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Factors underlying farmers' choice of market information system in Lilongwe, Malawi

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Abstract

The paper sought to investigate the effect of simultaneous use of radio- and mobile phone-based agricultural market information systems on smallholder farmers' access to information focusing on prices of agricultural inputs and commodities. A multivariate probit model was estimated to gauge potential use of each information system by farmers to access information on prices of agricultural inputs and commodities. Results reveals limited use of mobile phones to jointly access input and commodity prices as the devices were mainly for accessing information on commodity prices. The cost of using mobile phones was the dominant factor underlying the low use of mobile phones to access information on commodity prices. The cost of use along with farmers' access to extension and group membership were the major factors underlying the use of radio to access price information. Results predicted higher prospect for smallholder farmers to use radio- than mobile phone-based information system to access information on agricultural inputs and commodities. Endeavours to promote farmers access to markets information should focus on creating synergies with extension services and local initiatives linking farmers through groups. Future research on the subject matter should attempt to accommodate more means of acquiring market information including extension agents and explanatory variables to enhance robustness of the adopted model or its variants.

Keywords: AMIS, ICT, MIS, smallholder farmers

1. Introduction

Historically agricultural markets in Sub-Saharan Africa (SSA) have been inefficient and characterized by poor participation of smallholder farmers (SHFs) (Kherallah et al., 2000; Poulton and Kydd, 2006; Minot, 2010; Jayne et al., 2010b). There have been several donor and home-grown initiatives like liberalization of agricultural markets (Fafchamps and Gabre-Madhin, 2001; Chirwa, 2007) and enhancing SHFs' access to technology and information through agricultural extension and advisory services (Manda and Chapota, 2015) so as to increase their participation in agricultural markets. These efforts resulted into insignificant change in farmers' market access in Malawi due to several challenges such as low volume and poor quality of the produce; limited access to market development support services; high transaction costs and; poor quality of transportation, storage and market infrastructure (Jayne et al., 2010a; Jaffee et al., 2011). Earlier efforts to address the hardships through liberalization of agricultural markets and other fiscal policies did not bring the desired effects in Malawi (Fafchamps and Gabre-Madhin, 2001; Chirwa, 2007). Subsequently there have been concerted efforts to address some of the problems through enhancing the provision of agricultural market information.

Recent efforts to address the problem of poor access to market information have predominantly focused on development and promotion of communications means through two major interventions. One intervention hinged on radio-based agricultural market information system (AMIS). This intervention upholds the view that many SHFs in rural areas may rely on radio to get market information than other means of communication because it is cheap, easily

available and convenient for less educated people (Milan, 2009). The entry point has often been through community radio, which in the context of Malawi is in proximity to local communities and better positioned to articulate and accommodate local concerns and interests. The other intervention hinged on new generation ICT-tools based on mobile phone short message service (SMS). The rationale has been to exploit the potential created by the rapid diffusion of mobile phones among smallholder farmers (Malawi National Statistic Office, 2020) that is perceived to present immense potential for easing the provision of market support services to smallholder farmers and traders. In general, these interventions are ideal means to support other methods of disseminating agricultural information to SHFs and ensuring that they acquire it promptly. The desired effect on farmers' welfare is boosting their earnings through combined effects of increased crop productivity and sales, more effective market price discovery mechanisms and fairer exchange processes (Katengeza, 2011; Mhagama, 2015). This welfare effect can be realized if SHFs are effectively using radio and mobile phones for agricultural-related communication. However, empirical evidence reveals that SHFs' choice of communication means is bound to vary based on factors such as resources endowment, scale of production and extent of market participation (Sekabira et al., 2012; Chikuni and Kilima, 2019). This article seeks to assess joint use of radio- and mobile phone-based market information system (MIS) for agricultural related purposes and identify underlying factors. The ultimate goal is to make inferences about differential effect of the use of radio- vis-à-vis mobile phone-based MIS on farmers' production and marketing decisions. The major contribution to the existing knowledge is in terms of understanding how various interrelated ICT-based MIS are used by SHFs.

This article is organized in five sections including this introduction. The second section describes the context of the study whereas the third section offers a brief review of literature focusing mainly on factors underlying farmer's decision on the subject matter. The fourth section covers conceptual issues. The fifth section describes the data used as well as sampling and estimation procedures. This is followed by discussion of main findings in section six and summary and recommendations in the last section.

1.1 Context of the Study

Smallholder farms in Malawi continue to face unique difficulties in marketing their produce because there is notable variation in market access based on actual levels of production and distance from markets (Jayne et al., 2010b). Most of these problems are linked to their poor access to market information. The introduction of ICT-based MIS is perceived to be ideal to enhance farmers' access to market information and reduce transaction costs. However, some scholars (Steinfield *et al*., 2015) argue that mobile phone-based interventions in Malawi might be based on overstated mobile penetration rate because there is no accurate account of mobile ownership and use. Ownership of more than one phone among some farmers as well as shared use among others is common. Other scholars (Katengeza, 2011; Steinfield *et al*., 2015, Chalemba, 2016) have indicated that most of these interventions have been financed through donor initiatives which tend to be less effective when the support ends. Moreover, Chalemba (2016) observed that most SHFs have low levels of education to be able to fully exploit the potential created by ICT-based agricultural MIS initiatives. It is not yet well-established whether there are statistical differences in use of the ICT-based market information service among SHFs. Also, it is unknown whether a majority use the service for intended purposes.

An evaluation of actual use of ICT-based agricultural MIS among the SHFs in Malawi predicts higher use of radio- than mobile phone-based market information systems (Manfre and Nordehn, 2013; Opolot, 2016; Chikuni and Kilima, 2019). However, most of these evaluations are based on isolated models or case studies to estimate the likelihoods of adoption without due consideration of multiple use. Thus, it is important to establish whether there are statistical differences in the adoption prospect and use of radio- and mobile phone-based MIS. It is worth noting that there could be fundamental differences in information that farmers source through each means implying reliance on diversified means.

Profiling farmers' use of the information systems according to observable characteristics is imperative to inform future interventions seeking to address market failures through specific means of communication. This paper seeks to achieve this goal and is an extension of previous analysis of effects of mobile phone-based MIS on farmers' decision to participate in maize markets in Lilongwe, Malawi (Chikuni and Kilima, 2019). Findings from the previous study underscore the need to integrate radio and mobile phones in agricultural MIS and to provide farmers with information on production in addition to commodity prices.

1.2 Literature Review

Smallholder farmers are bound to make production and marketing decisions that are normally inseparable unless crop production is purely subsistence (Tadesse and Bahiigwa, 2015). Thus, they require information of agricultural inputs and commodities. The major source of information for SHFs in Malawi has been public extension services

mandated to disseminate among others knowledge on agricultural technologies, cropping system for different agro-ecological zones, agronomic practices and market information (Chowa et al., 2013). The public extension service in Malawi has been criticized to be irresponsive to varied needs for information among SHFs (Chowa et al., 2013). The farmers are increasingly becoming different because some are seeking entry into other market channels or venturing into contract farming (Chirwa and Matita, 2012; Forsythe et al., 2016).

The shortfall in the provision of extension services has led to a shift in policy towards supporting provision by agents from the private sector and lead farmers and harnessing the advancements in the information and communication technologies (ICTs) to diversify the source of information and ease its availability (Milan, 2009; Chowa et al., 2013). The proliferation of sources of information implies that farmers can potentially use multiple sources of- or means of acquiring information for similar purposes. It is important to understand how the major ICT-based interventions are used to satisfy different purposes intended by the users.

The question on whether smallholder farmers use mobile phones for agricultural-related communication and transaction has elicited massive interest among scholars. Empirical studies show that there is limited use of mobile phones for agricultural related purposes despite the huge investment in the MIS (Asingwire and Okello, 2011; Galtier *et al*., 2014; Chikuni and Kilima, 2019). Nevertheless, evidence reveal notable variation in the use of mobile phone for such purposes by sex (Huyer *et al*., 2005; Karim *et al*., 2009; Burrell, 2010; Mpazanje and Chigona, 2012); age (Karim *et al*., 2009; Kilima et al., 2016); location and extent of market development (Geldof, 2011; Steinfield and Wyche, 2013); level of education (Steinfield and Wyche, 2013); income (Okello *et al*., 2012) and extent of commercialization of crop production (Sekabira et al., 2012; Chikuni and Kilima, 2019).

Literature also recognizes a difference between ownership of ICT-based communication device and its use to access market information because one may own a mobile phone and use it for purposes other than accessing market information, a typical example would be predominant use of mobile phone for entertainment (Wei, 2008; Shava et al., 2016)—a more likely scenario among young people in Africa. The possibility of one using a mobile phone without owning it has also been reported (Issahaku et al., 2018). The act of sharing a mobile phone can have positive effect when there is equal access between people sharing it but is detriment when the use is predominantly by some. Married women, for example, could be systematically excluded from use when phones are shared with their husbands, especially in patrilineal societies (Burrell, 2010).

Moreover, there are other aspects surrounding the distinction in the use of mobile phones including multiple ownership of similar devices among some leading to sub-optimal use. Per capital ownership of more than one phone has been reported in Rwanda although most of the owners are relatively older and more educated people while effective use is among those with higher income (Blumenstock and Eagle, 2010). Also it has been established that men tend to call friends and business contacts while women call family members. Additionally, unlike men women are also reported to receive more calls but they call others less frequently (Blumenstock and Eagle, 2010; Blumenstock et al., 2012). The skewed use of mobile phones has also been reported in Malawi where some women are reported to use mobile phones as means to elevate their status and command higher recognition in work places and other social affairs, which casts doubts with respect to whether men and women are equally likely to use the device for agricultural communication and transactions.

Interestingly there is also evidence revealing higher use of radio than mobile phones for acquisition of agricultural-related information (Manfre and Nordehn, 2013; Opolot, 2016; Chikuni and Kilima, 2019). The higher use of radio than mobile phone is attributed to several factors. In a gender perspective radio seems to commands higher appeal among women because it allows them to listen to their favourite programmes while performing household chores (Opolot, 2016). It is worth noting that technical advancements that led to successful integration of radio and mobile phones has allowed men to leave their radio when away from home as they can conveniently use those inbuilt in their mobile phones thereby easing access to women. In terms of socio-cultural orientation, information aired through radio has been reported to be more flexible in terms of accommodating local flavours and interests. With respect to ownership, the proportion of smallholder farmers in rural areas of Malawi owning radio has always been larger than those owing mobile phones (Chalemba, 2016). Other reasons to explain the difference revolve around: availability and network coverage, which is better for users of radio than mobile phones and costs of acquisition and use that are also reported to be lower for radio than mobile phones (Megwa, 2007; Milan, 2009).

In summary there are differences in use of mobile phone and radio for agricultural communication. However, scholars are in favour of integrated use because users' profile and economic conditions rarely stay at the same levels. In the context of Malawi there has been a modest transformation from subsistence to commercial farming albeit for

some crops (Chirwa and Matita, 2012; Forsythe et al., 2016). This commercialization coupled with rapid diffusion of mobile phones imply a gradual shift in farmers' preference towards ICTs because farmers with commercial orientation are normally more willing to use ICT-based MIS for agricultural purposes than subsistence farmers (Chikuni and Kilima, 2019).

The optimism regarding future adoption potential of different means of communication in Malawi has not yet been fully assessed. Studies that have explicitly modelled multiple adoptions of communication means have generally been rare. Some of the previous studies have relied on descriptive analysis to compare the use of radio and mobile phone for agricultural related purposed (Katengeza, 2011; Mhagama, 2015; Chilemba, 2016) while others have examined the use of one device only (Steinfield *et al*., 2015). Parametric approaches (e.g. Chikuni and Kilima, 2019) have largely been applied to model the use of mobile phone-based MIS without due consideration of simultaneous use of the ICT-based MIS. Models that account for simultaneous adoption of radio- and mobile phone-based MIS among SHFs in Malawi are needed. These models normally give more reliable estimates than those considering adoption of one MIS.

1.3 Theoretical Framework and Analytical Model

Theoretical Framework

It has been established from the literature review that farmers can simultaneously use multiple sources of information for similar information needs. Thus, we allow simultaneous choice of radio- and mobile phone-based market information system among SHFs. This choice is normally modelled under the assumption of utility maximization and rational behaviour (Garín-Muñoz et al., 2019; Leng et al., 2020). Rational decision makers normally strive to attain the highest utility from adopting the ICT-based MIS. This utility is unobservable but measured indirectly by a decision maker in terms of his/her use value and satisfaction. The use value and satisfaction are depicted by user's choice of attainable means to acquire information on agricultural inputs and commodity prices.

Thus, a user will adopt both means ($Y_{ij} = 1$) if expected utility from simultaneous adoption of ICT-based market information systems ($\mathrm{E}(U_y)$) is greater than corresponding utility without simultaneous adoption ($\mathrm{E}(U_0)$). Otherwise no simultaneous adoption will occur ($Y_{ij} = 0$). This adoption process is given as:

$$Y_{ij} = \begin{Bmatrix} 1 \; if \; \mathrm{E}(U_y) - \mathrm{E}(U_0) > 0) \\ 0 \; if \; \mathrm{E}(U_y) - \mathrm{E}(U_0) < 0) \end{Bmatrix} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Specific assumptions about the relationship of error terms of the actual adoption equations with respect to whether there is potential correlation between errors or not is determined by the type of qualitative choice model specified in the analytical model. The paper deployed a multivariate approach to investigate correlations between using radio- and mobile phone-based MIS while at the same time exploring underlying factors. Interventions to promote farmers' access to market information should be based on thorough understanding of context-specific circumstances and factors that influence farmers' choice of ICT-based MIS and ultimate use.

Analytical Model

A multivariate probit model (MVPM) was estimated to derive insight on effects of farmers' socioeconomic factors that lead to their adoption of radio- and mobile phone-based MIS to access input and commodity prices. The model is more relevant than multinomial regression analysis because the assumption of independence of irrelevant alternatives fails when the error terms of the choice equations are not mutually exclusive (Greene, 2003). The choices among the options considered are not mutually exclusive because SHFs can access input and commodity prices using both radio- and mobile phone-based MIS. Thus, the random error components from the two choices may be correlated. The use of MVPM allows for the possible contemporaneous correlation in the two choices. The model has been widely used for related technology adoption scenarios in Malawi (Assa et al., 2014; Mulwa et al., 2017; Maonga et al., 2017) and elsewhere (Ulimwengu and Sanyal, 2011; Nakazi *et al*., 2018). The empirical model was specified as per Equation 2:

$$Y_{ij} = X'_{ij}\beta_j + \varepsilon_{ij} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Where, *i* identifies a farmer using a particular MIS, Y_{ij} (*j*=1, 2) represent the two different MIS available for the i^{th} farmer. Y_{ij} is a $1 \times k$ vector of variables hypothesized to affect the choice decision of a farmer, β_j is a vector of unknown parameters to be estimated, and ε_{ij} represent the error terms which are assumed to jointly follow a

multivariate normal (MVN) distribution with zero conditional mean and variance normalized to unity where the symmetric covariance matrix Ω is given as:

$$\Omega = \begin{bmatrix} 1 & \rho_{12} \\ \rho_{21} & 1 \end{bmatrix} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (3)$$

where ρ_{ij} represent the correlation between the two MIS. The unknown parameters in Equation (1) are normally estimated using simulated maximum likelihood, which uses Geweke-Hajivassiliour-Keane smooth recursive conditioning simulator procedure to evaluate the multivariate normal distribution.

Socio-economic Factors Affecting Farmers' Use of ICT-based Market Information System

The use of ICT-based technologies is influences by its attributes as well as user-specific variables. The former is implicitly imbedded in the ICT devises and are difficult to measure. The later have been identified to include age, sex, education level, access to extension services, group membership as well as extent of market participation and cost of use.

Age of a farmer can affect the use of ICT-based MIS because young and old people exhibit different risk attitudes. Literature shows that the use of ICT devices could be higher among younger than old people because they normally learn faster and are more willing to try new technologies (Morris and Venkatesh 2000; Cant and Shen, 2006). Also it has been established that young people tend to attach higher value to ICT-based communication than old people (Wilska, 2003) whose extensive experience and farming knowledge may make them more receptive to traditional sources of information. Therefore, is expected that increase in age will lead to less dependence on multiple sources of information.

Education plays key roles in shaping farmers' decisions to acquire and comprehend new information. Farmers with better education are normally more capable of managing, analysing and using new information more effectively than less educated farmers. Moreover, they are perceived to be early adopters as they are able to bear the risks associated with ICT-based communication devices and they also have a greater need for sophisticated information including ICT-based agricultural MIS (Just *et al*., 2006).

The differential impact of being male or female on use of ICT-based MIS is profoundly based on their literacy, competencies to use the devices and access to resources and income generating opportunities (Vekiri and Chronaki, 2008) where males are seen to have a competitive edge. Males are also expected to have better connections to market networks than female (Dessie et al., 2018). The greater connection implies that they are more likely to use multiples ICT-devices as means to fast-track business transactions (Karim *et al*., 2009).

The cost of use is expected to impact negatively on farmers' probability to use multiple ICT devices (Jayathilake et al., 2008). Thus, increase in use cost is expected to lower the use of multiple ICT-devices. Group membership could be instrumental in serving as platform for farmers to learn about how to use ICT devices for searching relevant information, which is vital to fast-track the adoption and use. Hatakka *et al*. (2014) reveal that there is always someone within the groups who can help the others to search for relevant information. Thus, group members are more likely to use multiple ICT-devices than non-members.

Empirical studies suggest a positive relationship between farmers' market participation decision and access to market information (Fan and Salas Garcia, 2018; Kilima and Chikuni, 2019). We therefore expect access to extension services, use of radio- and mobile phone-based MIS to be positively related to farmers' market participation. Thus, the use of diversified sources of information is likely to be higher among farmers who are already participating in agricultural markets.

2. Materials and Methods

Data used in the analysis were collected in 2017 from Lilongwe, Malawi because it is where most of the ICT-based MIS initiatives are launched and promoted. A cross-sectional survey was conducted to allow collection of similar information from 199 SHFs in 20 extension planning areas (EPAs). The EPAs are sub-divided into sections where Agricultural Extension Development Officers (AEDOs) are assigned up to five sections and have actual lists of the farmers to serve. A multistage sampling technique was adopted to select SHFs. The 1st stage entailed a random selection of five (Chitekwere, Ukwe, Ming'ongo, Thawale and Demela) EPAs which was followed by a random selection of two sections from each EPA during the 2nd stage. The 3rd stage involved a random selection of the 199

SHFs from the respective AEDO's lists for questionnaire interviews. The required sample size was 196 and was calculated following the United Nations (2005) handbook for designing household survey samples, which is given as:

$n_h = (z^2)(r)(1-r)(f)(k)/(p)(\breve{n})(e^2)$ ………………………….…… (4)

Where n_h is the required number of SHFs, r is the proportion of users of mobile phones, f is the sample design effect, k is a multiplier to account for non-response, p is the proportion of the target population in the entire population, $\breve{n}$ is the average household size and e is the margin of error to be tolerated. Recommended values for unknown constants are a z-statistic of 1.96 for the 95-percent level of confidence, a default value of 2.0 for f, and a value of 1.1 for k (United Nations, 2005). The Malawi National Statistics Office (2014), reports that the average household size $\breve{n}$ in Malawi is 6 people whereas Kundhlande *et al.* (2014) show that the proportion of SHFs in the entire population in Malawi (p) is 0.8. According to the National Statistics Office (2014) the overall proportion of Malawians owning mobile phones (r) is estimated to be 0.35. The actual sample was inflated to 199 to minimize potential problems such as non-response and participants denial to be interviewed.

During the survey, SHFs were interviewed by five experienced and well-trained enumerators using a structured questionnaire. The questionnaire was pretested prior to conducting the survey and reviewed to omit ambiguous and irrelevant questions. The interview solicited data on farmers' socio-economic characteristics; their access to radio- and mobile phone-based MIS as well as extension services; their market participation, involvement in farmer groups and other factors related to the subject matter.

Statistical tests that are performed include Chi-square test of independence to evaluate association between using radio- and mobile phone-based MIS to access the information and specific categorical variables that were used to describe farmers' characteristics. The null hypothesis for Chi-square test is that there is no association between farmers' socio-economic characteristics and their access to radio- and mobile phone-based MIS. We also use t-statistic to test for mean difference in quantitative variables between farmers using radio and mobile phone to access the information vis-à-vis those not using the services. The null hypothesis for the t-test is that there is no difference in age and weekly expenditure (cost) on radio and mobile phones between users and non-users of radio- and mobile phone-based MIS. These tests were performed Using STATA version 13.1.

The MVPM (Equation 2) is used to assess effects of farmers' socioeconomic factors that lead to their adoption of radio- and mobile phone-based MIS for accessing information on prices of agricultural inputs and commodities, which is the dependent variable in the model. Independent variable included in the model and prior assessments of effects on joint use of the ICT-based agricultural MIS are described in Table 1. The model was also estimated using the STATA software.

Table 1. Description of independent variables

Variable	Description	Type	Anticipated effect on joint use of radio- and mobile phone-based MIS
Gender	Sex of household's head (HHH) (1=Male, 0=Female)	Binary	Higher for male than female
Market-Participation	Whether the HHH participates in markets (1=Yes, 0=No)	Binary	Positive)
Extension-Service	Whether the HHH has access to extension services (1=Yes, 0=No)	Binary	Positive
Group-Membership	Whether the HHH is a member of farmer group(s) (1=Yes, 0=No)	Binary	Positive
Education	Whether the HHH has attained primary or lower education (1=Yes, 0=No)	Binary	Positive
Age	Age of HHH (years)	Continuous	Negative
Cost-Radio	Weekly cost for using radio (MK)	Continuous	Negative
Cost-Mobile Phone	Weekly cost for using mobile phone (MK)	Continuous	Negative

Sex of SHF affect the adoption prospect of radio- and mobile phone-based MIS because in Malawi production and marketing decisions are largely under the influence of males (Mudege *et al*, 2016). Moreover, they also have better access to resources and sources of knowledge (Vekiri and Chronaki, 2008) and connections to market networks (Dessie et al., 2018). The combined effects of these differences are to limit the adoption prospect among females. Market participation is hypothesised to have positive effect on farmers' adoption of the radio- and mobile phone-based MIS because ffective market participation requires farmers to have better and timely access to price information (Fan and Salas Garcia, 2018; Kilima and Chikuni, 2019). The provision of extension services is likely to have positive impact on the adoption of MIS as one of the roles of AEDOs in Lilongwe has been to sensitize farmers about reliable sources of market information. Farmer groups are appropriate means to enhance their access to sources of vital information on production and marketing and abilities to use ICT-based MIS and are likely to have positive effect on the adoption prospect (Fischer & Qaim, 2012; Hatakka *et al*. 2014).

The positive effect of education on farmers' adoption of radio- and mobile phone-based MIS arise from two factors: first, better educated SHFs are capable of using new information more effectively than less educated ones; second, they are more likely to adopt ICT-based agricultural MIS (Just *et al*., 2006). Old age can potentially undermine the adoption ICT-based MIS because it is normally associated with limited ability to learn new technologies and thus higher risk aversion for such technologies (Morris and Venkatesh 2000; Cant and Shen, 2006). The cost of use normally lowers farmers' probability to use multiple ICT devices (Jayathilake et al., 2008).

3. Results and Discussion

3.1 Socio-economic characteristics of smallholder farmers

Results presented in Table 2 show that the sample of respondents predominantly comprised male farmers (almost 89%) whose education level was below secondary school (89%). About 87% of the sampled SHFs were capable of selling surplus crops in various markets and their access to extension service was fairly good (95%). Almost 53% of the farmers were member of farmer groups. These statistics imply that production and marketing decisions are predominantly male affairs which is consistent with previous findings in Malawi (Mudege *et al*, 2016) and other agrarian economies in Africa (Kameri-Mbote, 2006; Mwangi, 2007; Enete and Amusa, 2010). It is worth noting that good access to extension services may not necessarily mean better access to relevant information on agronomic and market support services because extension agents and farmers in Africa normally face common challenges including high information search and other transaction costs. In the context of Malawi about 85% of the population live in rural areas where power supply is limited and erratic and communication infrastructure is weak (Malawi National Statistics Office, 2020). The observed low level of literacy and communication challenges for rural people combine to undermine the effectiveness of extension services in these areas and farmers' ability to tape into locally available communication technologies to reduce information search cost and engage more effectively in the market place. In connection to these challenges, some smallholder farmers (13%) in the study area reported inability to verify information sourced from extension workers as major challenge when making production and marketing decisions. Inability to own functional ICT tools (smartphone inclusive) needed to access market information and other business support services was also reported to be a major communication challenge among the farmers (11%).

In regards to agricultural extension services farmers were served by more than one expert including Agricultural Extension Development Offices (AEDOs), agents from a tobacco company, officers from Non-governmental Organizations (NGOs) and lead farmers. However, there were no clearly defined roles to minimize distortion and overlaps. Moreover, the service was biased towards provision of information on agricultural production (90% response) at the expense of other critical services including forestry and land conservation (27% response), agricultural marketing (25% response) and community health (17% response). The bias in focus areas has also been reported by Chinsinga (2011) who found that extension services in Malawi were mostly focused on input support programs and not the core business thereby making farmers less informed in some aspects of farming and agribusiness.

Chowa et al. (2013) found that the pluralistic approach to agricultural extension in Malawi was vital to broaden and compliment services offered to farmers but it occasionally over-emphasized what the agents were willing to promote, particularly the adoption of productivity-enhancing technologies without due consideration of SHFs felt needs. Masangano and Mthinda (2012) also found that the approach resulted into increased players in service delivery but identified government extension being the dominant player although it had limited resources as well as field staff with low qualifications. Moreover, they also noted low level of co-ordination in service delivery and inadequate staffing by the non-governmental providers.

Table 2. Characteristics of respondents

Variable	Description	Frequency	%
Sex of household's head (HHH)	Female	22	11.1
	Male	177	88.9
	Total	199	100.0
Whether the HHH participates in markets	No	26	13.1
	Yes	173	86.9
	Total	199	100.0
Whether the HHH has access to extension services	No	11	5.5
	Yes	188	94.5
	Total	199	100.0
Whether the HHH is a member of farmer group(s)	No	93	46.7
	Yes	106	53.3
	Total	199	100.0
Whether the HHH has attained primary or lower education	No	21	10.6
	Yes	178	89.4
	Total	199	100.0

A detailed assessment of membership in farmer organizations revealed that a majority (50%) had just joined the organizations as their membership was less than one year while a significant number (44%) joined within three years prior to this study. This young membership raises concerns with respect to effectiveness and sustainability of farmer organizations. Previous studies point significant challenges towards enhancing the performance of farmer organizations in Malawi. A comprehensive review of farmer organizations (Mloza-Banda, 2005) reveals many problems affecting the organizations in Malawi. These problems include: external motivation and influences during the formation; ad-hoc formulation of governance instruments leading to ineffective management; failure to form linkages with other organizations and institutions, limited ability to mobilize resources and poor financial management and accountability.

Statistics on farmers' participation in agricultural markets are impressive (87%) but agriculture is still subsistence farming because for a majority the primary purpose is to meet food needs, average farm size is less than 3 acres, the use of improved seeds is minimal and production is bellow recommended levels. Many of the farmers (66%) sold agricultural produce to vendors and other buyers in local markets, some (21%) sold to companies while the rest sold either to buyers in main trading centres (10%) or private traders (3%). The finding that a larger proportion of farmers were selling to vendors and other local buyers has direct ramifications on farmers' ability to contemplate marketing beyond village levels and type of production and marketing information they require to make decisions. An analysis of factors considered when making marketing decision revealed huge variation. A significant majority (33%) considered convenience to sell or transport the produce to market place. Some of the farmers weighed transaction costs vis-à-vis prices (32%) and others considered convenience and immediate need for cash (23%). The decision was also reported to be based on factors such as established relationship with buyers (5%), established relationship and price offered (3%), convenience and price (2%) or convenience, price and immediate need for cash (2%).

3.2 Differences in farmers' socio-economic variables

The observed variation in use of radio- and mobile phone-based MIS was assumed to be influenced by differences in socio-economic variables. Thus, the authors explored differences in farmers' decisions to use mobile phones (Tables 3 and 5) and radio (Tables 4 and 6) to access information on commodity and inputs prices based on the selected explanatory variables (Table 1).

Table 3. Differences in quantitative variables hypothesized to affect the use of mobile phone to access commodity and input prices

Variable	Whether used mobile phone to access commodity prices	N	Mean	Std. Error Mean	*t*-test for Mean difference (a-b)	Whether used mobile phone to access input prices	N	Mean	Std. Error Mean	*t*-test for Mean difference (c-d)
Age of household head (years)	Yes	18	42.83[a]	3.111	-1.90	Yes	2	58.00[c]	3.00	13.57
	No	181	44.73[b]	1.114		No	197	44.43[d]	1.06	
Weekly cost for using mobile phone (MK)	Yes	18	263.33[a]	137.800	261.23***	Yes	2	1300.00[c]	1100.00	1287.21***
	No	181	2.10[b]	1.229		No	197	12.79[d]	5.75	

*** means significant at 1% level

Results reveal that farmers who used mobile phone to access commodity (p>0.01) and input prices (p>0.01) incurred significantly higher cost than farmer who did not use the device for these purpose (Table 3). The proportion of farmers accessing the information through the device (Table 5) was larger among members of farmer groups than non-members (p>0.05).

Table 4. Differences in quantitative variables hypothesized to affect the use of radio to access commodity and input prices

Variable	Whether used radio to access commodity prices	N	Mean	Std. Error Mean	*t*-test for mean difference (e-f)	Whether used radio to access input prices	N	Mean	Std. Error Mean	*t*-test for mean difference (g-h)
Age of household head (years)	Yes	90	46.18[e]	1.60	2.95	Yes	9	41.11[g]	5.29	-3.615
	No	109	43.23[f]	1.38		No	190	44.73[h]	1.07	
Weekly cost for using radio (MK)	Yes	90	260.67[e]	104.70	253.33***	Yes	9	261.11[g]	105.34	145.79***
	No	109	7.34[f]	7.34		No	190	115.32[h]	50.23	

*** means significant at 1% level, * means significant at 10%

Table 5. Qualitative characteristics of respondents and use of mobile phones to access information on commodity and input prices

Variable		Whether used mobile phone to access information on commodity prices		Total	$\chi^2(df)$	Whether used mobile phone to access information on input prices		Total	$\chi^2(df)$
		No	Yes			No	Yes		
Whether the household's head (HHH) attained primary or lower education	No	18	3	21	0.78 (1)	21	0	21	0.24 (1)
	Yes	163	15	178		176	2	178	
Total		181	18	199		197	2	199	
Gender of HHH	Female	21	1	22	0.25 (1)	22	0	22	0.25 (1)
	Male	160	17	177		175	2	177	
Total		181	18	199		197	2	199	
Whether the HHH participated in markets	No	21	5	26	0.98 (1)	26	0	26	0.31 (1)
	Yes	88	85	173		171	2	173	
Total		109	90	199		197	2	199	
Whether the HHH was a member of farmer group(s) or associations	No	89	4	93	4.78 (1) **	92	1	92	0.01 (1)
	Yes	92	14	106		105	1	105	**
Total		181	18	199		197	2	199	
Whether the HHH had access to extension services	No	10	1	11	0.01 (1)	11	0	11	0.12 (1)
	Yes	171	17	188		186	2	188	
Total		181	18	199		197	2	199	

** means significant at 5%

Table 6. Qualitative characteristics of respondents and use of radio to access information on commodity and input prices

Variable		Whether used radio to access information on commodity prices		Total	$\chi^2(df)$	Whether used radio to access information on input prices		Total	$\chi^2(df)$
		No	Yes			No	Yes		
Whether the household's head (HHH) attained primary or lower education	No	10	11	21	0.49(1)	21	0	21	1.11 (1)
	Yes	99	79	178		169	9	178	
Total		109	90	199		190	9	199	
Gender of HHH	Female	11	11	22	0.23 (1)	22	0	22	1.17 (1)
	Male	98	79	177		168	9	177	
Total		109	90	199		190	9	199	
Whether the HHH participated in markets	No	21	5	26	8.16 (1)	26	0	26	0.30 (1)
	Yes	188	85	173	***	171	2	173	
Total		109	90	199		197	2	199	

Whether the HHH was a member of farmer group(s) or associations	No	59	34	93	5029 (1) **	89	4	93	5.03 (1) **
	Yes	50	56	106		101	5	106	
Total		109	90	199		190	9	199	
Whether the HHH had access to extension services	No	8	3	11	1.52 (1)	9	2	11	0.12 (1)
	Yes	101	87	188		181	7	188	
Total		109	90	199		190	9	199	

Results presented in Tables 4 and 6 show that farmers who used radio to access information on commodity prices differ significantly from those who did not use the device to access the information as they spent more money on radio-related expenses ($p<0.01$) and had higher proportions of group members ($p<0.05$). Farmers who used radio to access information on input prices were statistically different from those not using the device for similar purpose because a majority were members of farmer groups ($p<0.05$).

Overall, the use of either mobile phones or radio to access information other than commodity and input prices was rare. The findings reveal positive association between the extent of use of the two devices to access price information and cost of use. Observing the positive association is reasonable because users are expected to incur some direct cost including re-charging the devices and where applicable paying subscription fees or buying air-time unless they are subsidized. Implicitly the users are expected to have higher income than non-users. We tested for income difference and found that farmers who used mobile phones to access input prices had higher income than those not using the device for similar purpose ($p<0.05$). A study in Kenya found that income and value of assets could explain the intensity of using mobile phones for agricultural-related transaction (Okello *et al*., 2014).

The findings also reveal a positive association between group-membership and extend of using the devices to access the price information. However, it is difficult to make direct inferences on this association because there is no theoretical foundation revealing causality. The outcome is likely through its indirect effect, for example farmer groups may serve as platforms for awareness creation thereby making members more aggressive to seek for market information. Katengeza et al. (2011) found that farmers' awareness of electronic-based MIS in Malawi was partly influenced by being member of farmer groups.

3.3 Results from multivariate probit model

Results from the MVPM are consistent with results from the preliminary statistical analysis using *t*-tests and Chi-square tests with respect to predicted effects of farmers' access to extension services, agricultural markets and membership to farmer groups. Results are also consistent with respect to predicted effect of cost of use.

Results to predict farmers' use of mobile phone-based MIS to access information on inputs and commodity prices are presented in Table 7. An evaluation of this model indicated that the variables hypothesized to influences the use of mobile phone-based MIS to access the information are jointly significant ($p<0.10$). However, cost of using mobile phone is the only variable predicted to reduce the likelihood of farmers using the device to access information on commodity prices ($p<0.01$). The model revealed a higher marginal success probability for using mobile phones to access information on commodity (0.09) than input prices (0.01) although the overall success probity for the joint use was generally low (0.01).

Table 7. Multivariate probit estimation of determinants of farmer's use of mobile phone-based MIS

Variable	Commodity price	Input price
Age of household's head	-0.0085	0.0453
	(0.0113)	(0.0470)
Number of people in the household	0.0021	-0.2377
	(0.0922)	(0.4981)
Total land owned by the household for agricultural use (acre)s	0.1190	-0.5543
	(0.0837)	(0.6936)
Whether the household head attained primary or lower education	-0.7140	3.3446
	(0.4406)	(3.9140)
Whether the HHH was a member of farmer groups or association	0.3362	2.3945
	(0.3599)	(2.5402)
Whether the HHH had access to extension services	-0.2122	2.4023
	(0.7236)	(2.6834)
Weekly cost for using mobile phone (MK)	-0.0146***	-0.0038
	(0.0040)	(0.0032)
Sex of HHH	-3.8601	-0.3783
	(4.1023)	(0.3942)
Constant	-1.0181	0.0441
	(0.9131)	(1.0491)
Number of observations	199	199
Overall fitness, probabilities and correlation matrix		
Number of draws (#)	16	
Log likelihood	-41.8429	
Wald ($\chi^2(14)$)	21.46	
Prob > χ^2	0.09*	
Predicted probability	0.088	0.010
Joint probability (success)	0.0374	
Joint probability (failure)	0.5402	
Estimated correlation matrix	ρ_1	ρ_2
ρ_1	1	
ρ_2	0.0440 (1.0471)	1
Likelihood ratio test of $\rho_1 = \rho_2 = 0$		
χ^2 (1) = 0 .0018		
Prob > χ^2 = 0.966		

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Results to predict farmers' use of radio-based MIS to access information of inputs and commodity prices are presented in Table 8. The model indicates that the variables hypothesized to influences the use of radio-based MIS to access price information are highly significant (p<0.01). The model predicts positive effect of membership to farmer groups (p<0.05) and negative effect of cost of using radio (p<0.001) on farmers' likelihood to use the device to access commodity prices. The negative effect of cost is also predicted for its use to access input prices. Access to extension services is seen to exert a positive effect on farmers' likelihood to access input prices using the radio-based MIS. The model fitted the data well (p>0.01) and it predicted higher marginal success probability for using mobile phones to access information on commodity prices (0.45) than input prices (0.05). The predicted success probability for the joint use of radio to access commodity and input prices (0.04) is higher than the success probability for the joint use of mobile phone (0.01) to access the information.

Results from the MVPM have two major implications. Firstly, the use of mobile phone-based MIS is predominantly for accessing commodity and not input prices. Previous studies reveal more concerted efforts by government to subsidize the supply of agricultural inputs, especially fertilizers (Dorward and Chirwa, 2011; Holden and Lunduka, 2013). The practice is perceived to have depressed sales of unsubsidized fertilizer, distorted prices of inputs and affected the development of input markets, especially in more remote areas (Doward et al., 2008). These conditions can potentially make farmers more dependent on subsidized inputs and less willing to incur expenses to access information on input prices.

Table 8. Multivariate probit estimation of determinants of farmer's use of radio-based MIS

Variable	Commodity price	Input price
Age of household's head	0.0101	-0.0037
	(0.0067)	(0.0128)
Number of people in the household	0.0613	0.1475
	(0.0567)	(0.1106)
Total land owned by the household for agricultural use (acre)s	0.0884	-0.1946
	(0.0614)	(0.1713)
Whether the household head attained primary or lower education	-0.1940	4.9224
	(0.3205)	(6,835.2755)
Whether the HHH was a member of farmer groups or association	0.4444**	0.2505
	(0.1982)	(0.3706)
Whether the HHH had access to extension services	0.0094	-1.1252*
	(0.4525)	(0.5947)
Weekly cost for using mobile phone	-0.0028***	-0.0012**
	(0.0008)	(0.0005)
Sex of HHH	0.0668	-8.2128
	(0.3118)	(6,837.2682)
Constant	-1.3303**	0.6151**
	(0.6399)	(0.3029)
Number of observations	199	199
Overall fitness, probabilities and correlation matrix		
Number of draws (#)	16	
Log likelihood	-143.3826	
Wald ($\chi^2(14)$)	34.11	
Prob > χ^2	0.0053***	
Predicted probability	0.4515	0.0465
Joint probability (success)	0.0370	
Joint probability (failure)	0.5390	
Estimated correlation matrix	ρ_1	ρ_2
ρ_1	1	
ρ_2	0.5477	1
	(0.2120)	
Likelihood ratio test of $\rho_1 = \rho_2 = 0$		
χ^2 (1) = 4.77371		
Prob > χ^2 = 0.0289**		

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Secondly, there is a higher prospect for SHFs to use radio- than mobile-based MIS to access price information. The outcome is attributed to factors such as low literacy among users to effectively use mobile phones (Chikuni and Kilima, 2019) and high cost associated with acquisition and use as previously established by other scholars (Megwa, 2007; Milan, 2009). Thus, it is more convenient for SHFs to acquire price information using radio- than mobile phone-based MIS.

4. Conclusion and Recommendations

The paper sought to investigate the effect of use of radio- vis-à-vis mobile phone-based agricultural market information systems (AMIS) on smallholder farmers' access to price information focusing on agricultural inputs and commodities. A multivariate probit model was adopted to fit data collected from Lilongwe, Malawi in 2017. Results revealed limited use of mobile phones to access both input and commodity prices because these devices were predominantly used to access information on commodity prices. The cost of using mobile phone was identified as a key factor underlying the low use of mobile phone to access information on commodity prices. The cost of use along with farmers' access to extension and group membership were the major factors underlying the use of radio to access price information. Results predicted higher prospect for SHFs to use radio as means to acquiring information on prices of agricultural inputs and commodities than mobile phones. Endeavours to promote farmers access to markets information should aim at creating synergies with extension services and other local initiatives linking farmers through

groups. Future research on the subject matter should accommodate more means of acquiring agricultural information and explanatory variables.

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