lack of market information. The need to facilitate farmers' access to markets has seen the emergence of many projects that employ electronic tools in the provision of market information services (MIS). This study used a triple hurdle analysis to examine the factors influencing farmer awareness of electronic based (e-based) MIS projects, the decision by smallholder farmers in Kenya to participate in such projects and the use of services they provide. It finds that the drivers of awareness, decision to participate in e-based projects and use of the use of e-based MIS various farmer, farm and location-specific characteristics as well as endowments with physical, financial, human, and social capital. It specifically finds that education, distance to market, membership to farmer organizations, household income and cell phone ownership affect both the decision to participate in e-based projects and the use of MIS services such projects offer. The study concludes that transaction costs and social, financial and human capital endowments play an important role in smallholder farmer participation in e-based projects and the use of e-based MIS. The study discusses the implications of these findings for policy and practice.

Key words: Smallholder farmers, e-based projects, use of MIS, Kenya

1. Introduction

Market access is one of the critical factors influencing the performance of smallholder agriculture in developing countries, and in particular least developed countries (Barrett, 2009; Kirsten, 2010). Access to new and better-paying markets for agricultural products is vital in enhancing and diversifying the livelihoods of poor subsistence or semi-subsistence farmers (Barrett, 2009). Such markets can be local (including village markets), catering for the local populations, regional markets that serve regional consumers in counties/districts/provinces within one country or between countries, and international/export markets in both developed and developing countries.

Smallholder producers form the majority of both the total and rural poor in many developing countries, especially in Africa. Most smallholder farmers are engaged in subsistence and semi-subsistence agriculture with low productivity, low marketable surplus (hence low

returns) and low investment, a situation described as low equilibrium poverty trap (Barrett, 2009, Barrett and Swallow, 2006). Enhancing returns from agricultural production through improved access to markets can therefore be a vital element of poverty alleviation strategies and livelihood improvement. Improved market access results in commercialization of agriculture, which can result in the production of marketable surplus and hence gains in income from agriculture and higher revenues, savings and hence investment in productivity enhancing technologies.

Despite its importance, market access in many developing countries remains severely constrained by poor access to agricultural/market information. Poor access to market information results in information-related problems namely moral hazard and adverse selection which in turn increase transaction costs and hence discourage participation in market by some farmers (Omamo, 1998; Fafchamps and Hill, 2005; Shiferaw et al., 2009). Recent attempts to resolve the problem of poor access to better performing markets by smallholder farmers have thus focused on promoting information transfer through e-based technologies (i.e., information and communication technologies (ICTs)) (Tollens, 2006; Aker, 2008). These technologies include mobile phones, internet/web-based means, and interactive video and CD-ROM as well as old generation ICTs such as the radio and television (Munyua, 2007).

The increased focus on modern e-based methods of information provision comes from the realization that they can play a major role in i) communicating knowledge and information to rural farmers, ii) delivering education and training modules to farmers at low cost, 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. A 2007 survey found 39 projects that were using the old and new generation ICT tools to provide different market information services (MIS) to farmers. Such projects provide a range of market information services to members including information on input and output price, volume, where to buy, produce quality, and where to sell.

Comment [P1]: Who conducted this survey? Cite source of this information

Despite the increase in the use of e-based MIS projects in agriculture in many African countries, little is known about farmers' awareness of e-based MIS projects and what informs their decision to participate in and usage of services they provide. This study aims at filling these gaps in the literature and supporting policy in the application of ICT in enhancing access to agricultural information by smallholders. Such knowledge is essential in the

scaling-up and out of successful interventions and re-designing failed e-based projects. The specific objectives of this paper are to: i) determine the factors affecting awareness of e-based MIS projects ii) examine the drivers of participation in such projects and iii) assess the determinants of use of e-based MIS by farmers

This paper focuses on smallholder farmers in located areas of Kenya that have been targeted with e-based MIS projects. Smallholder farmers form majority of the farming community in Kenya. Such farmers usually face major difficulties in accessing agricultural information hence are the key targets of e-based MIS projects. The rest of this paper is organized as follows: Section 2 presents the conceptual framework of the study. Section 3 outlines the empirical methods. Section 4 discusses the study results while Section 5 provides some concluding remarks and discusses the policy implications of the study findings.

2. Conceptual framework

This study employs the Transaction Cost theory to model the behavior of economic agents in agricultural markets. Transaction Cost theory is part of the New Institutional Economics – NIE - (Hubbard, 1997; Clague, 1997; Poulton *et al*, 1998). The concept of transaction costs was first introduced by Coase (1937) and has been widely used in studies in agricultural economics and related fields in developing countries (Jaffee, 2005; Fafchamps, 2004; Fafchamps and Hill, 2005; Okello and Swinton, 2007).

Transaction cost is loosely defined as cost of doing business or cost of exchange between two trading partners, in our case farmers and buyers. It posits that difficulties in economic exchange between two partners arise because of exchange related problems that include asymmetric information. In small farm situation, 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 Williamson (1985) or "self-interest seeking with guile" (Miller, 2005). In the case of 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 terms of exchange beforehand.

However, while the terms of the exchange can be specified *a priori* (i.e., through a contract), the uncertain nature of future outcomes makes it impractical to write complete contracts resulting instead in the use of informal agreements (i.e., incomplete contracts) (Williamson, 2000; Menard, 2005). That is, even though economic agents may be rational in their decision-making, they are bounded by the uncertainty of future outcomes. Under such circumstances, the buyer even with a priori agreement on terms of exchange can take advantage of the farmer by engaging in actions that are contrary to the specifications of the agreement, a condition known as moral hazard. Alternatively, the buyer may claim ability to meet the terms of the agreement (e.g., buy the entire commodity from the farmer) only to fail to do so due to changes in the market, a situation called adverse selection. These conditions prevail in many farming environments in Africa where agricultural information is generally unavailable and has been one of the factors behind the push for e-based projects. Lack of information between the seller (farmer) and the buyer make the exchange of goods (i.e., trade) more costly (Williamson, 2004). Coase (1937) argued that these costs of exchange include search and screening costs, negotiation costs, costs of monitoring and enforcing terms of agreement, and costs of adapting to change in market environment (also known as maladaptation 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 dictate adjustments in 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), Fafchamps (2004), and Fafchamps and Gabre-Madhin (2006) for instance highlight some of these costs in relation to African farmers and traders. The bottom-line is that lack of market information increases the costs of exchange between the farmer and

buyer. Smallholder farmers are especially disadvantaged because they trade in small volumes usually in geographically dispersed markets hence are not able to take advantage of economies of scale to reduce the unit transaction costs of exchange. Theoretically, households that use market information services provided by e-based projects are expected to face lower transaction costs. Unlike their counterparts, such farmers are likely to use the services offered by the project to resolve some of the idiosyncratic market failures resulting from high transaction costs.

3 Empirical methods

This study uses a triple-hurdle model to address the study objectives. The first stage (hurdle) uses logit regression model to assess whether farmers are aware of the e-based MIS or not. The second stage (hurdle) also uses a logit regression model to examine the conditioners of decision to participate in e-based projects. Lastly, the third stage (hurdle) uses a Poisson regression model to extent of usage of e-based MIS provided by the project by farmers who have decided to participate in the e-based projects. These stages are discussed in detail below.

3.1 Assessing awareness of and decision to participate in e-based MIS projects

The awareness of e-based MIS projects (decision to participation in e-based MIS) by farmers can be measured as a dichotomous variable that assumes the value of 1if the farmer is aware (decides to participate) and 0 otherwise. It can therefore be analyzed using a 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 (1983, 2001), the probability, *P*, that a household is aware of (decides to participates in) e-based MIS project is given by:

$$P = e^{z}/1+e^{Y} \quad (1)$$

and,

$$Y= ln(P/1-P) \quad (2)$$

where;

$$Y = Y(F, R, K, L)+ \varepsilon \quad (3)$$

Y in is a latent variable that takes the value of 1 if the farmer is aware of (decides to participate in) e-based MIS project and 0 otherwise, e is the exponent, F is a vector of farmer characteristics, R is a vector of farm level variables, K is a vector of capital

endowments, Z is a vector of locational variables and ε is the stochastic term assumed to have a logistic distribution.

The factors hypothesized to influence the awareness of (decision to to participate in)e-based projects include farmer, farm, capital endowment and location specific variables. These variables are selected based on the literature and *a priori* expectation:

1) Farmer specific variables (F) = *age* (years), *lnage* is natural logarithm of age, *gender* (1 if male, 0 otherwise), *occupation* (1 if farming, 0 otherwise), devproj (1 if farmer participates in other development projects, 0 otherwiise).
2) Farm specific variables (R) = distance to the market in kilometers, *enterprises* is the count of crop and livestock of enterprises, *hhdsize* is count of individuals in the household, member of other development project (1 if yes, 0 otherwise) and *transport* is the natural log of transport cost in Kenya Shillings.
3) Capital endowment variables (*K*): Physical capital = value of assets (Kenya Shillings[1]), *lfarmsize* (size of land in acres) *mobile phone* (1 if farmer owns mobile phone, 0 otherwise); Human capital = education (years), experience (years of farming); Social capital group (1 if member of farmer group 0 otherwise); Financial capital: income = crop income (Kenya Shillings).
4) Location variables (L): *kiriyanga* (1 if study district is Kirinyaga, 0 otherwise), *bungoma* (1 if study district is Bungoma, 0 otherwise), *migori* (1 if study district is Migori, 0 otherwise).

3.2 Assessing the intensity of use of e–based market information services

The intensity of use of e–based MIS is proxied in this study by the number of e-based market information services used by the farmer. The e-based market information services considered in this study include information on input price, output price, market where to buy, market where to sell, quality of produce, and quantity (volumes) of produce. The number of services used by a farmer assumes integer values of discrete nature and is therefore a nonnegative count variable. In such cases, count data models are employed in the analysis of the intensity of use of any technology.

[1] Exchange rate at the time of survey was 1USD = 75 Kenya Shillings

The most common regression models 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 PRM is used in this study since the test of under-dispersion and over-dispersion, common problems that render estimates of PRM biased, found absence of these problems in the estimated PRM.

Following Wooldridge, 2002 and Greene, 2008, the density function of the Poisson regression model is specified asfollows;:

$$f(y_i|x_i) = \frac{e^{-\lambda(x)}\lambda_i(x)^y}{\Gamma(1+y_i)} \quad (4)$$

Where $\lambda_i = \exp(\alpha + X'\beta)$ and $y_i = 0,1,...,i$ is the number/count of 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 e-based MIS as the dependent variable and similar explanatory variables as those of the aware/use model specified in equation 4 above.

3.3 Sampling procedure and data

This study used survey data collected from smallholder farmers in Kirinyaga, Bungoma and Migori districts in Kenya. The districts were selected for this survey because they present diversity of social and economic backgrounds. Kirinyaga district has export oriented agriculture with several export crops (French beans, various Asian vegetables and baby corn) being produced. Smallholder farmers in Bungoma district grow mainly maize with some sugarcane. In Migori, on the other hand, the main crops are maize and some little tobacco. Thus, the choice of the districts provides diverse socio-economic and cultural backgrounds as described in Okello *et al* (2010).

The study targeted smallholder farmers including those who participate in e-based project whose aim is to facilitate smallholder farmer linkage to markets through the use of e-based MIS and those who do not. The respondents in this study were therefore stratified by participation in such e-based agricultural projects. A three-stage sampling procedure was used to identify 379 farmers spread across the three districts. First, in each district, an area with an e-based project that provides the MIS services identified above was identified. Second, for each such area, a list of all farmers participating in the e-based projects was drawn with the help of project leaders and farmer leaders. A second list of farmers that do not participate in the e-based projects was also obtained with the help of local administration

(village elders and area agricultural extension officers). Third, the respondents were sampled from the two lists using probability proportionate to size sampling method. This procedure resulted in 162 farmers who have participated in e-based interventions and 216 non-participants. A total of 379 farmers were therefore interviewed in this study. This comprised of 127, 130 and 122 respondents from Kirinyaga, Bungoma and Migori districts respectively. The data was collected through personal interviews using a pre-tested questionnaire in April 2010. The information collected included farmer-specific characteristics, farm-specific characteristics, household capital/asset endowments, and locational characteristics. The household survey was conducted in April 2010. Table 1 summarizes the data and presents the t-test of differences in means of e-based project participating and non-participating farmers.

Table 1: Characterizing respondents by participantion in e-based projects

Variable definition	Participant (N-164)	Non participant (N=215)	Mean difference	t-values
Dependent variables				
participation	0.74	0.58	0.16***	3.19
Use of MIS (1,0)	0.81	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
Education	8.62	8.21	0.41	1.08
Hhd 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				
distance to market	6.32	4.73	1.60***	3.12
transport cost	3.04	2.81	0.23	1.49
Enterprises	4.85	4.11	0.74*	1.71
Member of other Dev project	0.64	0.22	0.42***	9.05
Capital endowment variables				
Land size	2.58	2.21	0.37	1.54
Experience	18.63	17.22	1.40	1.16
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
Locational 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

Note: Significance level: *10 %t, **5% and ***1%.

The t-values suggest that there are differences between participants and non participants of e-based projects with respect to farmer-specific, farm-level and capital endowment characteristics. Specifically, there appears to be differences in household size and hence household adult equivalent. Interestingly, non-participating households are bigger and hence have a bigger adult equivalent.

Results further show significant difference between e-based project participants and their counterparts with regard to distances to the local market, nearest input market, nearest output market and nearest agricultural extension office. The participating households were further from the markets than their counterparts. Participants also have more crop enterprises than the non-participating households, suggesting that the participating households are more risk averse than their counterparts.

4.0 Results and Discussion

Results for the triple-hurdle model are presented in Table 2. We discuss the results of each of the hurdles below.

4.1 Drivers of awareness of e-based market information services projects

The factors influencing awareness of e-based MIS projects are presented in Table 2. Results show that literacy of the household head, household asset endowment and farm level characteristics (proxied by transport cost to the main market) positively influences awareness of e-based MIS. Regional characteristics have both negative and positive influence on the awareness of the e-based MIS. The marginal effects show that, a unit increase in the natural log of assets increases the likelihood of awareness of e-based projects by 0.07, holding other things constant, suggesting that farmers with more asset endowments are more likely to learn about the presence of an MIS project in an area. esults further show that a unit increase in literacy and transport cost to the main market increase the likelihood of awareness of e-based MIS by 0.23 and 0.02 respectively, holding other factors constant. This finding suggests that farmers living far from the main markets may opt to use e-based MIS to counter the costs of travelling to the market to obtain market information.

Table 2: Results of the priple-hurdle model estimations

Variable definition	1st hurdle (awareness of e-based MIS) Dep. variable: Farmer is awareness of e-based MIS project				2nd hurdle (decision to use participate) Dep. variable: Farmer decides to participate in e-based MIS project				3rd hurdle (Intensity of using e-based MIS) Dep. variable: Number of e-based MIS			
	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												
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
Education Level	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												
Distance to the market	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												
Mobile phone	-0.065	0.812	-0.016	0.812	0.323	0.058	0.091	0.066	-0.060	0.330	0.349	0.004
Farm size	-0.004	0.841	-0.001	0.841	-0.013	0.885	-0.004	0.885	0.024	0.494	-0.070	0.329
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
Assets	0.264	0.005	0.065	0.005	0.023	0.688	-0.006	0.688	0.027	0.048	0.028	0.494
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 Prob > chi^2 = 0.000 Pseudo R^2 = 0.201 Log likelihood = -208.36				Number of obs = 379 Prob > chi^2 = 0.000 Pseudo R^2 = 0.138 Log likelihood = -171.64				Number of obs = 379 Prob > chi^2 = 0.000 Pseudo R^2 = 0.207 Log likelihood = -174.38			

Similarly, results show that farmers from Bungoma, districts are more likely to be aware of e-based projects, holding other factors constant. Farmers in Kirinyaga are less likely to be aware of the e-based MIS by a factor of 0.19 holding other factors constant. This finding is likely to be due to the popular radio auction program (Soko Hewani) hosted by KACE in western Kenya.

4.2 Factors affecting the decision to participate in e-based MIS

Results of the drives of decision to participate in e-based MIS projects are also presented in Table 2 show that human capital (literacy level), farm specific variable (proxied by transport cost to the nearest output market), financial asset endowment (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 participate in such projects .

Results further show that location variables, namely district of survey (Bungoma and Kirinyaga) positively influence the decision to participate in e-based MIS projects. Results of the marginal effects show that a unit increase in farmer literacy level increases the likelihood of participation in e-based project by used 0.13, holding other factors constant This finding suggests the importance of education in using e-based MIS and corroborates the findings of Okello et al (2010). Similarly, owning a mobile phone and increases the likelihood of participating in e-based projects 0.09 and increasing farm income by 1% increases the likelihood of participation by1%, ceteris paribus. Results further show that belonging to a farmers' organization increases the likelihood of participation in e-based MIS projects by 0.1, other factors being constant, and suggests the role that farmer organizations can play in facilitating farmers' use of services provided by such projects. At the same time, increasing the log of transport cost to the local output market by 1% as well increases the likelihood of participation in e-based MIS use by 0.02 other things constant, indicating that farmers that face higher transaction costs use more MIS than their counterparts. Farmers from Bungoma and Kirinyaga have a probability of 0.19 and 0.09 respectively of using e-based MIS holding all other factors constant.

4.3 Factors affecting the intensity of use of services provided by e-based MIS projects

Results of the Poisson model fitted to assess the intensity of use of e-based MIS are presented in Table 2 above. They show that farmer literacy level, transport cost to the nearest output market and natural crop income and financial assets, positively affect the expected number of e-based market information services used by the farmers. Results further show that location variables, namely district of survey also positively influences intensity of use of e-based MIS. Results of the marginal effects show that a unit increase in farmer literacy level increases the expected number of e-based market information services by 0.55, holding other factors constant. This finding further support the argument above that education is important in the use of e-based market information and services.

Similarly, a unit increase in transport cost to the local output market increases the expected number of use of e-based MIS by 0.004 other things being constant. While not unexpected, the finding suggests that farmers seek to counter the effects of high transportation (hence transaction) costs by using MIS. Results also show that, other things constant, increasing the log of household income and financial assets by 1 unit each, increases the expected number of e-based MIS used by farmers by 0.03 and 0.03, respectively. At the same time the expected number of e-based MIS used by farmers increases by 0.35 and 0.41 if a farmer resides in Bungoma and Kirinyaga, respectively, holding all other factors constant.

5. Conclusions and policy implications

Comment [JJ2]: REVISE TO INCLUDE AWARENESS

This study examines the conditioners of participation in e-based MIS projects and the use of e-based market information services by smallholder farmers in Kenya using a triple hurdle model. The study finds that participation in the e-based projects is driven by household size, experience in farming, level of education of the household head, social capital (proxied by membership to a farmer organization/group) and endowment with financial assets. The study also finds that, among others, distance to the nearest output market (a proxy for transaction costs), education level of the household head, by membership to a farmer organizations/groups and endowment with physical and financial assets explain the use and intensity of use electronic services. The study concludes that participation in e-based MIS projects and the use of e-based MIS is conditioned by a wide range of farmer specific, farm specific, capital endowments, and locational characteristics. These findings suggest that high transaction costs drive the use of MIS provides by e-based projects and indicate that capital endowments play an important role in smallholder farmers' decision to participate in e-based

projects. They suggest the need for supporting such farmers to work together as groups to facilitate their participation in such projects.

The overall implication of these findings is that strategies that seek to promote the provision of market information services to smallholder farmers through expansion of the coverage of e-based MIS projects in rural areas should take into account the incentives such projects provide and capacity of the smallholder farmers to use them. In addition, attention should be given to the farmer, farmer and locational characteristics of the targeted farmers.

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