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Full Length Research Paper

Ownership and use of mobile phones for agricultural transactions by traders: The case of the Analanjirofo and Atsinanana Regions – Madagascar

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This paper analyzes the use of Information and Communication Technologies (ICT) in improving the performance of agricultural markets. It focuses on ownership and use of mobile phone by the rural traders in the Regions of Analanjirofo and Atsinanana, a target zone of the public-private initiative "*Programme de Promotion des Revenus Ruraux*" (PPRR) that develops a market information services program. The paper uses data obtained through personal interviews with traders, stratified by being located within the PPRR zone of intervention and outside, to identify the drivers of mobile phone ownership and use for agricultural transactions. Statistical tests (t-test) of differences in means of key variables and binary logistic regression models are used to examine the effect of PPRR on ownership and use of mobile phones. The findings show that traders inside the PPRR zone are more likely to own and use mobile phones for agricultural transactions. In addition, his/her personal and socio-economic characteristics affect ownership of mobile phones. Further findings also suggest that mobile phone use depends especially on its usefulness for the transaction activities and on users' socio-economic characteristics and environment. The paper concludes that the presence of PPRR increases the likelihood of use of mobile phones for agricultural transactions. It recommends the need to improve access to affordable mobile phone handsets and to reduce calling costs, invest in improving literacy levels and complementary infrastructure so as to spur greater use of mobile phones for agricultural transactions, among others.

Key words: Mobile phone, ownership, use, market information service program, Madagascar.

INTRODUCTION

The development of Information and Communication Technologies (ICT) in Africa has substantially improved over the past thirty years (Maumbe and Okello, 2010). Their importance, place and role in all segments of the economy can no longer be ignored. In Madagascar, the National Statistics Institute (INSTAT, 2004) shows that 53.2% of households in Antananarivo and its sorroundings access mobile phone services. It indicates that access to information and communication tools present immense potential for spurring the process of economic development in Madagascar especially with regards to productivity improvement and competitiveness.

Various authors have examined in the past the functioning of agricultural markets and the role that ICT can play in the transformation of such markets in developing countries (Fafchamps and Gabre-Madhin, 2006;

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Jensen, 2007; Aker, 2008a; Muto and Yamano, 2008; De Silva, 2010; Okello et al., 2010). Fafchamps and Gabre-Madhin (2006) examine agricultural markets in Benin and Malawi and highlight the importance of transaction costs in limiting trade among commercial grain traders in the two countries. These costs include search/screening, monitoring, negotiation, enforcement, and mal-adaptation costs related to agricultural transactions. In Africa, limited access to modern technology has tended to force traders to travel long distances to search for and physically be present at the time and place of purchase or sale to verify the quality of the product being traded. On another hand, Fafchamps and Minten (1998) provide evidence of better personal relationships in helping successful traders in Madagascar. Aker (2008a) assessed the impacts of mobile phone use on agricultural markets in Africa. Her study centered on how the development of mobile phone network in Niger affected the welfare of grain traders and consumers. It found that the development of mobile phone towers led to significant reduction in seasonal grain price differentials by 20% and that of the annual price variation by 12% (Aker, 2008b). Other studies, such as De Silva (2010) and Okello et al. (2010), attribute the positive effects of phone network coverage and the use of mobile phone to reductions in transaction. However, yet other studies suggest the need for a more thorough evaluation of the use of mobile phone in agriculture for a better understanding of the impact on the economy and the society (Aker and Mbiti, 2010). Muto and Yamano (2009) analyze the effect of mobile phone on households and rural communities in Uganda. Their analysis emphasizes the expected effect of a broader coverage of mobile phone network through the reduction of transaction costs in the agricultural sector. Their results indicate greater market participation by producers in remote areas.

The Malagasy government has recently initiated a number of development strategies that aim at improving the welfare of rural communities. As part of these strategies, the government has designed, with donor support, rural programs that are intended to make markets work better for rural dwellers. A case in point is the "Programme de Promotion des Revenus Ruraux" (PPRR) translated as the Program targeting the enhancement of rural incomes. The PPRR makes use of a computer-based platform to disseminate market information to farmers and traders via mobile phones. In spite of the increase in ICT (particularly mobile phone) use in many African countries, little is still known about the influence of ICT-based MIS programs such as the PPRR on the ownership and use by traders and the kinds of information owners and users of such tools seek. This paper therefore examines whether such program has contributed to increase in the ownership and use of mobile phone for agricultural transactions and the information farmers seek for when using mobile phones.

It also examines other drivers of mobile phone ownership and use by agricultural traders.

CONCEPTUAL FRAMEWORK AND STUDY CONTEXT

The functioning of agricultural markets in Africa has traditionally been constrained by lack of market information. Market liberalization in many African countries in 1980s and 1990s removed some of these barriers to private sector participation in the provision of agricultural services in many developing countries. The entry by the private sector into service provision was expected to address the problems facing agricultural markets including information flow. However, agricultural markets did not respond fully to the policy changes in developing countries (Kydd and Doward, 2005; Poulton et al., 2006). The poor flow of market information in turn results in high transactions costs in the input markets which makes agricultural transactions costly.

The need to improve the performance of agricultural markets has led to the search for new models of providing agricultural services to farmers. One of the strategies being adopted by both the public and private sectors is the use of new generation ICT-tools especially the mobile phones. Hence several public and private sector interventions have emerged that target provision of market information services (MIS) to agricultural market actors (that is traders) using ICT-based technologies. The proliferation of ICT-based MIS is especially greatest in Africa where rapid penetration of cell phones has created interest in the opportunities that exist in applying ICTs in agriculture. A recent scoping study on the application of ICT in agriculture found 34 agricultural projects with ICT components in Kenya alone (Munyua, 2008). Several such ICT-based MIS projects have also been reported in Malawi, Ghana, Uganda, Benin, Madagascar (Okello et al., 2009). Projects that use new generation ICT tools to provide market information to farmers and traders have also been reported in India (Jensen, 2007), Niger (Aker, 2008a) and Sri Lanka (De Silva, 2010).

In some countries such as Madagascar, the public sector, private sector or both have designed projects and programs that aim to harness the potential provided by ICT to spur development in Agriculture. Examples of such initiatives in Madagascar include the PPRR which operates in the Atsinanana and Analanjirofo Regions, and the Madagascar Last Mile Initiative (MLMI) project found in the Rural Commune of Ranomafana in the Vatovavy Fitovinany Region and that of Moramanga in the Alaotra Mangoro Region. Both programs are located on the East Coast of Madagascar, an area with orientation towards export crops. The present study covers only the PPRR Regions.

The PPRR was implemented in late 2005 in the Region of Analanjirofo and extended to some Communes of the Atsinanana Region. It is financed mainly by the International Funds for Agricultural Development (IFAD),

the Organization of Petroleum Exporting Countries (OPEC) and the Malagasy Government. The broad objectives of the program are to reduce rural poverty through: (i) the increase of producers' incomes and, (ii) improvement of the communities' ability to take charge of their development. The specific objectives, on the other hand, are (i) the improvement of producers' access to markets and value addition of their products, and (ii) the intensification of production and the diversification of the productive base in ways that do not hurt the environment and the most vulnerable populations.

As shown in Figure 1, PPRR undertakes several activities and functions. These include (i) development of partnerships between farmers and commercial traders through a strategy known as "the Poles of Partnerships" and "the Market Access Centers" (CAM), (ii) upstream and downstream management of the agricultural commodity marketing system. The downstream management targets market actors that engage in the collection, transformation and transportation of products, and (iii) development of linkages between producers and commercial traders.

One component in the PPRR involves establishing the "Market Information System" (MIS) based on the use of mobile phone voice and short messaging system (SMS) options. The PPRR uses a computer-based platform called Bazar-Mada, affiliated to the international eSOKO, to disseminate market information to farmers and traders. eSOKO provides the tools for managing, analyzing and disseminating market information, including (a) a web portal providing information on the market in 12 countries of Africa and Asia, (b) a database managed by a MIS administrator, and (c) an interface between the database and the GSM that allows the automated diffusion of information by SMS to a given group of users. Information available through the PPRR include supply and demand situation (that is outlook), market prices in different regions, zones of production, list of buyers and sellers, list of partners, list of transporters and other information on the market. A wide range of products are covered under the project. These include inputs (for example fertilizers), food, cash, export and industrial crops, and livestock.

The advantage of using the Bazar-Mada /eSOKO platform would be that it would promote transparency in the market, limit traveling by traders (hence reduce search costs) and decrease the time taken to complete transactions. Individual farmers or farmer organizations and traders can register at each CAM and use the services provided under PPRR. The use of these services was free until December 2009. Since then, user charge equal to regular cost of sending an SMS is levied. At the same time membership fee of up to Ariary 3 000 per month (about US$ 1.5) is charged. Information is also available based on 3-month subscription. The subscription allows for the receipt of regular alerts sent automatically from the eSOKO platform. The alerts can be on price or supply situation and covers up to four commodity markets. The users have the option of consulting / calling the PPRR office directing their telephone or contacting a network of agents supported through collaboration between Food and Agriculture Organization (FAO) and the local authorities. The MIS's record shows that each of the 15 operational Poles/CAM has been given a mobile phone. By 30 May, 2010, the number of information transmitted to the CAMs in the Analanjirofo Region attained 4,058 and 2,055 in the Atsinanana Region. They concerned information such as products prices and offers to purchase. The number of information received by the MIS amounted up to 1,300.

METHODS

This study used multistage stratified random sampling technique to obtain the respondents. It focused on Analanjirofo and Atsinanana regions because the PPRR project operated in these regions. The two were first divided into two zones namely, the areas covered by PPRR and those that are not. The PPRR intervention zone comprised areas that had benefitted from the promotion and sensitization of ICT use (especially mobile phone) under the MIS system (Table 1). The non PPRR zone, on the other hand, included areas where the use of ICT for agricultural transactions (especially trading) has not been promoted.

A total of 211 traders from six types of agricultural market actors were interviewed (Tables 1 and 2) in the two zones. These included (i) *brokers* who are local agents employed by produce assemblers or working on their own but who mediate transactions between producers and other market actors, (ii) *rural produce assemblers* who travel to the production areas and link producers with downstream actors, (iii) *wholesalers* and (iv) *the retailers* who are generally local traders and act as a link between producers or other market actors and consumers, (v) *processors* who added value to raw/unprocessed agricultural product, and (vi) *input providers.* As shown in Table 2, majority of the traders fall mainly into the two categories namely, rural produce assemblers and retailers.

Data was collected on four broad categories of independent variables that are expected to capture the relationships with each of the two dependent variables (ownership and use of mobile phones for agricultural transactions by traders) namely, (i) the usefulness of mobile phone for the trader, (ii) personal characteristics of the trader, (iii) socioeconomic characteristics of the trader, and (iv) environmental factors. Figure 2 summarizes these variables.

Statistical tests (t-test) of differences in means of key variables relating to the respondents in the PPRR zone and non-PPRR zone were used to examine if traders who own and/or use mobile phones are significantly different from their counterparts. Though such analysis gives insight into the distinctiveness of the traders in the two areas, they do not provide insights into the causal effects of the different variables under consideration. Thus econometric techniques were used to assess the effect of trader characteristics and participation in PPRR services on their ownership and use of mobile phone.

The ownership and use/adoption of mobile phone by agricultural traders in undertaking agricultural transactions can be analyzed using two binary regression models. The most widely used binary regression model for analyzing discrete / binary choice variables is

the logit regression model. Each logit model is specified as follows:

$$Y = \begin{cases} 1 \text{ if } y^* = X\beta + \varepsilon > \tau \\ 0 \text{ if } y^* \leq \tau \end{cases} \quad (1)$$

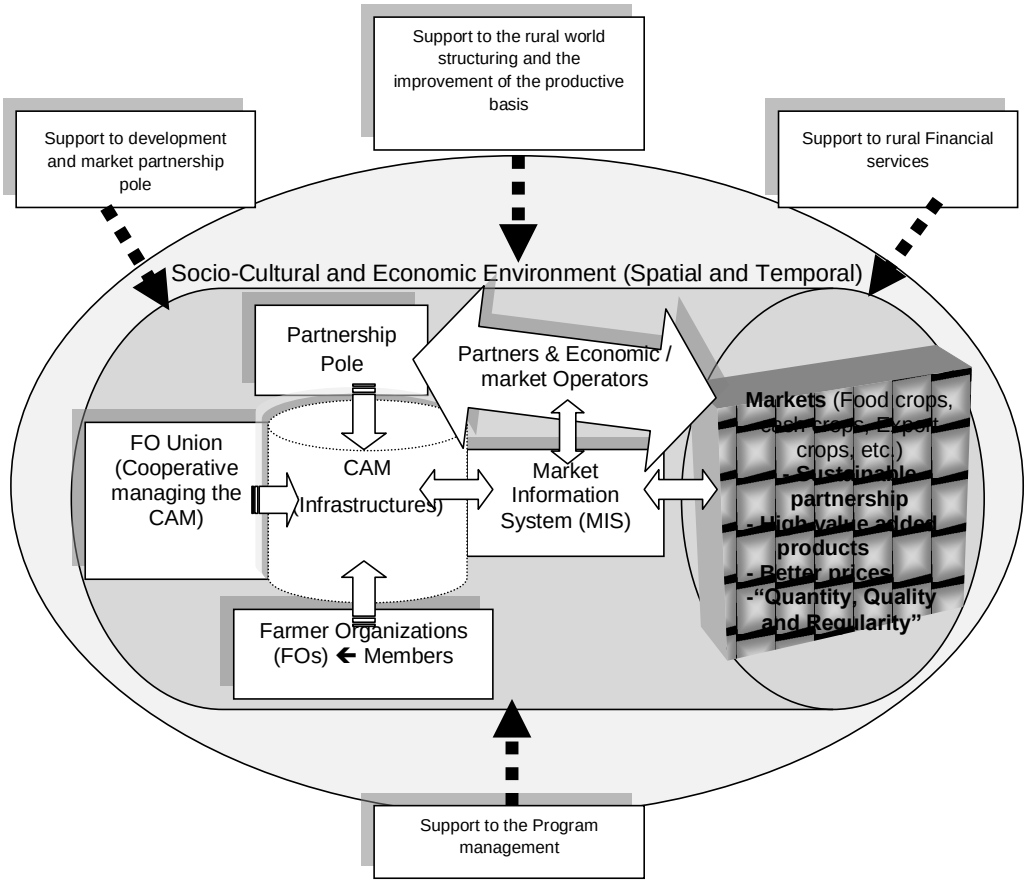

Figure 1. Schematic diagram of the PPRR operational system. Source: Authors' survey (2010).

Table 1. Market survey sampling by region and district within and off PPRR zone.

Region	District of survey		PPRR Zone		Total	Creation date of CAM by PPRR	Sensitizing of traders in PPRR zone about the MIS
			Outside	Within			
Analanjirofo	*Fenerive Est*	N	0	26	26	2006 to 2007	2008 to date
		%	0.0	41.30	12.32		
	Vavatenina	N	0	37	37	2006 to 2007	2008 to date
		%	0.00	58.70	17.54		
Atsinanana	*Toamasina I*	N	0	29	29	2009	2008 to date
		%	0.0	46.80	13.74		
	Toamasina II	N	0	12	12	2009	2008 to date
		%	0.0	19.40	5.69		
	Brickaville	N	23	21	44	2009	2008 to date
		%	26.74	33.90	20.85		
	Mahanoro	N	27	0	27		
		%	31.40	0.00	12.80		
	Vatomandry	N	36	0	36		
		%	41.86	0.00	17.06		
Grand total		N	86	125	211		
		%	100.00	100.00	100.00		

Source: eARN Africa survey (markets) in the Regions of Analanjirofo and Atsinanana, February-March 2010.

Table 2. Principal activity of the surveyed economic operators by zone.

Zone			Principal activity as an economic operator						Total
			Produce assembler	Broker	Wholesaler	Retailer	Input supplier	Processor	
PPRR zone	Outside	N	12	4	10	48	9	3	86
		%	13.95	4.65	11.63	55.81	10.47	3.49	100.00
	Within	N	42	15	12	49	2	5	125
		%	0.34	0.12	0.10	0.39	0.02	0.04	100.00
Total		N	54	19	22	97	11	8	211
		%	25.59	9.00	10.43	45.97	5.21	3.79	100.00

Source: eARN Africa survey (markets) in the Regions of Analanjirofo and Atsinanana, February-March 2010.

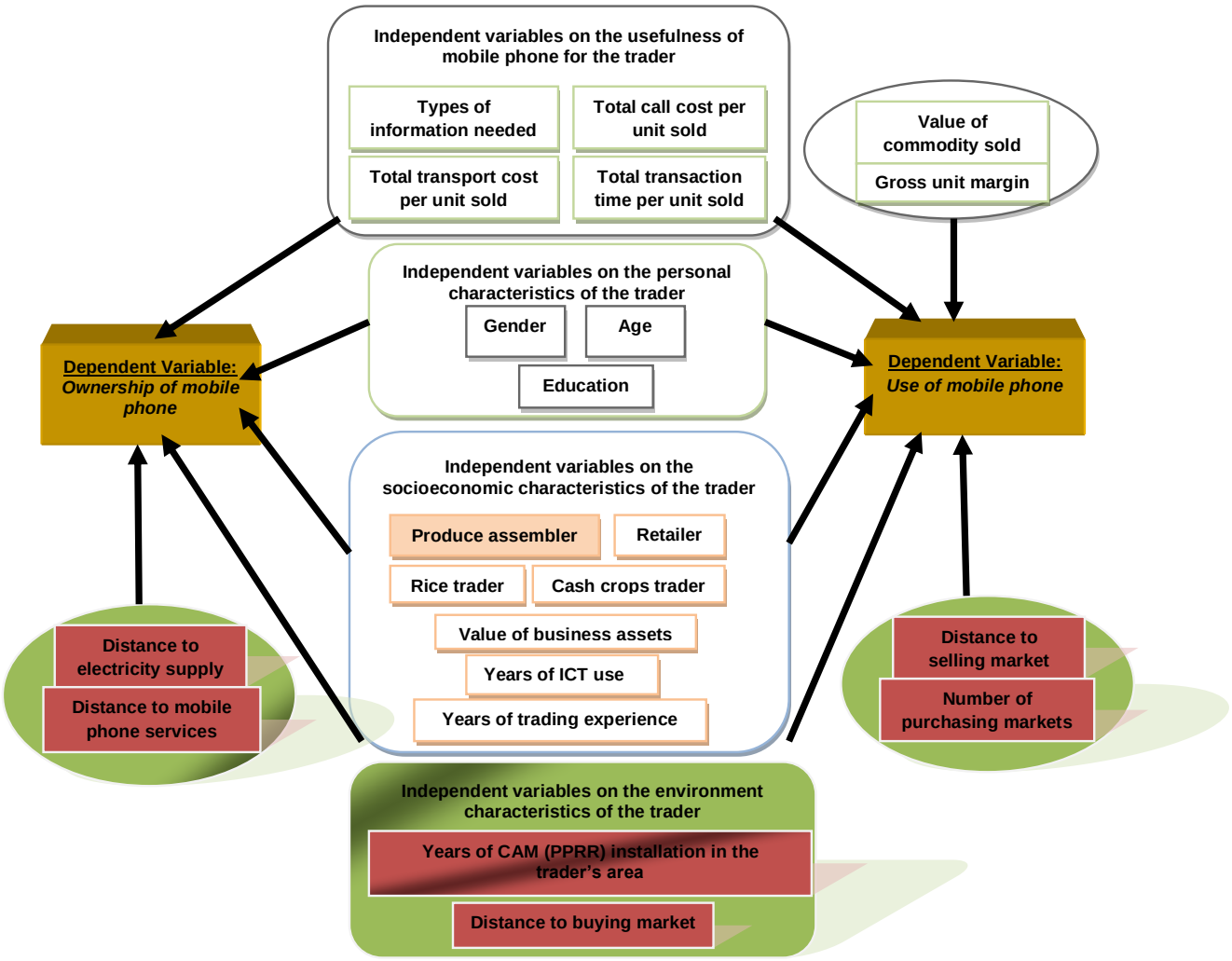

Figure 2. Relationships between the dependent, independent and other variables. Source: Authors' survey (2010).

Where Y is a binary dependent variable, y* the latent variable, β the vector of parameters associated to the vector of explanatory variables X included in the model, and ε is the error term assumed to follow a standard logistic distribution. The probability of the

dependent variable Y taking the value of 1 is then given by:

$$\Pr[Y=1|X] = F(X\beta) \quad (2)$$

Where F(.) is the cumulative density function of the logistic distribution. Interpretation of the results is based on changes in the odds ratio which is expressed as:

$$\Omega(X) = \frac{\Pr[Y=1|X]}{\Pr[Y=0|X]} = \frac{\Pr[Y=1|X]}{1-\Pr[Y=1|X]}$$

and

$$\text{Log}[\Omega(X)] = X\beta \quad (3)$$

It is generally more practical to consider the logarithm of Ω (X), known as *logit,* while assessing the effects of changes in the explanatory variables X. The effect of variable X_j can be expressed in terms of a percentage change in the probability of Y = 1.

Drivers of ownership and use of mobile phone in agricultural transactions can be categorized into those that relate to "social pressure" and those that confer "social benefits" (De Silva and Ratnadiwakara, 2009). Other authors have categorized drivers of use/adoption of technologies into incentives and capacity (Shiferaw et al., 2007; Shiferaw et al., 2008). In the present study, the model estimated to assess the drivers of ownership and use of mobile phone by traders encompasses explanatory variables drawn from these broad categories. The specific variables are presented in Tables 3 to 6 along with their definitions. They include: (i) the usefulness of mobile phone in market transactions, (ii) personal factors, (iii) socio-economic factors, and (iv) environment factors. These tables also present the expected signs of the variables used to assess the drivers of mobile phone ownership and use by traders in agricultural transactions.

RESULTS AND DISCUSSION

Characteristics of the traders inside and outside the PPRR zone

Figure 3 presents data on the use of mobile phones (as well as other ICT tools) inside and outside the PPRR zone. It shows that a larger number of traders within the PPRR zone (89%) use mobile phones for their agricultural transactions compared to those outside the zone (61%). Further, the Figures also shows that majority of the traders in both study zones tend to mainly use call (voice) function (94%) while a few (6%) make use of both text messaging and call functions. The radio is ranked second among the ICT tool most used by traders to seek market information. In both cases (that is mobile phone and radio), the information sought include price, volume, quality, where to purchase the produce, and where to sell it. Figure 4 presents the extent to which traders use mobile phones to seek information on where to sell their produce. The trend is as expected, since it shows that more traders within the PPRR zone (35%) use mobile phones to make inquiries about where to sell their produce compared to those outside the zone (17%).

These findings corroborate those of Aker (2008) and Okello (2011) who find that traders in areas covered with mobile phones tend to use mobile phones to seek markets for their produce than their counterparts.

Table 7 presents the results of the statistical mean-comparison tests of some characteristics between traders located within the PPRR intervention zones and those that are not. The mean difference represents the difference between the sample mean of the traders outside and within the PPRR zone. The p-value provides the statistical significance of the difference between the means. Only the mean values of the statistically significant variables are discussed here with standard errors in brackets. As shown, there is evidence that traders located within PPRR zone seek, on average, significantly more types of information (p-value = 0.000) than their counterparts outside the PPRR zone. These traders differ in terms of their personal characteristics from their counterparts. For instance, there were 25% (0.068) more males among such traders within PPRR zone. Traders in the PPRR zone were also on average 2.5 (1.267) years older and also had 1.081 (0.382) more years of education. In terms of socio-economic characteristics, traders within the PPRR zone have Ariary 8.666 (1.951) more in terms of value business asset and also possessed 1.189 (0.415) more years of experience in using ICT tools. Among the environmental factors, traders within PPRR zone visit 0.188 (0.063) more purchasing markets, and are located 0.750 (0.446) more kilometers away from electricity supply points. They are also 2.819 (0.799) kilometers further away from mobile phone service centers. Overall, these differences suggest that the existence of the PPRR program encourages traders to transact business with distant and / or other markets to buy or sell commodities.

Determinant of mobile phone ownership

Figure 5 presents the ownership of mobile phones by traders inside and outside the PPRR zone. As shown, a greater number of traders inside the PPRR zone own mobile phones than their counterparts who are located outside that zone. In particular, the data show that 91% of the respondents within the PPRR zone owned mobile phone compared to 76% outside the PPRR zone. In order to assess the factors that condition the ownership of mobile phones by traders, we estimated a logit model with ownership of the mobile phone as the dependent variable. The explanatory variables include usefulness of using mobile phone, personal and socio-economic characteristics of the trader and the environmental variables. The results of the estimated logit model are presented in the first two columns of Table 8. As shown, the Pseudo R^2 is 0.589 and the p-value of Wald test is 0.000 indicating that the model fits the data quite well.

Among the variables related to the usefulness of mobile phone in market transactions, the number of different types of information sought yield statistically significant

Table 3. Rationale of the variables in the logistic regressions - usefulness of mobile phone.

Variable	Code	Rationale	Expected sign for mobile phone	
			Ownership	Use
Total value of main commodity sold last season	Ln (Ariary)	High value commodities, either by their nature or in terms of volume, would require marketing search / screening, thus the use of mobile phone.	+	+
Number of trade information types demanded (price, volume, quality, place to buy, place to sell)	0 to 5	The number of trade information types demanded influences mobile phone ownership and use.	+	+
Average Gross Unit Margin of Main Commodity last season	Ln (Ariary)	Higher gross margin (Average Sell Unit Price - Average Buy Unit Price) would incite the trader to use mobile phone.	+	+
Total call costs per unit sold incurred on last transaction of last season	Ariary / per unit sold	Transaction call costs (Search / screening, Negotiation, Monitoring, Enforcement / following up, Renegotiating terms of trade) would determine the trader's ownership and use of mobile phone.	+/-	+/-
Total transport costs per unit sold incurred on last transaction of last season	Ariary / per unit sold	The decrease in total transport costs would determine the traders' ownership and use of mobile phone.	-	-
Total transaction time per unit sold spent on last transaction of last season	√Minutes	Transaction time (Search / screening, Negotiation, Monitoring, Enforcement / following up, Renegotiating terms of trade) would determine the trader's ownership and use of mobile phone.	+/-	+/-

Table 4. Rationale of the variables in the logistic regressions - personal characteristics.

Variables	Code	Rationale	Expected sign for mobile phone	
			Ownership	Use
Gender of the trader	1=Male, 0 otherwise	Studies suggest that males are keener to own and use mobile phone	+	+
Age of the trader	Years	Younger traders are likely to be opened to new technology	-	-
Education of the trader	Years	Educated traders are likely to be opened to new technology	+	+

effect. An increase in the number of different types of information needed by the trader likely increases the likelihood of a trader owning a mobile phone. Of the personal characteristics, the data shows that gender (that is being male) and higher levels of education increase the likelihood of a trader owning a mobile phone respectively, other things constant. The finding that education level affects the likelihood of owning mobile phone corroborates the findings of Okello et al. (2009) in Kenya. Among the socio-economic factors, the results show that being a retailer and the years of experience in trading increases the likelihood of owning a mobile phone respectively. The evidence relating to ownership of mobile phones to trade in rice (Malagasy staple food) is

Table 5. Rationale of the variables in the logistic regressions - socioeconomic characteristics.

Variables	Code	Rationale	Expected Sign for mobile phone	
			Ownership	Use
Main function of the trader: Produce assembler	1=Yes, 0 otherwise	The trader's main function influences her/his ownership and use of mobile phone	+/-	+/-
Main function of the trader: Retailer	1=Yes, 0 otherwise	The trader's main function influences her/his ownership and use of mobile phone	+/-	+/-
Main commodity traded (rice)	1=Yes, 0 otherwise	The type of the trader's main commodity traded influences her/his ownership and use of mobile phone	+/-	+/-
Main commodity traded (cash crops)	1=Yes, 0 otherwise	The type of the trader's main commodity traded influences her/his ownership and use of mobile phone	+/-	+/-
Value of assets helping in business	√(10 000 Ariary)	Traders with higher value assets would own and use mobile phone more intensively	+	+
Number of the longest years the trader has been using ICT tools (radio, TV, fixed or mobile phone)	Years	The longer the trader has been using ICT, the more s/he would be open to new technology	+	+
Number of years s/he has been working as a trader	Years	The longer the trader has been working as a trader, the more s/he would be open to new technology	+	+

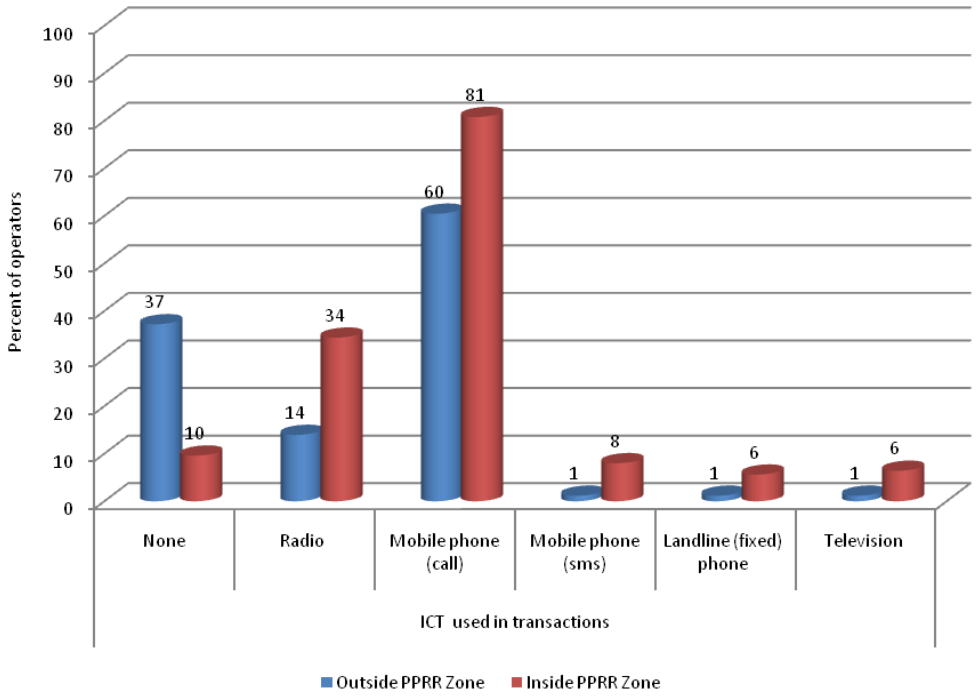

Figure 3. Types of ICT tools used by the operators to acquire information in agricultural transactions inside and outside PPRR zone. Source: Authors' survey (2010).

Table 6. Rationale of the variables in the logistic regressions - environment characteristics.

Variables	Code	Rationale	Expected sign for mobile phone	
			Ownership	Use
Number of years a CAM (PPRR) was installed in the trader's area	0=Off PPRR Zone, 1 to 4 = Number of years	The duration of the CAM (PPRR) installation in the trader's area enhances ownership and use of mobile phone.	+	+
Average distance to buying markets of Main Commodity last season	Km	The nature of PPRR's MIS activities intends to boost communication with remote areas	+	+
Average distance to selling markets of Main Commodity last season	Km	The nature of PPRR's MIS activities intends to boost communication with remote areas	+	+
Number of purchasing markets last season	Number	The nature of PPRR's MIS activities intends to boost communication with remote areas	+	+
Distance to nearest center with electricity	Km	Availability of electricity facilitates traders' adoption/use of mobile phone	+	+
Distance to nearest mobile phone services (repair, credit, etc.)	Km	Availability of mobile services facilitates traders' adoption/use of mobile phone	+	+

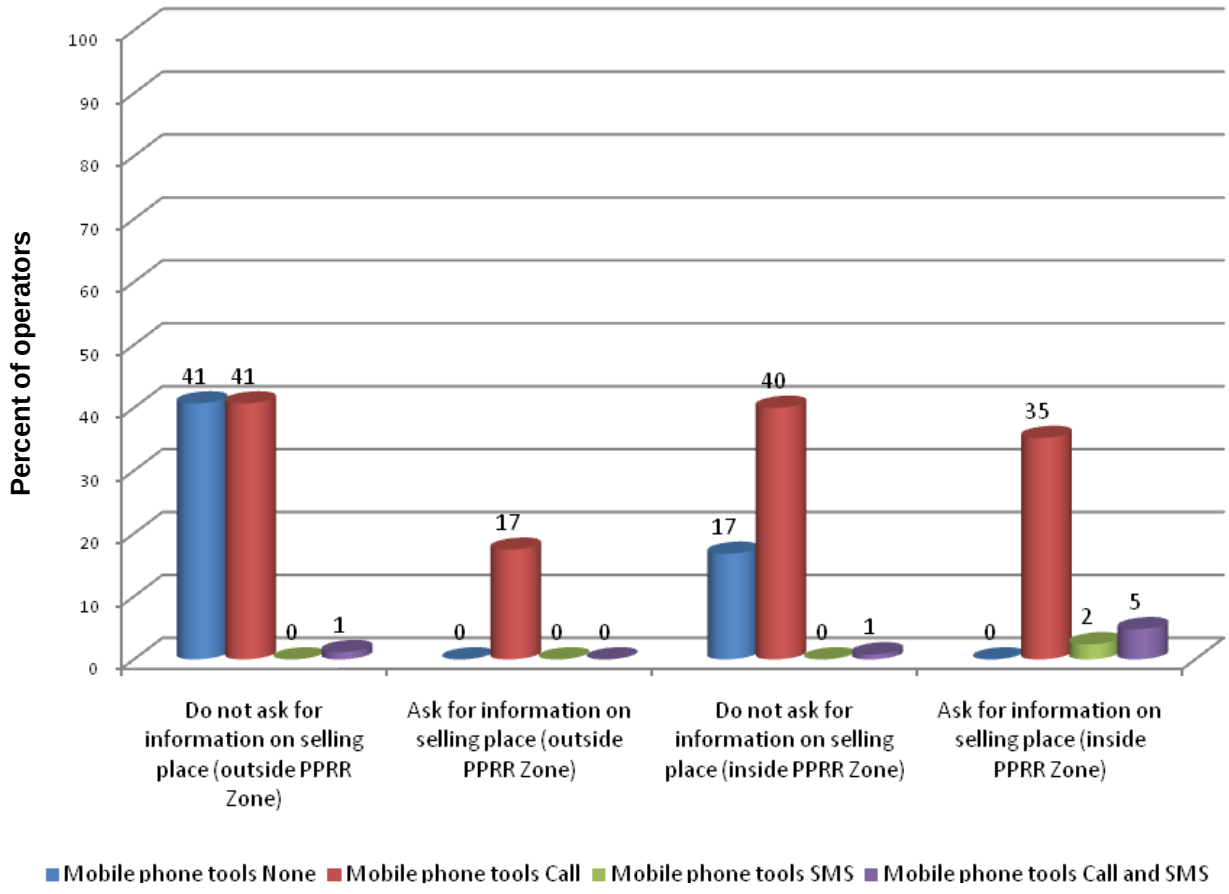

Figure 4. Proportion of traders seeking information on where to sell produce inside and outside the PPRR zone. Source: Authors' survey (2010).

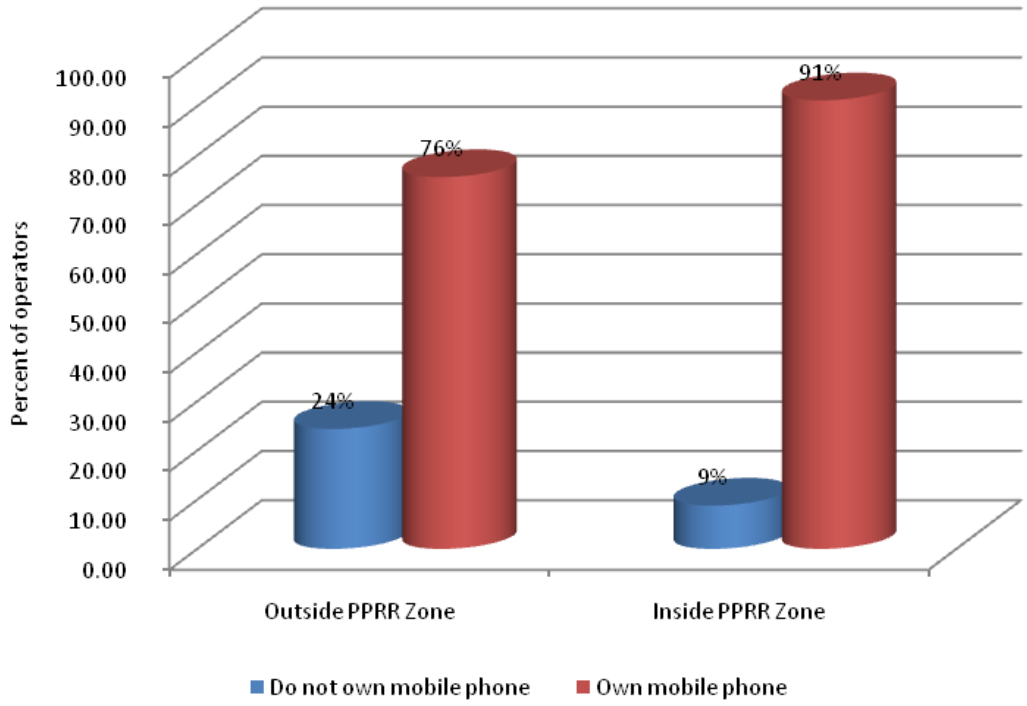

Figure 5. Ownership of mobile phone by the traders inside and outside the PPRR zone. Source: Authors' survey (2010).

Table 7. Results of mean - comparison tests of the actors' characteristics outside and within the PPRR zone of intervention.

Usefulness of mobile phone	Mean difference (*)	Std. Err	P-value
Commodity sold value	-0.340	0.266	0.202
Number of information types demanded	-1.044	0.233	0.000
Gross unit margin	0.053	0.139	0.708
Total call cost per unit sold	-0.769	0.013	0.560
Total transport cost per unit sold	5.868	3.668	0.109
Total transaction time per unit sold	0.393	0.309	0.305
Personal characteristics			
Gender	-0.251	0.068	0.000
Age	-2.537	1.267	0.047
Education	-1.081	0.382	0.005
Socio economic characteristics			
Value of business assets	-8.666	1.951	0.000
Years of ICT use	-1.189	0.415	0.005
Years of trading experience	-0.337	0.991	0.735
Environment characteristics			
Distance to buying market	17.735	14.657	0.225
Distance to selling market	-6.045	10.605	0.566
Number of purchasing markets	-0.188	0.063	0.003
Distance to electricity supply	-0.750	0.446	0.094
Distance to mobile phone services	-2.819	0.799	0.001

(*) Mean difference = Outside – Within (PPRR Zone).

Table 8. Logistic regressions for ownership and use of mobile phone.

Variables	Logistic regressions (Robust)					
	Ownership of mobile phone			Use of mobile phone		
	Coef.	Std. Err	P-value	Coef.	Std. Err	P-value
Usefulness of mobile phone						
Value of commodity sold (log)	-		-	0.055	0.289	0.841
Types of information needed	1.920	0.455	0.000	4.493	1.325	0.001
Gross unit margin (log)	-		-	1.076	0.464	0.020
Total call cost per unit sold	0.280	0.224	0.211	2.023	0.597	0.001
Total transport cost per unit sold	-0.010	0.023	0.670	-0.118	0.047	0.012
Total transaction time per unit sold	0.117	0.095	0.218	0.518	0.211	0.014
Personal characteristics						
Gender	2.189	1.047	0.034	-0.206	1.288	0.866
Age	-0.111	0.058	0.058	-0.028	0.076	0.712
Education	0.210	0.124	0.088	-0.038	0.173	0.835
Socioeconomic characteristics						
Produce assembler	0.813	1.232	0.509	2.002	1.741	0.250
Retailer	2.822	1.418	0.050	4.093	1.522	0.007
Rice trader	1.156	0.723	0.109	-0.903	0.982	0.357
Cash crops trader	0.386	1.135	0.736	-6.683	2.808	0.017
Value of business assets	0.171	0.117	0.144	0.277	0.092	0.003
Years of ICT use	-0.718	0.170	0.000	-0.366	0.871	0.674
Years of trading experience	0.151	0.077	0.051	0.078	0.177	0.395
Environment characteristics						
CAM (PPRR) installation	0.528	0.259	0.041	0.911	0.403	0.026
Distance to buying market	0.019	0.007	0.004	-0.015	0.008	0.051
Distance to selling market				*0.071*	*0.024*	*0.003*
Number of purchasing markets				-2.511	1.993	0.207
Distance to electricity supply	0.113	0.073	0.122			
Distance to mobile phone services	-0.026	0.068	0.706			
Constant	-3.321	2.129	0.118	-9.692	7.631	0.205
		Number of obs = 211			Number of obs = 211	
		Wald chi2(19) = 51.05			Wald chi2(20) = 76.93	
		Prob > chi2 = 0.000			Prob > chi2 = 0.000	
		Pseudo R2 = 0.589			Pseudo R2 = 0.834	
		Log pseudolikelihood = -36.919578			Log pseudolikelihood = -18.766393	

however weak. On the other hand, results indicate that the likelihood of owning mobile phone decreases with age as well as years of ICT use. This suggests a the greater likelihood of mobile phones ownership among younger traders than older ones probably because younger people are more adept in using mobile phones. These findings corroborate those of Katengeza et al. (2011) for the Malawi grain traders. The negative correlation with a longer period of having used any ICT tools may result from traders' habits, since traditional technologies such as radio broadcasting or billboards are often present in many rural areas. As expected, traders in areas that have had CAM installation for a longer period are more likely to own mobile phones than their counterparts, other things constant. This finding probably relates to the demonstration effect of having a CAM that uses mobile phones (or other ICTs) for the dissemination of market information. The other environment factor which increases the likelihood of mobile phones ownership by traders includes distance to market where trader buys commodities. Specifically, results indicate that traders that buy their commodities in distant markets are more likely to own mobile phones than their counterparts. This finding supports those of Aker (2008a) that traders in areas

with mobile phone coverage seek and purchase grain from distant markets. This finding suggests that traders might own phones for use in acquiring market information as implied by the positive relation between mobile phone ownership and the types of market information needed.

Factors driving the use of mobile phones for agricultural transactions

The above discussion has indicated that there is greater ownership of mobile phones in the PPRR zone and also that traders in areas with longer CAM installation (a component of the PPRR program) are more likely to own mobile phones than their counterparts. Does the presence of PPRR in an area increase the likelihood of traders using mobile phone for agricultural transactions? In order to address this question, we estimated a logit regression model with use of mobile phone for agricultural transactions as the dependent variable and similar explanatory variables as in the mobile phone ownership model above. The corresponding results are presented in the last two columns of Table 8. As shown, the Pseudo R^2 is 0.834 and the p-value of Wald test is 0.000 indicating that model fits the data quite well.

As hypothesized, results indicate that being located in an area where PPRR operates (that is areas with CAM installation) indeed increases the likelihood of traders using mobile phones for agricultural transactions. The other drivers of the use of mobile phone for agricultural transactions include the number of information types needed by the trader, the profitability (benefit) of agricultural transactions, the total call and transport costs per unit sold, and the total transaction time used by a trader per unit sold.

Traders who seek information on price, volume, quality, place of purchase, and/or place of sale are more likely to use mobile phone. Okello (2011) finds similar results relating to use of mobile phones for seeking information on quality of produce by grain traders in Kenya. Results also show that high revenues (margin) from agricultural transactions increases the likelihood of using a mobile phone, probably because the trader is able to purchase airtime and the phone handset which tends to be the most expensive aspect of a mobile phone. In addition, the more the call cost per unit sold and time per unit sold used in agricultural transactions (i.e. smaller quantities traded) the higher the likelihood of using a mobile phone. But, the less the transport cost per unit sold (i.e. larger quantities traded) the higher the likelihood of using a mobile phone.

Among the personal characteristics, results indicate that the use of mobile phones for agricultural transactions is not affected by gender, age and education. The finding that education has no effect on the use of mobile phones for agricultural transactions is surprising since a study by Okello et al. (2009) found that education affects the ability of farmers to use some of the functions in a mobile phone, in particular the text messaging. Similar findings are also reported by Katengeza et al. (2011); Malawi and Egyir et al. (2011) in Ghana. However, this result may suggest that the majority of the traders tend to use the call (voice) function, with only a few using text messaging, for handiness and rapidity as shown in Figure 3.

A number of socio-economic factors also affect the likelihood of a trader using mobile phone for agricultural transactions. These include whether a trader is a retailer or a cash crop dealer and the value of business assets owned by a trader. As shown, being a retailer increases the likelihood of a trader using mobile phone for agricultural transactions, other things constant. This finding suggests that retailers might use phones for acquiring market information as implied by the positive relation between mobile phone use and the call and time per unit sold (smaller quantities traded). Results also show that traders who are endowed with more business assets, a proxy for capacity of the traders, are more likely to use mobile phones for agricultural transactions than their counterparts. This finding is not surprising given that traders that are more endowed with business assets are more likely to be financially stable and hence able to afford the high cost of using mobile phones for grain trading business. Indeed, technology adoption literature has long acknowledged the importance of household capacity (asset endowment) on adoption new technologies (Shiferaw et al., 2009).

Results further show that two other environment factors (besides location in PPRR zone) affect the likelihood of using mobile phones for agricultural transactions. These factors include distance to the point where the traders buy the produce and distance to the point where they sell. Other things constant, the less the distance the trader has to travel to buy the produce the more the likelihood that he/she will use mobile phones for agricultural transactions. On other hand, the greater the distance the trader has to travel to sell the more the likelihood that he/she will use mobile phones for agricultural transactions. This last result corroborates those of Aker (2008a,b) who finds that traders use mobile phones to check prices in distant markets before travelling to buy or sell their produce there.

CONCLUSIONS AND RECOMMENDATION

This study examined the effect of an MIS intervention known PPRR on the ownership and use of mobile phones by grain traders in Madagascar. The study finds that traders in areas covered by PPRR (especially those in areas with CAM installation) are more likely to own mobile phones and are also very likely to use such phones for agricultural transactions. The study also finds that several other factors affect the ownership and use of mobile phones by traders. These include factors that relate to the usefulness of mobile phones, trader specific characteristics, socio-economic factors and environmental

factors. The study therefore concludes that installation of PPRR's CAM infrastructure in an area induces the likelihood of ownership and use of mobile phones by traders. It also concludes that literacy is critical to use of mobile phones. The study further concludes that transaction costs (call and transport) and time taken in agricultural exchange in driving the likelihood of mobile phones use by traders relate to quantities traded. These findings imply that PPRR benefits traders by facilitating their access to market information in distant markets and/or markets in which traders take a lot of time to transact business. They further imply that ease of access to (and/or ownership of) mobile phone can potentially improve the performance of agricultural markets by reducing transaction costs.

This study therefore recommends that the government and private sector needs to find a way of reducing the cost of owning and using mobile phones. This can be done by either reducing the cost of mobile phone handset or reducing the cost of calling. The former is province of private sector (and can be done by making cheaper handsets) while the latter is the role of government and can be achieved by reducing taxes of call recharge vouchers. One of the impediments to the ownership and use of mobile phones for agricultural transactions is age, with older traders less likely to use mobile phones. This study therefore recommends the need to educate older traders on the benefits of using mobile phones in agricultural transactions. Given the finding that literacy affects the use of mobile phones by traders, this study recommends the need to increase investment in education in the long term and design handsets that are easier to use by the relatively less educated traders. At the same time, PPRR can greatly help by incorporating training ("learning by doing") based on the use of mobile phone tools (call, SMS, computing) in its promotional activities. Further, investments in infrastructures (especially electricity and mobile telephony network coverage) should be improved to make the reach of all grain markets by phone possible, which currently is not the case. Finally, the "tacit contracts" between farmers and produce assemblers/brokers such as "buying territories or zones" may not encourage competition to the benefit of farmers. This study did not investigate the effect of such activities. This study therefore recommends that future study examine the effect of such conduct on the use of mobile phones for agricultural transactions.

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