MSU International Development
Working Paper

Impact of Agricultural Market Information Systems Activities on Market Performance in Mozambique

Mozambique Country Report

by

Andrew M. Kizito, Cynthia Donovan, and John M. Staatz

MSU International Development Working Paper No. 124

July 2012

Department of Agricultural, Food, and Resource Economics
Department of Economics

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East Lansing, Michigan 48824

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Funding for this document was provided by the American people, via the Food Security III Cooperative Agreement (GDGA-00- 000021-00) between Michigan State University and the United States Agency for International Development, Bureau for Food Security, Office of Agriculture, Research, and Technology.

The authors gratefully acknowledge financial support from three key sources: the William and Flora Hewlett Foundation through the West Africa Market Information Project; the Bill and Melinda Gates Foundation, through the Guiding Investments in Sustainable Agricultural Markets in Africa (GISAMA) project; and the United States Agency for International Development (USAID) Mozambique Mission, through its support to SIMA.

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ISSN 0731-3483

Published by the Department of Agricultural, Food, and Resource Economics and the Department of Economics, Michigan State University, East Lansing, Michigan 48824-1039, U.S.A.

ACKNOWLEDGMENTS

The authors would like to thank Eric Crawford and Brent Ross in the Department of Agricultural, Food, and Resource Economics at Michigan State University, and Jack Meyer in the Economics Department at MSU for providing helpful comments on this paper.

Thanks also goes to participants in Mozambique National Household Survey (*Trabalho de Inquerito Agricola* (TIA)) surveys, the farmer focus groups in Nampula province in Mozambique who provided information that triangulated some of the findings in this study, and to Patricia Johannes who provided valuable formatting and editorial assistance.

The authors thank the Ministry of Agriculture, Directorate of Economics staff members, and leadership, especially the Agricultural Market Information System (SIMA) staff members for their insights and the Department of Statistics for access to the TIA dataset.

Any views expressed or remaining errors are solely the responsibility of the authors.

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EXECUTIVE SUMMARY

The objective of this research is to analyze the impact of agricultural market information systems (MIS) activities on market performance in Mozambique. This report analyzes factors that are associated with reception of improved agricultural market information from the MIS and other sources among farmers in Mozambique; and how the reception of improved agricultural market information affects prices obtained by sellers of maize in Mozambique. From the econometric analysis of a two-year panel household data set for four provinces in Mozambique, the study finds that the generic factors that are associated with the reception of improved agricultural market information include: (a) growing maize and large and small groundnuts; (b) owning a radio; (c) presence of a cell phone network in the village; (d) membership in a farmer association; (e) access to extension services; (f) proximity to a road with public transport; (g) being nearer to a village administrative post; (h) level of education; and (i) the agro-ecological zone in which the household is located. The analysis indicates that, holding other factors constant, reception of market information by staple crops farmers in Mozambique is associated with a higher probability of market participation of up to 34%.

From the econometric analysis of the effects of receiving information on prices received by smallholder farmers, the study finds that the mean price difference per kilogram of maize sold between households with and without information (also referred to as an information premium or information rent) is 12%. This premium translates into an average income gain of 0.32 meticais per kilogram of maize sold, or an income gain of $2.96 per household per year (about 1% of average gross household income in 2005 meticais, which was $361) for an average household that sells about 214 kilograms of maize in the main growing season per year. The estimated aggregate marginal population gain in income by an estimated a quarter million households that received information and sold maize is estimated to be $723,121 in the main marketing season per year. These gains are approximately six times more than the operational costs in MIS of $130,000 in 2002. This suggests that even if as little as 1/6 of the information received by Mozambican farmers in 2002 came from the SIMA and only maize price gains are included, that MIS was a socially profitable investment.

These results are consistent with the observation that providing improved agricultural market information helps to link farmers to markets, a process that improves their welfare, and moves them to more efficient market outcomes. Based on these findings, the following actions may increase reception of improved agricultural market information, and consequently market participation and increased incomes among users: (a) The MIS provides information on major marketable staples; (b) The MIS prioritizes radio as its most important diffusion channel of market information; (c) the MIS moves to include cell phones as an additional diffusion channel; (d) The MIS considers farmer associations and farmer groups as an important MIS clientele; (e) The MIS considers government and NGO extension staff as an important MIS clientele; (f) Information diffusion is focused in areas with potentially high supply response. Some of these options, such as cell phones, are likely to benefit more commercialized farmers with larger volumes to trade and greater assets, however these options contribute to a dynamic rural economy and increased opportunities across a broad spectrum of rural households

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ACRONYMS

ADRA	Adventist Development and Relief Agency
AFRE	Department of Agricultural, Food, and Resource Economics, MSU
CARE	A relief and development non-governmental organization
CLUSA	Cooperative League of the United States of America
CPI	Consumer Price Index
DID	Difference-in-difference estimators
FELICIDADE	A national NGO in Nampula Mozambique
FEWS NET	Famine Early Warning System Network
FIML	Full Information Maximum Likelihood
FOB	Freight on Board
FOC	First Order Condition
GDP	Gross Domestic Product
GISAMA	Guiding Investments in Sustainable Agricultural Markets in Africa
HH	Households
ICT	Information and Communication Technologies
IIAM	Institute of Agricultural Research of Mozambique
IKURU	A Mozambique Farmers Cooperative
INFOCOM	A market information system through the Ministry of Commerce and Industry
KM	Kilometer
MIS	Market Information System
MSU	Michigan State University
MTN	*Meticais da Nova Familia* – the currency of Mozambique),
NGOs	Non-Governmental Organizations
OLIPA	National NGO that helps farmers to produce and to find markets for the commodities in Mozambique.
OLS	Ordinary Least Squares
P4P	Purchase for Progress program
SIMA	Sistema de Informação de Mercados Agrícolas (Agricultural Market Information System of Mozambique)
SIMAP	Provincial SIMA units
TIA	*Trabalho de Inquerito Agricola*
USAID	United States Agency for International Development
USD	U.S. Dollar
VIF	Variance Inflation Factors
WFP	World Food Programme

1. IMPACT OF AGRICULTURAL MARKET INFORMATION SYSTEMS ACTIVITIES ON MARKET PERFORMANCE IN MOZAMBIQUE

1.1. Introduction and Research Questions

In many Sub-Saharan African countries, it is common that two nearby villages, districts or markets have significantly different farmgate, assembly, wholesale, or retail market prices for the same quantity and quality of agricultural produce. This can be caused by many factors, such as lack of market information, poor roads and bridges between the markets and/or villages, thin or near-missing markets, insecurity, or policies and actions that impede the flow of goods within and between countries. One of the actions that can help reduce price differences between locations at the same marketing level (e.g., farmgate, assembly market, or urban wholesale prices) is the provision of improved agricultural market information. Differences in prices of the same quantity and quality of agricultural produce between locations are expected. These differences, however, reflect problems when they differ significantly (e.g., beyond transaction costs between locations).

Agriculture is an important contributor to Mozambique's gross domestic product (GDP). According to World Development Indicators from the World Bank, in 2008, the percentage of value added to GDP from agriculture was 29%, and 63% of the population in Mozambique lived in rural areas. In Mozambique, many studies point out the importance of market information in improving market participation, sales revenue, and crop income (Boughton et al. 2007; Mabota et al. 2003; Mather 2012; Mather, Cunguara, and Boughton 2008). However, no study has empirically studied factors that influence the reception of market information by small-and medium-holder farmers in Mozambique. This report seeks to fill this gap.

The objective of this research is to analyze the impact of MIS activities on market performance in Mozambique. More specifically, this report analyzes factors that are associated with reception of improved agricultural market information from the MIS and other sources among farmers in Mozambique. The report also looks at the relationship between receiving price information and the prices received by farmers when selling maize in Mozambique.

Farmers obtain value when they make informed production and marketing decisions based on more complete information, such as decisions about size of areas to cultivate, what crops to grow, and whether to engage in selling or buying in the market, including decisions on spatial and temporal arbitrage. Economic theory postulates that improved market information helps improve market efficiency, redistribute welfare, or reduce the cost of being off-the equilibrium price and quantity (Aker 2010; Aker and Mbiti 2010; Hayami and Peterson 1972; Jensen 2007; Jensen 2010; Kizito 2009; Staatz et al. 2011).

It is hypothesized that farmers who receive price information are more likely, keeping other factors constant, to receive higher prices than do farmers without information. Higher prices from the sale of staple food crops lead to higher sales revenue, higher household incomes, improved food security, and reduction of poverty. The higher prices, however, are obtained at a search cost, and theory suggests that farmers will search up to that level where the marginal benefit equals the marginal cost of search (Stigler 1961), or until they get a price higher or equal to their reservation price (Varian 1980). Therefore, the specific research questions addressed in this report are:

1. What factors influence the reception of improved agricultural market information from the MIS and other sources among medium-scale and smallholder farmers?
2. Keeping other factors constant, is receiving improved agricultural market information positively associated with market participation in staple crop marketing?
3. Keeping other factors constant, are farmers who receive improved agricultural market information more likely to receive higher maize prices compared to farmers who do not?
4. How do the marginal and aggregate benefits from receiving improved agricultural market information for an average Mozambique farmer who participates in the market as a maize seller compare with the operational costs of a MIS?

The rest of the report is organized as follows. Section 1 presents the study hypotheses; describes the source of the data, the sampling design, and study coverage; the market information systems (MIS) in Mozambique between 2002 and 2005; and a summary of indicators used to measure the impact of information and the presence of information and communication technologies (ICT) that are used to transmit information on market performance. Section 2 presents the theoretical and empirical models of reception of market information and market participation and prices obtained. Section 3 presents factors that are associated with reception of improved agricultural market information and its role in linking farmers to markets in Mozambique. Section 4 presents the effects of the reception of improved agricultural market information on prices obtained by sellers of maize in Mozambique. Section 5 summarizes the main findings and their implications for MIS design and policy.

1.2. Hypotheses

1. Two types of factors are hypothesized to be associated with reception of improved agricultural market information by farmers in Mozambique. There are factors that are internal to the household and other factors that are external to the household. External factors are those that cannot be easily changed in the short-run (an agricultural season) or those that are out of the direct influence of households in the short-run. Internal factors are those that can be easily changed in the short-run. Internal factors that are hypothesized to be positively associated with reception of market information by farmers in Mozambique include commodity(ies) produced, ownership of a radio, ownership of a bicycle, and membership in farmer associations. External factors hypothesized to be positively associated with reception of market information include presence of a cell phone signal (network) in the village, availability of tapped[1] electricity in the village from electricity transmission lines, access to extension services, age of household head, the education level of the household head, the total land area, the value of total farm assets, geographical region, and the agro-ecological zone in which the household is located. External factors hypothesized to reduce the probability of reception of market information include longer distances to the nearest road with public transport, longer distances to village administrative post, and a household being headed by a female.
2. Households that receive improved market information are more likely to participate in staple crop markets, keeping other factors constant. To address reverse causality (endogeneity or simultaneity), market participation and reception of market information

[1] In many African countries, untapped electricity lines pass through many villages, implying that households in such villages do not use the electricity transmitted through their villages.

are estimated as a recursive biprobit model, with reception of market information appearing in the structural equation of market participation. The reverse-loop effect of market participation on reception of market information is not the focus of this report.
3. Receiving market information is positively associated with higher maize prices received among households in Mozambique.

Note that the boundary between external and internal factors to the household is porous. For example, membership in farmer associations may be decided within the household (internal) or due to incentives put in place by governments and non-governmental organizations (NGOs) for membership in farmer associations (external).

1.3. Data, Sampling Design, and Study Coverage

The above research questions and hypotheses are analyzed and tested using panel data collected in the National Agricultural Surveys conducted by the Directorate of Economics/ Department of Statistics in Ministry of Agriculture in Mozambique called *Trabalho de Inquerito Agricola* (TIA). Panel data for 2002 and 2005 are used. The survey used a stratified, cluster sampling design in 2002 and then revisited the same households in 2005, covering 4,908 rural small- and medium holder households from 80 out of 130 districts (Mather 2012). This study analyzes data from four provinces in Mozambique, namely Manica, Sofala, Zambezia, and Nampula. These provinces are in the central and northern parts of Mozambique, the main production areas of four main marketed staples (maize, common beans, large- and small groundnuts). These provinces are the main production areas given rainfall as well as other agro-ecological considerations as well as relatively high rural populations and access to national and regional markets in neighboring countries such as Zimbabwe, Zambia, and Malawi (Boughton et al. 2007).

The results from the analysis of survey data are triangulated by field study observation by the lead researcher, who visited Mozambique and interacted with employees of SIMA in Maputo, employees of the Provincial Information System for Agricultural Markets (SIMAP) in Nampula Province in northern Mozambique, farmers and farmer group leaders in Murrupula District in Nampula Province, local and international NGOs, food assistance organizations, donors, and traders in formal and informal market who utilize market information from SIMA and other sources.

1.4. Market Information Systems in Mozambique between 2002 and 2005

There are three formal systems that were operating in Mozambique during the period of the surveys (2002-2005): 1) the Agricultural Market Information System (known as SIMA), operated by the Ministry of Agriculture; 2) INFOCOM, a market information system through the Ministry of Commerce and Industry; and 3) the Famine Early Warning System Network (FEWS NET) program funded through USAID and associated with the Ministry of Agriculture.

1.4.1. SIMA

SIMA is the national MIS based in the Ministry of Agriculture and was started in 1991 with the aim of providing agricultural market information to farmers to enable them negotiate for better prices with traders, to traders and processors to identify opportunities, and to policymakers for food security planning and policy formulation. SIMA has representatives in each province, and is assisting provinces in decentralization such that each province in Mozambique will have a SIMAP. Some provinces did not have functional SIMAPs during the study period, many still are working to establish and maintain their SIMAPs.

The main commodities on which information is reported are white maize grain and flours, common beans, cowpeas, rice, large and small groundnuts, wheat flour, edible oil, and dry cassava. SIMA collects and provides information on transportation costs incurred by traders to move commodities between markets; producer, wholesale, and consumer weekly price levels using both standard and nonstandard units; estimated quantities of commodities available for sale in major wholesale markets; regional and international FOB prices, future prices of major commodities; and foreign exchange rates of neighboring and major countries' currencies. SIMA also provides market analysis covering opportunities and outlook for selected commodities in selected provinces based on field research and rapid appraisals (Mabota et al. 2003; SIMA 2009).

The main modes of diffusion used by SIMA at national level include email, national Radio Mozambique, national television, website, and newspapers. The main modes of diffusion used by SIMAP at provincial levels include local radio in local languages, email, notice boards, blackboards, hand-delivery, and through mail bins (pigeon holes) at the province headquarters once a month. Copies of the bulletin are given to local NGOs so that they can distribute the information through their extension agents. Also, the provincial officials take the market information bulletin with them when they go to visit the rural areas in districts. In addition, some district enumerators in provinces are expected to distribute the information they collect to the rural community radios.

1.4.2. INFOCOM

INFOCOM in the Ministry of Commerce and Industry provides price information for a range of consumer products from urban areas, primarily focused on the formal sector of supermarkets and stores, but it does not cover some of the staple crops and the rural markets covered by SIMA. The information from INFOCOM is published in the main local newspaper, *Noticias*, on Fridays, but the system has difficulties in maintaining the weekly information, especially during 2002-2005, and so there are gaps. There is no radio or television dissemination, but there is some dissemination of bulletins by email.

1.4.3. FEWSNET

In Mozambique, FEWSNET provides information on cross-border trade focused on volumes of trade for key agricultural commodities crossing the borders informally. It does not capture formal trade. FEWSNET gets secondary data on prices from SIMA. The information from FEWSNET is disseminated with emails to recipients such as NGOs, farmer associations, WFP, the World Bank, and individual users.

1.5. Measuring Impact of Information on Market Performance

Several indicators have been used to measure the impact of market information and presence of information and communication technologies that are used to diffuse information on market performance. Some of these market performance indicators include market participation and crop revenue or income (Boughton et al. 2007; Mabota et al. 2003); changes in price dispersion or variation (Aker 2008; Aker 2010; Goyal 2010; Jensen 2007); marketing margins and profits (Diarra, Traoré, and Staatz 2004; Holtzman et al. 1993); consumer surplus, producer surplus, and dead weight loss (Aker 2010; Goyal 2010; Hayami and Peterson 1972; Jensen 2007; Kizito 2009); elimination of waste (Jensen 2007); household-level prices received by sellers (Svensson and Drott 2010; Svensson and Yanagizawa 2009); aggregated prices paid by traders in markets (Goyal 2010; Svensson and Drott 2010; Svensson and Yanagizawa 2009); sales volumes (Goyal 2010); integration of markets (Shahidur 2004); number of new markets and entrants into value chains (Aker 2010; Dembélé, Tefft, and Staatz 2000; Jensen 2007); effects on production decisions or output response (Goyal 2010); decision-theoretic approaches (Eisgruber 1978; Nicholson 2002); and revealed and stated preferences. A detailed review of these is included in Kizito (2011).

1.6. Sources and Channels of Obtaining Information in Mozambique

In this study, sources of information and modes (channels) through which information is diffused are separated. Also, reception of information and access to information differ. Sources of information refer to the organization, firm, or person that collects and provides market information. An MIS is just one of these sources. Others include traders, extension and NGO workers, neighbors, friends, and relatives, normally through word-of-mouth. Modes or channels of diffusion refer to the methods used to disseminate information to users such as radios, word-of-mouth during meetings, cell phones, and the internet. Moreover, reception of market information implies access to market information, but access to market information does not imply reception of market information. For example, owning a radio or cell phone implies access to, but not reception of market information. Reception of information from any source using any channel and its effects on prices of maize received by households are the focus of this analysis.

In the 2005 household survey, the following question was asked about market information. *During the last 12 months, has the household received any information about agricultural prices (1=yes, 2= no) through: (1) radio, (2) association, (3) rural extension agent, (4) publication, (5) NGO, and (6) other sources?* Note that there was no distinction between *sources* and *channels* through which information was received in the survey. A household could report receiving information from more than one source or channel; and information received from all the different sources and channels could be from SIMA and other sources, implying that it is difficult to separate information from SIMA and other sources. For example, information from extension agents, NGOs, and associations could be from SIMA or from other sources such as traders. Also, the information diffused though radio, TV, and publications could all be from SIMA or other sources.

From observations during the case studies in Mozambique, in addition to radio and publications, other channels through which market information is disseminated include posts on notice boards at administrative headquarters, blackboards in urban markets, and through meetings or contact with provincial extension and NGO workers. The urban markets where information is disseminated are located near district headquarters (i.e., in municipalities).

Extension and community meetings are conducted in trading centers, or near areas with commercial activities (e.g., shops and commodity stores), administrative activities (e.g., district or village headquarters), or at community amenities (e.g., at schools and churches). In more rural districts, some community and extension meetings are conducted under large trees near junctions of main and feeder roads. Another observation was that households in Mozambique receive market information from farmers, farmers' associations, traders, traders' associations, rural extension workers, publication, and local and international NGOs. In some cases, this is information originally generated by SIMA.

Part I of Table 1 shows that the percent of households that reported to receive price information in Mozambique was 42 in 2002 and was 37 in 2005. Part II of Table 1 shows that in 2005, the sources and channels and their corresponding percentages used to receive information among households that received price information were radio (79%), extension agent (19%), other sources (19%), publication (9), associations (7%), and NGO (11%). Note that the total of sources and channels of information may be more than 100% because households could report more than one source or channel through which they received the information. Part II of Table 1 shows that in 2005, the sources and channels and their corresponding percentages used to receive information among all households were radio (29%), extension agent (7%), other sources (7%), publication (3%), associations (3%), and NGO (4%).

Using household panel survey data, this report looks at factors that are associated with reception of market information from any source and through any channel among farmers in Mozambique. Because there are many sources and channels through which households can receive information, this study then analyzes the effects of receiving information from all possible sources (including the market) and using all possible channels on marketing behavior and market performance rather than attempts to analyze the effects of receiving information from one source (e.g., the MIS or extensions agents) or from one channel (e.g., cell phone or radio). The advantages of this approach are that the analysis avoids the spillover effects problem in terms of different sources of information, and the attribution problem in terms of which dissemination channel contributed to better performance than the other. Indeed, users may find the different sources of information and the different channels used to receive information as complementary, with no single source dominating the other for decision making.

The general economic theory used to generate the hypotheses analyzed in this study is that improved agricultural market information helps to reduce information asymmetries (increased market transparency or reduction in transaction costs) resulting in increased market participation (linking farmers to markets) and increased capacity of farmers to negotiate for better prices with traders. When informed farmers participate in markets, they earn an information rent or information premium. Thus, this study focuses on how the provision of improved agricultural market information benefits the sellers, in the form of higher prices, but does not address whether that increase in higher prices comes at the expense of buyers or through an increase in overall economic efficiency. Therefore, higher prices received are used here as an indicator of the impact of market information on sellers' welfare, but not necessarily overall economic efficiency. Nonetheless, improved information helps move the price and output levels closer to those of a competitive market, thus leveling the playing field, and leading to income redistribution. Furthermore, reception of information leads to reduction in risk and efficient allocation of productive resources (assuming that farmers are risk averse). Thus, although not measured here, theory would lead us to expect that some of the gain received by farmers represents an increase in system-wide efficiency.

Table 1. Proportions of Households that Received Price Information and Their Sources and Channels of Reception in Mozambique

Part 1. Proportion of Households that Received Price Information in 2002 and 2005										
	Nampula (N=510)		Zambezia (N=603)		Manica (N=392)		Sofala (N=307)		Total (N=1812)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Received Information (2002)	0.70	0.46	0.23	0.42	0.56	0.50	0.27	0.45	0.42	0.49
Received Information (2005)	0.59	0.49	0.27	0.44	0.25	0.43	0.49	0.50	0.37	0.48
Part II. Sources and Channels of Receiving Information Among Households That Received Market Information in 2005										
	Nampula (311)		Zambezia (N=163)		Manica (N=86)		Sofala (164)		Total (N=724)	
Sources and Channels[a]	Mean	Mean	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Radio	0.87	0.87	0.68	0.47	0.88	0.33	0.74	0.44	0.79	0.41
Extension agent	0.15	0.15	0.23	0.42	0.11	0.32	0.30	0.46	0.19	0.39
Other sources	0.16	0.16	0.22	0.42	0.08	0.27	0.29	0.45	0.19	0.39
Publication	0.09	0.09	0.10	0.30	0.10	0.30	0.10	0.30	0.09	0.29
Association	0.10	0.10	0.04	0.20	0.01	0.11	0.07	0.26	0.07	0.25
NGO	0.06	0.06	0.22	0.42	0.00	0.00	0.05	0.21	0.11	0.31
Part III. Sources and Channels of Receiving Information Among All Households in 2005										
	Nampula (N=510)		Zambezia (N=603)		Manica (N=392)		Sofala (N=307)		Total (N=1812)	
Sources and Channels	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Radio	0.51	0.5	0.18	0.39	0.22	0.41	0.36	0.48	0.29	0.45
Extension agent	0.09	0.28	0.06	0.24	0.03	0.17	0.15	0.35	0.07	0.26
Other sources	0.09	0.29	0.06	0.24	0.02	0.14	0.14	0.35	0.07	0.25
Publication	0.05	0.22	0.03	0.16	0.02	0.16	0.05	0.21	0.03	0.18
Association	0.06	0.24	0.01	0.11	0	0.06	0.04	0.19	0.03	0.16
NGO	0.04	0.19	0.06	0.24	0	0	0.02	0.15	0.04	0.19

Source: Government of Mozambique 2002 and 2005; a: Sources and channels were collected in 2005 only.

2. THEORETICAL AND EMPIRICAL MODELS OF RECEPTION OF MARKET INFORMATION AND PRICES OBTAINED

The theoretical framework used in the analysis to generate hypotheses about how improved market information is likely to affect marketing behavior (willingness to supply to the market) is based on the agricultural household model (Singh, Squire, and Strauss 1986). Let p be a vector of prices; w a vector of input costs (e.g., marketing and search costs through radio and cell phones); q a vector of quantity sold; X a vector of production inputs such as land labor and capital; Z is a vector of control variables that affect prices received (such as market information, proximity to markets, education, gender, and agro-ecological zones); $F(q, X; Z) = 0$ is the production possibility set, and information helps farmers decide how to use the inputs in the production possibility set—i.e., it helps determine the production function itself; and θ is the Arrow-Pratt measure of risk aversion that captures production related risks (e.g., due to poor weather). Considering the production side of the household and using the mean-variance model to account for price expectations and production- and marketing-related risks, the farmers' maximization problem using a linear function of profits and profit variance is:

(1) $$\max \pi(p, w, Z) = \max_{q, X}\{E(pq - wX) - \theta / 2Var(pq - wX) : F(q, X; Z) = 0\}.$$

The first order conditions with respect to quantity sold, and inputs used are:

$$p_i - \theta q_i \sigma_p^2 - \lambda \frac{\partial F(q, X; Z)}{\partial q_i} = 0$$

$$-w_i - \lambda \frac{\partial F(q, X, Z)}{\partial X_i} = 0;$$

where σ_p^2 is the variance of the prices received by farmers and captures price expectations and production related risks. Solving the first order condition (FOC) from the above equation leads to the following inverse function for output supply, and input demands:

(2) Inverse of output supply: $p_i = s(q, w, \sigma_p^2, Z)$

(3) Input demand: $X_i = X(p, w, \sigma_p^2, Z)$

From the model, it is observed that the amount supplied and the input demands are both functions of the variance of prices. From the FOCs, the price variable has a positive sign (coefficient) and the variance of price variable has a negative sign. These imply that farmers require a higher price than a higher variance of the price. Also, these FOCs imply that input demand is negatively related to the variance of prices. Thus, if farmers receive better market information, the perceived variance of prices decreases, increasing both supply and input demand. In estimating the model, since information cannot be easily quantified because it is a non-physical input, the probability of it reception is computed.

2.1. Model of Receiving Information and Its Impact on Market Participation

This section presents the model used to estimate the factors that are associated with reception of improved agricultural market information, and how the reception of market information is associated with market participation. In this study, market participation is defined as a household that sold at least one of the four main staples (maize, large groundnuts, small groundnuts, or common beans) and zero otherwise. The factors that affect the reception of market information and its effect on market participation are estimated using a recursive bivariate probit model because the error terms are likely to be contemporaneously correlated.

(4) $$I_{it} = \Phi(Z_{it}\alpha_1) + \mu_{1it}$$

(5) $$S_{it} = \Phi(Y_{it}\gamma_1 + \gamma_2 I + \gamma_3 T + \gamma_4 I * T) + \mu_{2it}$$

$$E(\mu_{1it}) = E(\mu_{2it}) = 0;\ Var(\mu_{1it}) = Var((\mu_{2it}) = 1; Cov(\mu_{1it}, \mu_{2it}) = \rho$$

In the reduced form equation (4), I_{it} is a binary variable equal to zero when a household did not receive market information and equal to one when it received market information. Φ is the cumulative density function for the standard normal distribution, and α_1 is the vector of estimated parameters for Z_{it}-the vector of exogenous variables that affect reception of market information.

In equation (5), S_{it} is a binary variable equal to one when a household sold maize, large groundnuts, small groundnuts, or common beans, and zero otherwise. Y is a vector of all exogenous variables that affect market participation other than market information, and T is a time dummy. Equation (5) gives the expected probability that a household participates in the market given that it receives market information. Holding other factors constant, the estimated coefficient, γ_2 in equation (5) gives the sign of the partial effects of reception of market information on the probability of a household to participate in the market as sellers of any of the four commodities in the study (maize, small groundnuts, large groundnuts, and common beans). Of importance are the partial effects $\Delta\hat{P}(S = 1 | I) \approx [f(\gamma_2 I_i)\Delta I_i]$. Equations (4) and (5) imply that information search and market participation are simultaneous decisions. The strength of this model is that it recognizes that farmers receive information from multiple sources and through multiple channels, and thus does not suffer from spillover effects (in terms of what was the source of information) and attribution problems (in terms of which dissemination channel contributed to better performance than the other) encountered if one attempts to measure reception of information from one source or using one channel as is discussed in the second last paragraph of section 1.6.

2.2. Model of Receiving Information and Its Impact on Prices Received

The following structural model is used to measure the impact of market information on prices received.

(6) $$p_{it} = \beta_0 + \beta_1 I + \beta_2 T + \beta_3 I * T + \beta_4 Z_{it} + v_{it}$$

where $i = 1,....N$ households; p is the price of maize received; I is a market information dummy, T is a time dummy, and Z_{it} is a vector of control variables (other than access to information) that affect prices received by farmers when selling. For policy analysis, and in a pooled cross section over time data structure, the estimated coefficient β_3 on the interaction of year and information dummies is also called the difference-in-difference (DID) estimator (Wooldridge 2002). The variables in Z_{it} include quantity of maize sold, growing other complementary or supplementary staple crops such as groundnuts and common beans, distance to main roads with public transport, distance or administrative centers (where most markets are located), ownership of a bicycle, education levels, gender, dummies for agro-ecological conditions, availability of a cell phone network in the village, and provincial dummies. Also, Z_{it} contains the total number of drought days during the main growing season and price variance at the district level to capture production related risks. $v_{it} = a_i + \varepsilon_{it}$ is the composite random error term, i.e., the sum of unobservable effects a_i and the idiosyncratic error ε_{it} that affect prices received. Typically, v_{it} contains the known and unknown effects (e.g., missing variables and unobserved effects) that affect prices received. The assumptions are that a_i and ε_{it} have a zero expected mean and a constant variance.

2.3. Sample Size and Econometric and Statistical Concerns

The information reception and market participation models are estimated using data from all growers of any of the four staple crops, while the prices received model is estimated using data from only those households that sold maize. As shown in Table 2 and Table 3 the sample size for the information reception and market participation models is 3,624. The reason for including the four crops in the model of reception of market information and market participation was because SIMA disseminates information on these commodities, which can influence a farmer’s decision to grow and market any of the four commodities.

The price model can only be conducted for households that participated in the market (i.e., have positive prices and quantities sold). The price model was estimated for only maize because it is the most traded staple crop in Mozambique. Table 2 indicates that among the sample households, 924 sold maize, 185 sold large groundnuts, 376 sold small groundnuts, and 97 sold common beans. An alternative approach could have been to estimate a system of four equations—one for each crop. This, however, was not done because the data for prices and quantities sold for common beans, large groundnuts, and small groundnuts, as can be seen from the above figures, individually represented smaller samples, which could have led to substantial loss of degrees of freedom if one attempted to estimate a system of equations (i.e., one would end up with only 97 observations). For these reasons, the structural model of prices received is conducted for only maize. From 924 households that reportedly sold maize, part 3 of Table 2 shows that the enumerators recorded a price and quantity sold for only 836. Therefore, the econometric model for prices of maize received is conducted for N=836 households.

The econometric and statistical concerns such as endogeneity due to suspected measurement errors in prices received, simultaneity between information reception and market participation, and omitted variables bias; identification of the market participation and reception of information models; attrition bias; multi-colinearity and heteroscedasticity; transformation of continuous variables; the use of rural price inflators; and heterogeneous effects are discussed in the Appendix 1.

3. FACTORS THAT AFFECT RECEPTION OF IMPROVED AGRICULTURAL MARKET INFORMATION AND ITS ROLE IN LINKING FARMERS TO MARKETS IN MOZAMBIQUE

3.1. Factors that Affect Reception of Improved Market Information

Table 2 presents the summary statistics of market participation and factors hypothesized to be associated with reception of market information in Nampula, Zambezia, Manica, and Sofala in Mozambique in 2002 and 2005. Table 3 shows the results of the analysis conducted using a biprobit model of receiving market information (hhinfo) and market participation (mp). The strength of this estimation method is that it (1) uses Full Information Maximum Likelihood (FIML), which leads to gain in asymptotic efficiency, (2) solves the endogeneity problem of information reception and market participation, (3) gives robust errors and thus accounts for heteroscedasticity in the error terms, (4) accounts for the sampling design used to collect the data, (5) accounts for the panel structure of the data, and (6) corrects for attrition bias if there is any because it uses the attrition-bias corrected weights. The results in Table 2 and Table 3 are discussed concurrently.

3.1.1. Model Evaluation

The coefficient correlation, ρ between the errors from the two equations is -.53 and the Wald test indicates that it is significantly different from zero at a 0.1% level of significance, implying that probabilities of reception of market information and market participation are dependent on each other (mutually dependent) and that estimating the two equations jointly is satisfactory. The econometric model for reception of information correctly predicts *with information* and *without information* 67% of the time. The model of market participation correctly predicts *participated in the market* and *did not participate in the market* 66% of the time.

3.1.2. Staple Crops Grown

Table 3 shows that 71% of households grew maize, 15% grew large groundnuts, 32% grew small groundnuts, and 7% grew common beans. Overall, 84% of the households grew at least one of the four commodities in the study. From the econometric analysis, growing maize, growing large groundnuts and small groundnuts increased the probability of receiving information at a 0.1% level of significance. The expected marginal effect resulting from growing maize on the probability of receiving market information is 0.12, while that of growing large groundnuts is .16, and that of growing small groundnuts is .13. This means that holding other factors constant, there is a 12% higher probability that a farmer who grows maize will receive market information than one who does not. This probability is 16% when the farmer grows large groundnuts and 13% when the farmer grows small groundnuts.

Table 2. Summary Statistics of Market Participation and Factors Hypothesized to Affect Reception of Market Information in Nampula, Zambezia, Manica, and Sofala in Mozambique in 2002 and 2005

Variable Labels, Names Units, and Types of Variables	Without Information		With Information		Pooled sample		
	Obs	Mean	Obs	Mean	Obs	Mean	Std. Dev.
Part 1. Access to Market Information Variables							
HH grew maize (Yes=1, No=0)	2122	0.68	1502	0.76	3624	0.71	0.45
HH grew large groundnuts(Yes=1, No=0)	2122	0.11	1502	0.20	3624	0.15	0.36
HH grew small groundnuts (Yes=1, No=0)	2122	0.26	1502	0.39	3624	0.32	0.47
HH grew beans-common (Yes=1, No=0)	2122	0.06	1502	0.07	3624	0.07	0.25
HH grew at least one of the 4 crops (Yes=1, No=0)	2122	0.78	1502	0.91	3624	0.84	0.37
HH has a radio (Yes=1, No=0)	2122	0.43	1502	0.64	3624	0.52	0.50
Electricity within village (Yes=1, No=0)	2122	0.12	1502	0.17	3624	0.14	0.35
Cell phone network within the village (Yes=1, No=0)	2122	0.17	1502	0.18	3624	0.18	0.38
HH owns bicycle (Yes=1, No=0)	2122	0.29	1502	0.33	3624	0.31	0.46
Distance to nearest road with public transport (Km)	2122	31.97	1502	32.57	3624	32.22	33.19
Distance to village administrative post (Km)	2122	19.99	1502	17.74	3624	19.04	20.17
Distance to district headquarters (Km)	2122	44.38	1502	41.23	3624	43.05	26.90
HH belongs to an association (Yes=1, No=0)	2122	0.03	1502	0.08	3624	0.05	0.22
HH received extension (Yes=1, No=0)	2122	0.07	1502	0.25	3624	0.15	0.35
Female heads HH (Yes=1, No=0)	2122	0.26	1502	0.17	3624	0.22	0.42
Age of HH head	2122	42.17	1502	40.48	3624	41.45	14.09
Household size	2122	4.92	1502	5.16	3624	5.02	2.56
HH members between 15 and 59	2122	2.35	1502	2.48	3624	2.41	1.26
Years of education of HH head	2122	1.94	1502	2.50	3624	2.18	2.41
No formal education (Yes=1, No=0)	2122	0.49	1502	0.36	3624	0.44	0.50
0- 4 years of formal education (Yes=1, No=0)	2122	0.36	1502	0.44	3624	0.39	0.49
5+ years of formal education (Yes=1, No=0)	2122	0.14	1502	0.20	3624	0.17	0.37

Table continued on next page

Table 2 (continued)

Variable Labels, Names Units, and Types of Variables	Without Information		With Information		Pooled sample		
	Obs	Mean	Obs	Mean	Obs	Mean	Std. Dev.
Total land area (hectares)	2122	1.66	1502	1.99	3624	1.80	1.72
Value of total farm assets (05 meticais)	2122	1125	1502	1934	3624	1468	6439
HH in Nampula province (Yes=1, No=0)	2122	0.25	1502	0.56	3624	0.38	0.49
HH in Zambezia province (Yes=1, No=0)	2122	0.54	1502	0.23	3624	0.41	0.49
HH in Manica province (Yes=1, No=0)	2122	0.12	1502	0.12	3624	0.12	0.32
HH in Sofala province (Yes=1, No=0)	2122	0.10	1502	0.09	3624	0.10	0.29
HH in Low Agro-ecological Zone (Yes=1, No=0)	2122	0.12	1502	0.06	3624	0.10	0.30
HH in Low to Medium Agro-ecological Zone (Y=1, N=0)	2122	0.52	1502	0.53	3624	0.52	0.50
HH in Medium to High Agro-ecological Zone (Y=1, N=0)	2122	0.36	1502	0.41	3624	0.38	0.49
Drought days in main growing season	2122	29.98	1502	23.63	3624	27.30	20.69
Time dummy (2002=0, 2005=1)	2122	0.51	1502	0.48	3624	0.50	0.50
Part 2. Market Participation[a]							
HH sold maize (Yes=1, No=0)	1559	0.33	1198	0.34	2757	0.34	0.47
HH sold large groundnuts(Yes=1, No=0)	284	0.30	316	0.32	600	0.31	0.46
HH sold small groundnuts (Yes=1, No=0)	581	0.27	551	0.39	1132	0.33	0.47
HH sold beans-common (Yes=1, No=0)	203	0.29	163	0.24	366	0.27	0.44
HH sold at least one crop (mp)	2122	0.31	1502	0.41	3624	0.35	0.48
Part 3. Maize Price and Quantity Variables[b]							
Quantity of maize produced (kg)	431	562	405	694	836	623.85	944
Season 1 area under corn (ha)	431	0.75	405	0.83	836	0.79	0.88
Quantity of maize sold (kg)	431	164	405	269	836	214	520
HH-specific sale price of maize in 2005 meticais[c]	431	2.66	405	2.87	836	2.76	1.30
Units of measurements (0=liters tins, 1=kg bags)	431	0.64	405	0.70	836	0.67	0.47

Source: Government of Mozambique 2002 and 2005; a. Percentages out of total households that grew crops; b. Variables here cover only households that sold a positive quantity of maize; c. In 2005, 1 dollar = 23.061 Meticais.

Table 3. Estimated Parameters and Robust Standard Errors in Parentheses from the Recursive Bivariate Probit Model of Reception of Market Information and Market Participation

	Hypothesized Effect on hhinfo[1]	Bivariate Probit		Marginal effects after biprobit (dy/dx)[2]		Mean
VARIABLES		hhinfo	mp[3]	hhinfo	mp	X
HH[4] received market information			0.9369***		0.342	0.42
			(0.190)			
HH grew maize	+	0.3050***		0.117***		0.71
		(0.073)		(0.027)		
HH grew large groundnuts	+	0.3927***	0.2917***	0.155***	0.111	0.15
		(0.071)	(0.081)	(0.0280		
HH grew small groundnuts	+	0.3342***	0.3201***	0.131***	0.120	0.32
		(0.057)	(0.073)	(0.022)		
HH grew beans-common	+	-0.0034	0.5222***	-0.001	0.203	0.07
		(0.096)	(0.097)	(0.038)		
HH has a radio	+	0.4244***	-0.1018	0.164***	-0.037	0.52
		(0.061)	(0.069)	(0.023)		
Cell phone Network in the Village	+	0.2336**		0.092**		0.14
		(0.090)		(0.036)		
Electricity in the Village	+	0.0562	-0.1914*	0.022	-0.068	0.18
		(0.080)	(0.080)	(0.032)		
HH owns bicycle	+	-0.0857	0.0708	-0.033	0.026	0.31
		(0.064)	(0.063)	(0.025)		
Log of distance to nearest road with public transport (KM)	-	0.0914***	0.0518	0.036***	0.019	2.87
		(0.025)	(0.027)	(0.010)		
Log of distance to village administrative post	-	-0.0987***	-0.0067	-0.038***	-0.002	2.43
		(0.028)	(0.028)	(0.011)		

Table continued on next page

Table 3 (Continued)

	Hypothesized Effect on hhinfo	Bivariate Probit		Marginal effects after biprobit (dy/dx)		Mean
VARIABLES		hhinfo	mp	hhinfo	mp	X
HH belongs to an association	+	0.2646*	-0.1394	0.105*	-0.050	0.05
		(0.126)	(0.123)	(0.050)		
HH received extension	+	0.7457***		0.290***		0.15
		(0.077)		(0.028)		
Female heads HH	-	-0.1074	-0.0252	-0.042	-0.009	0.22
		(0.070)	(0.070)	(0.027)		
Log of HH size	+	-0.0425	-0.0666	-0.017	-0.024	1.48
		(0.052)	(0.053)	(0.020)		
Age of HH head	+	0.0161	-0.0210*	0.006	-0.008	41.45
		(0.010)	(0.009)	(0.004)		
Age of HH head squared	+	-0.0002*	0.0002*	0.000*	0.000	1917
		(0.000)	(0.000)	(0.000)		
Head had 1 to 4 years of formal education (Yes=1, No=0)	+	0.1256*	-0.0910	0.049*	-0.033	0.39
		(0.061)	(0.059)	(0.024)		
Head had at least 5 years of formal education (Yes=1, No=0)	+	0.1299	-0.2545**	0.051	-0.090	0.17
		(0.083)	(0.083)	(0.033)		
Log of total land area	+	0.0454	0.1233**	0.018	0.045	0.30
		(0.039)	(0.038)	(0.015)		
Log of value of total farm assets	+	-0.0018	0.0528***	-0.001	0.019	5.50
		(0.014)	(0.014)	(0.006)		
HH in Manica province (Yes=1, No=0)	-	-0.0808	0.2142	-0.031	0.081	0.12
		(0.084)	(0.138)	(0.032)		
HH in Sofala province (Yes=1, No=0)	-	-0.1132	-0.2396*	-0.044	-0.084	0.10
		(0.073)	(0.097)	(0.028)		

Table continued on next page

Table 3 (Continued)

	Hypothesized Effect on hhinfo	Bivariate Probit		Marginal effects after biprobit (dy/dx)		Mean
VARIABLES		hhinfo	mp	hhinfo	mp	X
HH in low-medium agro-ecological zone (Yes=1, No=0)	+	0.4984***		0.192***		0.52
		(0.088)		(0.033)		
HH in medium-high agro-ecological zone (Yes=1, No=0)	+	0.5393***	0.1546*	0.210***	0.057	0.38
		(0.090)	(0.061)	(0.035)		
Year Dummy (2005=1, 2002=0)	+	-0.0902	0.2448***	-0.035	0.090	0.50
		(0.058)	(0.073)	(0.023)		
Log of dist. to district headquarters	-		0.1016*		0.037	3.50
			(0.040)			
HH in Zambezia province (Yes=1, No=0)	-		0.0663		0.024	0.41
			(0.069)			
Drought Days in main growing season	-		-0.0076***		-0.003	27.30
			(0.002)			
Constant		-1.5928***	-1.0441***			
		(0.255)	(0.256)			
athrho			-0.5916***			
			(0.163)			
rho[5]			-.5311***			
			(.117)			
Observations		3624	3624			
Percent correctly predicted		67	66			

+ Positively associated, - Negatively associated with hhinfo; 1. hhinfo=household received market information; 2. dy/dx is for discrete change of dummy variable from 0 to 1; 3. mp= market participation; 4. HH=household; *** p<0.001, ** p<0.01, * p<0.05; 5. Wald test of rho=0: chi2 (1) = 13.1612, Prob > chi2 = 0.0003.

3.1.3. Ownership of a Radio

Table 3 shows that 52% of households in the four provinces in Mozambique own a radio. The table also shows that owning a radio increased the probability of receiving market information at the 0.1% level of significance. The expected marginal effect resulting from having a radio, holding other factors constant, to reception of market information is 0.16. This finding concurs with observations made during field visits in Nampula Province, where farmers reported radio as the main channel through which they receive market information. From interviews with farmer groups in Nampula province, 5 out of 14 farmers interviewed had a radio.

3.1.4. Presence of a Cell Phone Network

In the four provinces under study, 14% of households had a cell phone network in their village from the 2002 and 2005 panel data. Availability of a cell phone network in the village increased the probability of information reception at a one percent level of significance. From the econometric analysis, the expected marginal effect of availability of a cell phone network, ceteris paribus, on the probability of receiving market information is 0.09. The marginal effect of the presence of a cell phone network in the village is less than that of owning a radio which is 0.16, at least in the 2002-05 period. This could be because there was no SMS system yet for diffusing market information during that study period and communications with cell phones was not very common as it is currently. Moreover, there was a known radio broadcast of market information, at least in Nampula and parts of Zambezia during the study period. An alternative variable would have been ownership of a cell phone, but these data were not collected in either round in the household surveys. To the extent that those who own cell phones share information with neighbors, either directly or through their actions in the market that affect other actors' behavior, the presence of mobile telephone network might actually be a better variable, as it picks up some of the spillover effects.

3.1.5. Availability of Electricity

In the four provinces under study in Mozambique, 18% of households have electricity in their villages. Electricity is a complementary good with nearly all ICT equipment such as TVs, radios, computers, and cell phones. The hypothesis was that, holding other factors constant, households in areas with electricity could use more ICT gadgets, and therefore have a higher probability of receiving market information. The coefficient of the dummy variable indicating availability of electricity in the village was positive but not statistically significant at a 5% level. It was observed during the field visit in Murrupula District in Nampula Province that farmers use old car and motorcycle batteries as an alternative source of electricity to power their radios and televisions, and to charge cell phones in rural areas. They also use dry cell batteries for their radios, although some complained that their cost of 30 meticais ($1.07 using the 2009 exchange rate) in 2009 per pair was high. These alternative sources of electricity could have reduced the effect of having electricity in the village on information reception.

3.1.6. Ownership of Means of Transport and Access to Roads and Public Amenities

In the four provinces under study in Mozambique, 31% of households own a bicycle, and the average distance to the nearest road with public transport is 32 kilometers. The average distance to the village administrative post is 19 kilometers, and the average distance to the district headquarters is 43 kilometers. From the econometric analysis, a unit increase in the natural logarithm of the distance in kilometers to the nearest road with public transport increased the probability of receiving market information at a 0.1% level of significance, rejecting the null hypothesis that households closer to the roads with public transport are more likely to receive market information. The expected marginal effect resulting from a unit increase in the natural logarithm of the distance to the nearest road with public transport on the probability of receiving market information is 0.04. It was hypothesized that a good road network brings in more agricultural commodity traders who are a source of market information, although some farmers in Mozambique do not trust information from traders. Thus, farmers near roads with public transport, it was assumed, would be more likely to receive market information, in addition to obtaining higher prices for their agricultural commodities. The possible reasons for this unexpected outcome could be that more distant farmers put in more search to avoid the risks and higher costs of delivering produce to markets when prices are not favorable compared to farmers near roads with public transport. In addition, in areas where markets are more competitive, farmers may rely on the market itself as their information source, although they probably do not report this as a source of market information. The idea here is that the behavior of markets themselves transmits information about supply and demand conditions, and if markets are working well, they are efficient transmitters of this information, making MIS less needed.

Holding other factors constant, an increase in the natural logarithm of distance to village administrative post decreased the probability of receiving market information at a 0.1% level of significance. The expected marginal effect resulting from a change in the natural logarithm of the distance to the nearest village administrative post by one unit, on the probability of receiving market information is -0.04. In Mozambique, market information is also disseminated at administrative headquarters (e.g., on blackboards and notice boards in markets and district or provincial headquarters), implying that as households move further from these locations, their probability of getting information declines. The policy implication is that reception of market information could be improved if the government moved services closer to the people by increasing decentralization of information systems.

3.1.7. Belonging to Farmer Associations

In the provinces under study, only 5% of households belonged to a farmers' association. Membership in farmers' associations increased the probability of receiving market information and was significant at the 5% level. From the econometric analysis, the expected partial effect of belonging to a farmer association, *ceteris paribus*, on the probability of receiving market information is 0.11. In Mozambique, many international NGOs such as ADRA in Zambezia, CLUSA and CARE in Nampula, and national and local NGOs and organizations such as FELICIDADE, IKURU, and OLIPA distribute the SIMA and SIMAP information bulletins in addition to their own bulletins to farmers through farmer associations. Some smallholder farmers in Murrupula are organized in farmer associations and sometimes jointly market maize. Some farmer groups are legally registered and others are not. Registered farmer associations usually have bank accounts and can sell to World Food Programme (WFP)'s Purchase for Progress (P4P) program, and theoretically earn more money and minimize price risks. It is not clear, however, what percentage of poorer farmers in Mozambique have a strong voice and are active participants in farmer association activities that can provide farmers with increased reception of market information.

3.1.8. Access to Extension Services

In some provinces in Mozambique such as Nampula, market information bulletins are given to the extension unit for dissemination through radio or through meetings. In addition, many national and international NGOs provide advisory services to farmers including market information. In the provinces under study, 15% of households received extension services in the pooled 2002 and 2005 data. From the econometric analysis, access to extension services increased the probability of receiving market information at the 0.1% level. The expected partial effect of receiving extension services, holding all other factors constant, on the probability of receiving market information is 0.3. Extension has the largest partial effect in the study, suggesting that improvements in extension services can lead to more information reception among small-scale farmers (assuming causality), or that there have been more investments in MIS where extension investments also occur (complementarity of MIS with other services).

3.1.9. Gender of Household Head

In the four provinces under study, 22% of households were headed by females, and having a female head of household did not significantly reduce the probability of reception of market information at the 5% level of significance. Household activities impede the capacity of female household heads to obtain market information from sources away from home, such as association and community meetings where market information is disseminated by NGO employees and extension workers. It may be argued, however, that females usually have many domestic activities, which compels them to stay at home near radios compared to males. Prolonged staying at home among female household heads can potentially increase their probability of listening to market information from radio compared to male household heads who work away from home (unless men travel with radios, such as drivers of vehicles with radios or take them with them to the fields to work).

3.1.10. Family Size and Age of Household Head

The average family size was five members, the average age of the household head was 41 years, and the average number of household members between ages 19 and 59 years was 2.4. From the econometric analysis, the hypothesis that larger family sizes may be positively associated with larger social networks and therefore increase the probability of receiving market information was rejected at the 5% level of significance. From the econometric analysis, the test of hypothesis that reception of information increases with age was not significant at the 5% level but the age variable had a positive coefficient. The coefficient of the squared term of age of household head, however, was negative and significant at the 5% level. Taken together, these age results suggest that as the age of the household head increases, the probability of receiving market information also increases and reaches a maximum value at the age of 40 years, after which an additional year starts to reduce the probability of receiving market information.

3.1.11. Education and Literacy Level of Household Head

Table 3 shows that the average years at school of the household heads were 2.2. Household heads with no formal education represent 44% of household heads in the sample, those with one to four years of formal education are 39%, and those with more than five years of formal education are 17%. According to the World Bank World Development Indicators, the literacy rate in 2008 among adults aged 15 years and above was 54%. From the econometric analysis, the household head receiving one to four years of education increased the probability of reception of market information at a 5% level of significance compared to a household head having no formal education. The expected marginal effect of a household head receiving between one to four years of education, holding other factors constant, on reception of market information is 0.05. Having five or more years of formal education did not increase probability of receiving market information significantly above that of those having no education. It is likely that household heads with more than five years of formal education engage in other non-farm activities or employment and participate in markets as net buyers of food—a group that this study did not analyze due to lack of data on net staple crop food purchases.

3.1.12. Size of Land Holdings and Farm Assets

The demand for information depends on levels of production, which also depend on factor inputs such as size of land holdings or cultivated area, and farm assets. In the four provinces under study, the average value of total farm assets was 1,468 meticais (64 dollars using the 2005 exchange rate), and the average size of household land was 1.8 hectares. In the econometric analysis, the natural logarithm of total land area is positively associated, but does not significantly influence, reception of market information at a 5% level. The natural logarithm of the value of total farm assets is negatively associated and does not significantly affect reception of market information at 5% level.

3.1.13. Geographical and Administrative Setting

Some provinces have relatively developed infrastructure such as markets, bridges, and administrative facilities, implying that services such as transport, markets, and extension are closer to farmers and traders in some provinces. Proximity to some of these services increases the probability of receiving market information. Overall, 38% of households are located in Nampula, 41% in Zambezia, 12% in Manica, and 10% in Sofala. Among households that do not receive information, 25% are in Nampula, 54% in Zambezia, 12% in Manica and 10% in Sofala. From the econometric analysis, a household being located in Manica and Sofala reduces the probability of receiving market information compared to being located in Nampula province, although the relationship is not statistically significant at the 5% level. The dummy variable for a household being located in Zambezia was dropped from the reception of information equation because it was collinear with the variable measuring whether a household received extension. During the period covered by this study, the Ministry of Agriculture Provincial Directorate had a price information system with radio broadcasts that could be heard in Nampula and parts of Zambezia. There was no such system operating at the time in Sofala, and the Manica system functioned intermittently. This could be the reason why being located in Manica or Sofala reduces the probability of receiving market information.

3.1.14. Agro-Ecological Zones

Some areas are located in good agro-ecological zones with high production potential, which increases the demand for market information. Three agro-ecological zones are included in the analysis. They include: (1) the low potential agro-ecological zone, where 10% of the households interviewed resided; (2) the low-medium potential agro-ecological zone, with 52% of households; and (3) the medium-high potential agro-ecological zone, with 38% of households. These agro-ecological zones are constructed from the new 10 agro-ecological zone classifications by the Institute of Agricultural Research of Mozambique (IIAM) based on agricultural potential taking into account (1) altitude, (2) precipitation, (3) temperature, and (4) soil types. In the econometric analysis, the dummies for the low-medium potential agro-ecological zone and medium-high potential agro-ecological zone capture differences across agro-ecological zones. These dummies significantly and positively affect the probability of reception of market information at a 0.1% level, compared to the probability in the low potential areas. The expected marginal effect of a household being located in the low-medium potential agro-ecological zone, *ceteris paribus*, on the reception of market information compared to a household in the low-potential agro-ecological zone is 0.19, and that of a household being located in the medium-high agro-ecological zone is 0.21. These results are consistent with the theoretical argument that the demand for information is higher in areas with high production potential and hence a higher potential supply response to market information. Production potential and supply responsiveness should be two main criteria for identifying target crops for market information and areas where market information is disseminated (Kizito 2009).

3.2. Effect of Reception of Information on Market Participation

From the pooled sample, 34% of farmers who grow maize participate in the markets as sellers, 31% of farmers who grow large groundnuts participate in the market as sellers, 33% of farmers who grow small groundnuts participate in the market as sellers, and 27% of farmers who grew common beans participate in the market as sellers. Altogether, 35% sell at least one of these four main staple commodities. In this study, market participation is defined as a household that sold at least one of these four main staples. This definition of market participation is different from some definitions that divide market participation into two or three categories - the net-sellers, net buyers, and autarkic for one or a bunch of commodities (Bellemare and Barrett 2006; Goetz 1992; Key, Sadoulet, and De Janvry 2000) because data on purchasing behavior of respondents was not collected. The analysis in this section only considered sellers of the four staples. This implies that the effect of reception of market information, as stated in the objectives, is analyzed from seller's standpoint, not the buyer's standpoint.

The econometric results indicate that receiving market information significantly increases the probability of market participation at the 0.1% level. The expected marginal effect resulting from reception of market information, holding other factors constant, on the probability of market participation is .34 when evaluated at the mean of the 42% of households that received market information. This is in contrast with a study by Boughton et al. (2007) that finds market information not to significantly affect market participation. Reasons why the results differ may include the following:

1) The Boughton et al. (2007) study used national data for the whole country, while this study used data from the four main production provinces only, where supply response is

likely to be higher. These four provinces account for 57% of the households in the 10 provinces of Mozambique.

2) This study analyzed reception of information for four main staple crops for which SIMA provides information while the Boughton et al. (2007) study included cash crops (cotton and tobacco) and only one staple (maize). SIMA does not provide price information about cotton and tobacco, nor does any other MIS in Mozambique.

Other factors that significantly increase the probability of market participation, and their expected marginal effects (evaluated at their means) on the probability of market participation and significance levels of the estimated biprobit coefficients in brackets include: growing large groundnuts (.11, p<0.001), growing small groundnuts (.12, p<0.001), growing beans (.2, p<0.001), the natural log of total land area (.05, p<.01), the natural log of value of farm assets (.02,p<0.001), a household being located in medium-high agro-ecological zone (.06,p<0.05), the year dummy for 2005 (0.09,p<0.001), and the natural log of distance in km to district headquarters (.04,p<0.05). The dummy variable for growing maize was excluded in the structural model of market participation to meet exclusion restrictions, which require that there be some overlap of statistically significant exogenous variables in the structural and reduced-form equations.

Factors that significantly reduce the probability of market participation, and their expected marginal effects (evaluated at their means) on the probability of market participation and significance levels of the estimated biprobit coefficients in brackets include: presence of electricity in the village (-0.07, p<0.05), age of household head (-0.01, p<0.05), the household head having higher than five years of education (-0.09, p<0.01), a household being located in Sofala province (-0.08, p<0.05), and the number of drought days during the main growing season at the district level (-0.003, p < 0.001).

It was anticipated that presence of tapped electricity (public electricity network) in a village would increase market participation since it increases the production stages such as processing in the value chain of commodity subsectors (e.g., milling in case of maize). It was anticipated that processing staple crops in a village increases the range of products that a household can sell, in addition to the grown product, and thus increase the likelihood that farmers would sell in the market. It is not clear why this variable produced counter-intuitive results. One possibility is that its effects were captured by other variables.

Holding other factors constant, each additional year of the household head age reduces the probability of market participation, reaching the minimum value at the age 53 years, after which each additional year increases market participation. It was anticipated that as age of household head increases, market participation would also increase, reach a certain age and then start to decline —i.e., that age would be concave. There is no apparent conjecture as to why this variable produced counterintuitive results. Holding other factors constant, each additional day of drought reduced the probability of market participation by 0.3%. The intuition is that when there is drought, there is less production and therefore less market participation by households as sellers.

4. EFFECTS OF THE RECEPTION OF IMPROVED AGRICULTURAL MARKET INFORMATION ON PRICES OBTAINED BY SELLERS OF MAIZE IN MOZAMBIQUE

4.1. Evaluation of the Econometric Models

Table 4 presents the means and standard deviations of the factors hypothesized to be associated with prices received. The table also presents the results of the estimated coefficients (and robust standard errors in parentheses) of the regression of prices of maize received on reception of market information. To account for other confounders that may affect prices received and to test the robustness of the results, the structural model of prices received is estimated using four estimation methods and five equations: pooled ordinary least squares (OLS) (including a restricted and unrestricted pooled OLS model), a fixed effects model, a random effects model, and robust regression. The full results of the estimated models are included in Appendix 2. This section presents the results of the random effects model, which assumes that the unobserved effects are random and puts them in the error term.

4.2. Effect of Improved Agricultural Market Information on Prices Obtained

4.2.1. Effects of Market Information on Prices Received

From Table 4, the random effects model estimates show that a household that receives market information received a price that is 12% higher than that received by a household that does not receive market information. This difference is statistically significant. Other factors that significantly and are positively associated with prices of maize received include household owning a bicycle, the log of household members aged between 15 and 59 years, and the 2005 year dummy. Factors that significantly and are negatively associated with prices of maize received by households include a household being located in Zambezia, Manica, and Sofala provinces, compared to Nampula.

It was hypothesized that variation in prices may be due to the difference in units of measurement used to sell maize. A dummy variable indicating whether households used kilogram units or liter tins as units of measurements was included in the regressions and was not found to be statistically significant at the 5% level. This makes intuitive sense. If farmers were systematically getting higher prices selling using one type of container over another, they would probably figure this out over time and shift to selling more using the container offering the higher price. So it appears that over time, the effective price per kilogram has equalized across container types.

The variable on number of drought days in the main growing season was included in the model to control for the spatial and annual differences in rainfall patterns that might affect prices received. The estimated coefficients on this variable were not significant. Seasonality effects associated with the peak and off-peak marketing periods between large and small farmers is partly captured by including a quantity-sold variable in the price model. The estimated coefficients on this variable were not significant. Another variable that could have helped to capture these seasonality effects would be a dummy variable that indicates whether farmers sold in the four peak marketing months or in the off-peak marketing months. This variable was not included in the panel data analysis because data on the months in which sales were made was only collected in one round of the panel—the 2005 TIA.

Table 4. Means, Standard Deviations, and Regression Coefficients (Robust Standard Errors in Parentheses) of Reception of Market Information on Prices of Maize Received

Variable Name	Mean	Std. Dev.	Random Effects
(1)	(2)	(3)	(4)
HH received market information	0.47	0.50	0.1131*
			(0.053)
Variance of district price	1.63	1.22	0.0280
			(0.022)
HH grew large groundnuts	0.16	0.37	-0.0681
			(0.047)
HH has a radio	0.60	0.49	-0.0366
			(0.042)
Cell phone Network in the Village	0.12	0.32	0.0891
			(0.060)
HH owns bicycle	0.43	0.49	0.0869*
			(0.043)
HH belongs to an association	0.05	0.22	-0.0765
			(0.093)
HH received extension	0.18	0.39	-0.0282
			(0.047)
Female heads HH	0.17	0.38	-0.0434
			(0.060)
Units used in sale (0=liter tins, 1= kilogram bags)	0.67	0.47	0.0711
			(0.043)
Log of distance to nearest road[1] (KM)	3.22	1.19	-0.0210
			(0.021)
Log of distance to district headquarters	3.69	0.83	0.0247
			(0.029)
HH members between 15 and 59	0.83	0.43	0.1004*
			(0.049)
Head had 1 to 4 years of formal education	0.43	0.50	0.0549
			(0.041)
log of quantity of maize produced (kg)	5.88	1.05	-0.0082
			(0.022)
HH in Zambezia province (Yes=1, No=0)	0.48	0.50	-0.2603***
			(0.054)
HH in Manica province (Yes=1, No=0)	0.18	0.39	-0.2044*
			(0.080)
HH in Sofala province (Yes=1, No=0)	0.07	0.25	-0.1810*
			(0.080)
HH in Nampula province (Yes=1, No=0)[1]	0.27	0.45	

Table continued on next page

Table 4 (Continued)

Variable Name	Mean	Std. Dev.	Random Effects
(1)	(2)	(3)	(4)
HH in low medium agro-ecological zone	0.32	0.47	-0.0751
			(0.067)
HH in medium to high agro-ecological zone	0.55	0.50	-0.0587
			(0.063)
Log of drought days in main growing season	2.70	1.47	-0.0329
			(0.021)
Year dummy	0.48	0.50	0.2043**
			(0.079)
Interaction of year and information dummies	0.21	0.41	-0.0608
			(0.075)
Constant			0.9028***
			(0.172)
Observations			833
R-squared			
Adj. R-squared			
Number of hhid			654

Source: Authors' estimate from TIA data 2002 and 2005. Robust standard errors in parentheses; *** $p<0.001$, ** $p<0.01$, * $p<0.05$; 1: Nampula has no regression results because it is the base.

The study did not control for the size and number of buyers in the regions. Some provinces such as Manica have relatively larger buyers (one large miller and one large poultry production firm) who may offer higher prices compared to small buyers in other provinces in northern Mozambique. It is noted, however, that oligopsony (a few large buyers) and lower competition would suggest lower prices to sellers. Increased efficiency under oligopsony, however, in buying could suggest higher prices to sellers. Therefore, the effects of a few relatively large buyers could go either way in terms of affecting the prices received by sellers. Also, when there are many buyers, the market is likely to be more competitive, and become an information system itself, thus reducing the need and value of information from an independent MIS. These effects are partly captured by the regional (provincial) dummies that were included in the model. The regional dummy indicating whether a household was located in Manica is significant but negative in all models, which rejects the hypothesis that households in regions with relatively larger buyers (as measured by a regional dummy) receive higher prices.

In conclusion, the econometric analysis implies that holding other factors constant, households are likely to participate in markets and obtain higher prices when they receive improved agricultural market information. Increased market participation and higher prices received from the sale of surplus staple crops translate into increased incomes and improved wellbeing of households.

4.2.2. Limitations of the Model

The modeling in this chapter focuses on sellers (producers), but not buyers (consumers), of maize. This implies that the effect of reception of market information on prices, as stated in the objective 3 in section 1.1., is analyzed from only the producers' standpoint, not the buyers' standpoint. One question from this is: how would the results of this analysis differ for net buyers of maize? Answering this question would need further empirical research with greater information on commodity purchases by farm households. The authors' yet untested hypothesis is that in the short run, the gains from reception of improved information (e.g., increase in welfare and its redistribution) through increased market participation are captured more by producers than by consumers. In the long run, however, to the extent that improved market information leads farmers and traders to invest in more efficient production and marketing systems, it is likely that buyers would also benefit from the MIS. Moreover, even if the net gain from improved market information to individual consumers is small, when the number of consumers is large, then the aggregate net benefits to consumers may become greater than those to producers.

Another limitation of this model is that it does not show what part of the benefits that farmers get is from buyers. The model does not show what part of the benefits from information is a net efficiency gain and what part of it is redistribution of income, say from buyers to sellers. Therefore, one implication of the results from this study is that they give suggestions of willingness of sellers to pay for improved market information, but not the willingness of buyers to pay for improved market information.

4.3. Marginal and Aggregate Benefit from Information Reception

This section deals with research question number 4 in section 1.1. which is: How do the marginal and aggregate benefits from receiving improved agricultural market information for an average Mozambique farmer who participates in the market as a maize seller compare with the operational costs of an MIS? The section uses results from the descriptive and econometric analysis to compute the marginal and average benefits of reception of agricultural market information by an average maize farmer who sells maize in Mozambique under the SIMA. It then compares these aggregate benefits to the operational costs of a provincial MIS. At the time of these TIA surveys, the SIMAP were the only MIS providing price information to rural areas, in collaboration with SIMA at the central level. During the TIA 2005, 37% of the households received price information and 29% of households reported that radio was their main channel through which they received price information. Among households that received price information, 79% received the price information via radio. Ideally search costs by households would be estimated at the household level and costs of providing market information at the MIS level. Table 5 gives the model parameters and the estimated marginal and aggregate benefits from reception of improved agricultural market information in Mozambique.

Table 5. Model Parameters and Expected Marginal and Aggregate Benefits from Improved Market Information in Mozambique

Row	**Part I. Model Parameters**	Value
1	Average HH[1]-specific sale price of maize (2005 MTN per kg) without information (TIA data from Table 2.)	2.67
2	Random effects information coefficient (column (4) in Table 4.)	0.1131
3	Average Quantity of maize sold (kg) (TIA data from Table 2)	214
4	Exchange rate of 1 USD to the MTN in 2005	23.06
5	Total HHs in 4 provinces of Nampula, Zambezia, Manica, and Sofala	2,117,691
6	Percentage of HHs that grew maize (TIA data from Table 2.)	71%
7	Percentage of HHs that sold maize given that they grew maize (TIA data from Table 2.)	34%
8	Percentage of HHs that received information given that they sold maize=405/836 (TIA data from Table 2.)	48%
9	Estimated HHs that received information given that they sold maize in the 4 provinces: Row (5)*(6)*(7)*(8)	244,675
	Part II. Marginal and Aggregate Benefits Analysis	
10	Marginal percentage price gain per kilogram due to information	12.0%
11	Marginal price gain (information premium/ information rent) per kg in 2005 meticais	0.32
12	Average gain in income by one average household (USD)	2.96
13	Estimated aggregate population gain in income by HHs that received market information given that they sold maize (USD)	723,121

1. HH= Household.
Row 10= (exp (row 3)-1) x100
Row 11= (row 10) x (row 1)
Row 12= (row 11) x (row 3))/ (row 4)
Row 13= (row 12) x (row 9)

As indicated above, the goal is to get a sense of the magnitude of farmer benefits to market information for maize selling and compare to a minimum operational costs for market information provision.

4.3.1. Estimated Benefits Analysis

Row 10 in Table 5 shows the marginal percentage price gain per kilogram due to information, as estimated from the econometric analysis reported in section 4.2.1. It shows that the average marginal percentage price gain per kilogram due to reception of information is 12%.

Row 11 shows the marginal price gain in meticais equivalent and is obtained by multiplying the marginal percentage price gain (row 10) by the price received without information (row 1) This marginal price gain in meticais is equivalent to about 0.32 meticais per kilogram. This can also be considered as the marginal information premium or marginal information rent per kilogram of maize sold by a household that received information.

Row 12 shows the gain in income by one average household (i.e., a household that sold 214 kilograms of maize (row 3) in USD. It is obtained by multiplying marginal price gain (row 11) by the average quantity sold (row 3) and dividing it by the 2005 USD to MTN exchange rate (row 4). The average gain in income by one household from improved market information per household is 2.96 USD over each main marketing season using data for 2002 and 2005. This figure is considered as the benefit of searching market information by an average household in 2002 and in 2005. This gain from information search is about 1% of the estimated average gross total income of the households in the sample in 2005 meticais, which was $361. This implies that during 2002-2005, an average farmer could search profitably for information as long as the search costs were less than $2.96 in the principal marketing season of a year.

Row 13 estimates the average population gain in income by all households that received information given that they sold maize in the four provinces of Nampula, Zambezia, Sofala, and Manica. It is obtained by multiplying the gain in income by one household (row 12) by the number of households that received market information given that they sold maize (row9). The number of households that received information given that they sold maize (row 9) is estimated by multiplying the number of households in the four provinces (row 5) by the probability of growing maize (row 6) times the conditional probability of selling maize given that a farmer grew maize (row 7) times the conditional probability of receiving information given that a farmer sold maize (row 8). The average population gain in income by all household that received information—about a quarter million households—given that they sold maize (row 13) is estimated to be 723,121 USD per year based on 2002 and 2005 panel data. This finding implies that information systems whose aggregate investment cost is less than or equal to 723,121 USD per year would be profitable investments. Moreover, this aggregate benefit is only for maize selling activities. If the benefits were measured across other crops, they would be higher.

4.3.2. MIS Operational Costs in Mozambique

Table 6 shows the total operating costs in SIMA at the national level and in two SIMAPs in Nampula and Manica Province in 2002. The table shows that in 2002, the total operational costs of the system (SIMA and the two SIMAPs), including staff salaries, communication and transport, were around 3.3 billion meticais, or US$130,000 (Mabota et al. 2003). Based on the number of households that reported receiving improved market information from the TIA (2002), Mabota et al. (2003) estimated that the national average operational cost of providing market information to each rural household was 2,267 meticais, or about US$0.09.

Table 6. Annual Operating Costs of SIMA in 2002

System	Costs (Mt)	Cost ($US)a
National SIMA	2,447,472,934	
Provincial SIMA (Nampula)	749,876,840	
Provincial SIMA (Manica)	82,957,500	
Total	3,280,307,274	130,000

Source: (Mabota et al. 2003); a. One US dollar was equivalent to approximately 25,000 meticais.

Based on the MIS budget, the operating costs of running an MIS in Mozambique was about $130,000 for the whole country, and about $ 30,000 in Nampula province (Mabota et al. 2003). The average population gain in income by all household that received information given that they sold maize, estimated to be 723,121USD per year, approximately 6 times more than the entire operating costs of MIS in Mozambique in 2002. This suggests that even if as little as 1/6 of the information received by Mozambican farmers in 2002 came from the SIMA, that MIS was a socially profitable investment.

4.4. Limitations of the Study and Areas of Further Research

Market information is highly covariant with other explanatory variables because improvements in the provision of improved market information have often gone hand-in-hand with other market reforms and other investments that are not controlled for in this model. This suggests that some of the attribution of the returns to market information found in this study may be attributable to a whole package of actions rather than just market information separately. There may also be important differences between returns to investment in different channels for MIS dissemination, especially as ICT use begins to expand with cell phones, especially.

Due to data limitations, the models of reception of information, market participation, and prices of maize received consider only recipients of information as sellers (producers), but not buyers (traders and consumers). This means that the marginal effects of reception of information are under-estimated since they are computed based on selling decisions by producers only. Also, the model of prices received is estimated for only maize, yet there are many other staple crops grown and sold in Mozambique on which the MIS disseminate market information. Thus, focusing only on maize (which was necessary due to data limitations) also underestimates the effects of reception of information on the production and marketing decisions of farmers who sold other crops.

The models limit themselves to only the first round effects of information reception on market participation and prices received and do not estimate the general equilibrium effects (e.g., the effects of reception of information on crops grown or area planted) and the second order effects resulting from reception of market information. Taking these general equilibrium effects into account would, however, require much more data than were available for Mozambique and bigger multimarket models or computable general equilibrium models, which were beyond the scope of this study.

The reverse loop of the effects of market participation on the reception of market information is not estimated, although the endogeneity problem was dealt with by use of a bivariate probit model. Examining the impact of market participation on reception of market information is thus an area for future research. Also, in the future, the models could be estimated in *differences* in order to look at how changes in explanatory variables affect changes in reception of market information, market participation, and prices received. Also, assuming data becomes available, econometric models can be run to determine the effects of reception of market information among farmers on (1) area cultivated, (2) crops grown, (3) temporal arbitrage behavior, (4) frequency of transaction, (5) spatial arbitrage behavior, and (6) choice of forms of vertical coordination. Also, future studies could look at the effects of seasonality on the effect of prices received and demand for information.

5. SUMMARY AND MAIN FINDINGS AND THEIR IMPLICATIONS FOR MIS DESIGN AND POLICY

In many Sub-Saharan African countries, it is common that two nearby villages, districts or markets have significantly different farmgate, assembly, wholesale, or retail market prices for the same quantity and quality of agricultural produce. One of the actions that can help reduce price differences between locations at the same marketing level (e.g., farmgate, assembly market, or urban wholesale prices) is the provision of improved agricultural market information. In Mozambique, many studies point out the importance of market information in improving market participation, sales revenue, and crop income. However, no study has empirically studied factors that influence the reception of market information by small-and medium-holder farmers in Mozambique and the derived benefits in comparison with the investment or running costs of such services.

The objective of this research was to analyze the impact of MIS activities on market performance in Mozambique. This report analyzes factors that influence the reception of improved agricultural market information from the MIS and other sources among farmers in Mozambique; and how the reception of improved agricultural market information affects prices of maize received among smallholder farmers in Mozambique.

The rationale for providing improved agricultural market information is that farmers obtain value when they make informed production and marketing decisions based on better information, such as decisions about size of areas to cultivate, what crops to grow, and whether to engage in spatial and temporal arbitrage. From economic theory, improved market information helps improve market efficiency, redistribute welfare, or reduce the cost of being off the equilibrium price and quantity. It was hypothesized that farmers who receive price information were more likely, keeping other factors constant, to receive higher prices than were farmers without information. It was also hypothesized that the aggregate benefits from investing in the provision of improved agricultural information outweighed the associated running costs of providing the information to smallholder farmers.

The main result from the bivariate probit analysis is that, holding other factors constant, reception of market information by staple crops farmers in Mozambique significantly increases their probability of market participation by 34%. From the econometric analysis, the study finds that the factors that are associated with reception of improved agricultural market information include (a) growing maize, large and small groundnuts; (b) owning a radio; (c) presence of a cell phone network in the village; (d) membership to farmer association; (e) access to extension services; (f) proximity to a road with public transport; (g) the distance to village administrative post; (h) level of education; and (i) the agro-ecological zone in which the household is located.

The econometric analysis also showed that the mean percentage price difference per kilogram of maize sold between households with and without information (also referred to as an information premium or information rent) is 12%. This premium translates into an individual household marginal income gain of 0.32 meticais per kilogram of maize sold, or an income gain or information premium or information rent of $2.96 per household per year (about 1% of average gross household income in 2005 meticais, which was $361) for an average household that sells about 214 kilograms of maize in the main growing season per year. Therefore, reception of improved information increases market participation, and market participation increases household income. The estimated aggregate marginal population gain in income by an estimated a quarter million households that received information and sold maize is estimated to be $723,121 in the main marketing season per year. These gains are approximately six times more than the operational costs in MIS of $130,000 in 2002. This suggests that even if as little as 1/6 of the information received by Mozambican farmers in 2002 came from the SIMA, that MIS was a socially profitable investment.

These findings lead to the following question: how can the reception of improved agricultural market information be increased among users so that they participate in markets and increase their household income?

a) Focus MIS information on major marketable staples. Higher reception of market information, and hence higher market participation and increased household income, can be achieved when the MIS provides more information on the major marketable staples such as maize, groundnuts, and common beans.
b) Prioritizing radio as important diffusion channel of market information. The analysis suggests that higher reception of market information, and hence higher market participation and increased household income, can be achieved when the MIS make radio an important diffusion channel. It is noted that there have been big improvements in the availability and use of cell phone technologies in Mozambique since 2005. There is a possibility that the relative importance of radio compared to cell phones in terms of diffusion of improved market information could have shifted overtime. Reaching a wide population base, however, is important to realize gains from improved market information and during this research period, radio diffusion was the most widely used method.
c) Making cell phones an important diffusion channel. The presence of a cell phone network in the village was positively associated with reception of price information. Higher reception of market information, and hence higher market participation and increased household income, can be achieved when the MIS make cell phones an important diffusion channel. This option, however, is likely to benefit more commercialized farmers who are likely to afford to purchase cell phones and to buy airtime to use in search than the less commercialized ones.
d) Making associations an important MIS clientele. It is important for MIS to consider associations and farmer groups as important clientele of MIS, as the results showed that membership in such a group increased access to market information. It is not clear, however, what percentage of poorer farmers in Mozambique are active participants in farmer association's activities that can benefit them from increased reception of market information. Group marketing also enables farmers to amalgamate their produce to attain higher volumes. The implication is that there is need to encourage farmers to form or join marketing associations and to market in groups, which is likely to increase reception of market information.
e) Making extension an important MIS clientele: The implications are that the benefits from investing in MIS can significantly increase when the MIS provides more information to extension workers and NGO workers to disseminate to users.

The econometric analysis also indicated that distance to the nearest road with public transport, distance to village administrative post, a household head receiving between one to four years of education, and the agro-ecological zones in which a household is located affects reception of market information. These factors imply that information is useful when users can act on it and that information is complementary with other government programs and policies such as infrastructure development and investment in education. For example, some types of information (e.g., higher prices in distant markets) are more useful when farmers can transport their produce to markets on good feeder roads. Some types of improved market information (e.g., favorable or unfavorable price and quantity forecasts) are more useful when farmers can respond and produce more or less based on their agro-ecological conditions. Some types of improved market information (e.g., those diffused through newspapers, bulletins, SMS, television, and billboards) are useful when farmers have formal education to gain the capacity to read and write, and consequently the capacity to search and use written market information. The capacity of the MIS, however, to influence these factors is limited, since they depend on resources available to governments and donors and their opportunity costs. If resources were available, and governments and donors invested in these complementary services (e.g., universal education—including adult education—and improvements in feeder road infrastructure), then the results in the econometric analysis indicate that more households would likely receive improved market information.

In summary, this research has shown conditions under which households are likely to receive improved agricultural market information from the MIS or any other source. The study also shows reception of improved agricultural market information is associated with higher prices at which farmers sell their staple food crops. These higher prices due to improved market information from the sale of staple food crops should lead to higher sales revenue, higher household incomes, and reduction in poverty levels. These results are consistent with the observation that providing improved agricultural market information helps to link farmers to markets, a process that improves their welfare, and moves them to more efficient market outcomes.

APPENDICES

APPENDIX 1. ECONOMETRIC AND STATISTICAL CONCERNS

Endogeneity: Endogeneity means that one of the explanatory variables is related to the error term and may be caused by (1) measurement errors (in the dependent and or independent variables); (2) simultaneity, which means that one of the dependent variables is determined together with the independent variable; and (3) omitted variables that are correlated to the included variables (unobserved variables that are time-constant or time-varying). Each of these sources of endogeneity when observed was dealt with as follows.

Measurement Error in Prices Obtained—a Dependent Variable: The price data was suspected to have measurement errors due to use of non-standardized units of measurements such as modified liter tins, in addition to allegedly kilogram bags of varying weights. In many Sub-Saharan countries, buyers alter the shape of tins (or containers) by expanding the sides so as to pay a lower per unit cost to sellers. In contrast, sellers contract the sides of tins so as to obtain a higher per unit price from buyers. After examining the stem-and-leaf displays, the histogram, and the results from the *grubbs* procedure in STATA during the analysis of maize prices, 37 observations (4%) of households that sold maize were dropped because their prices were unusually high, which resulted in the following outcomes. Comparing the original and cleaned pooled data on prices of maize received by households, the sample mean reduced from 3.1 to 2.8, the sample variance from 5.2 to 1.7, the skewness from 3.8 to 1.1, and the kurtosis from 25.2 to 4.8, representing a 66% relative gain in precision and a significant improvement in the distribution of the data towards normality. From a survey sampling point of view, trading off 4% of the sample observations for movement towards normality and a 66% relative gain in precision is an excellent way of dealing with non-sampling errors.

In the econometric analysis, maize prices received are used as a dependent variable and a second assumption is that any remaining measurement errors in dependent variables do not violate any of the OLS assumptions (Greene 2003; Pindyck and Rubinfeld 1998; Wooldridge 2002). Thirdly, the price variable is transformed by taking its natural logarithm. Taking logarithms of continuous variables stabilizes the variance and hence reduces the effect of outliers (some of which result from measurement errors). Also, when measurement errors are present (in addition to heteroscedastic errors), the use of robust regression produces more efficient estimates than OLS.

Simultaneity: Using a Hausman simultaneity test, information reception was found to be endogenous with market participation, but not with prices received. The test involved estimating a linear probability model of information reception, and obtaining the residuals. The residuals and the dummy variable for reception of information were included in the structural probit model of market participation, and in the OLS structural model of prices received. Using a t-test, the residuals were found to be significantly different from zero at a one percent level of significance in the structural model of market participation, confirming simultaneity between reception of market information and market participation. Additionally, using a t-test, the residuals were not significantly different from zero at a five% level of significance in the structural model of prices received, confirming that there was no simultaneity between reception of market information and prices received. Endogeneity of reception of market information and market participation is solved by estimating a recursive bivariate probit of reception of market information and market participation.

Could the factors that affect growing any of the four staple crops in this analysis be the same factors that affect reception of market information? I.e., is growing any of the four staple food crops and reception of information jointly determined? We argue that the answer to this question is no for two reasons. First, farmers can receive information whether they chose to search for it or not because they naturally belong to networks in which some information flows—i.e., they voluntarily and involuntarily receive market information. Secondly, many farmers in central and northern Mozambique have grown and sold these 4 staple food crops before improved market information started to be provided, although improved information makes them alter their production and marketing decisions.

Omitted Variables Bias: The price model is also estimated using a fixed effects model. The use of a fixed effects model deals with endogeneity caused by some of the missing variables (e.g., time-constant unobserved effects). In all the models, any unknown or unobserved time-varying independent variables are assumed to be randomly distributed in the sample and left in the error term.

Identification: Exclusion restrictions require that there be some overlap of statistically significant exogenous variables in the structural and reduced equations. The structural equation of market participation is identified because the dummy variables for growing maize, cell phone network in the village, the household having received extension services, and the household being located in low-medium agro-ecological zones are excluded in the model of market participation but included in the equation of information reception. The equation of reception of market information is identified because the natural logarithm of distance to district headquarters and the number of drought days during the main growing season at the district level are excluded in the equation of reception of market information but included in the market participation equation.

Attrition Bias: The attrition rates between the two surveys in the four provinces covered by this study were 16% in Nampula, 17% in Zambezia, 18% in Manica, and 26% in Sofala (Mather, Cunguara, and Boughton 2008). Overall, 17% of the households in the TIA were not re-interviewed in 2005 due to sample attrition. Eighty-three percent of the attrition was due to 4 reasons: (1) households moved away (48.4%), (2) members were not available at the time of the interview (16.1%), (3) the household was not found in the household listing of the enumeration area (9.9%), and (4) death of the household head resulted in household dissolution (8.4%) (Mather, Cunguara, and Boughton 2008). All panel data estimates are made using sampling weights corrected to attrition bias computed by Mather and Donovan using Inverse Probability Weights (Mather and Donovan 2008).

Multi-colinearity and Heteroscedasticity: Variables suspected to be collinear were detected by examining the Pearson correlation matrix and by the variance inflation factors (vif) procedure in STATA. The interaction terms between different sets of regions and crops were tried and dropped because they introduced multi-colinearity and were not significant. Using the Breusch-Pagan test, heteroscedasticity was detected in the linear probability model of reception of information and in the OLS of prices received model; thus, robust standard errors were used.

Transformation of Continuous Variables: Some continuous variables were transformed in order to improve on the normality of the data and to stabilize potential outliers. This was done after inspecting the stem-and-leaf plots, kurtosis, skewness, and the probability density functions of the data. In four variables (distance to nearest road with public transport, distance to village administrative post, value of total farm assets, and number of dry days in the main growing season), the missing values generated due to taking natural logarithms of values with zero were replaced with zeros after the transformation. This was because the natural logarithm of zero is undefined and yet zero is a valid observed outcome. So implicitly, original observations of zero were replaced with observations of one, as the natural logarithm of one is zero, therefore slightly biasing the observations upwards.

Rural Price Inflators: The 2002 prices were adjusted to 2005 *Meticais da Nova Familia* (MTN – the currency of Mozambique), based on rural price deflators and not the Consumer Price Index because the CPI is constructed using consumer prices from only three cities consisting of Maputo, Beira and Nampula (Mather, Cunguara, and Boughton 2008). The consumer prices in towns are different from prices received by rural households in Mozambique. The rural price deflators were derived from the consumption baskets identified by the national Household Budget and Expenditure Surveys (Inquérito dos Agregados Familiares -IAF), and prices from the national agricultural market information system (Sistema de Informação de Mercados Agrícolas, SIMA) (Mather and Donovan 2008).

Heterogeneous Effects: It is sometimes necessary to conduct post-stratification and analysis of the data according to some variables of interest (e.g., different administrative regions, agro-ecological zones, or production potential) and to come up with different estimates to account for heterogeneity between strata. When well done, post-stratification increases efficiency of sample estimates. This is not done in this study because analysis is conducted in internally homogeneous strata, where the stratification variable of interest is the high production potential of the four provinces.

Appendix 2. Regressions of Prices of Maize Received on Reception of Market Information

Variable Name	Restricted POLS	Unrestricted POLS	Fixed Effects	Random Effects	Robust Regression
(1)	(2)	(3)	(4)	(5)	(6)
HH received market information	0.1440**	0.0702	0.1486	0.1131*	0.1010*
	(0.051)	(0.052)	(0.103)	(0.053)	(0.048)
Variance of district price		0.0284	0.0188	0.0280	0.0472**
		(0.026)	(0.051)	(0.022)	(0.017)
HH grew large groundnuts		-0.0881	-0.2490*	-0.0681	-0.0705
		(0.047)	(0.122)	(0.047)	(0.043)
HH has a radio		-0.0614	0.0341	-0.0366	-0.0481
		(0.044)	(0.089)	(0.042)	(0.037)
Cell phone Network in the Village		0.1238	0.1945	0.0891	0.0580
		(0.068)	(0.113)	(0.060)	(0.057)
HH owns bicycle		0.0773	0.1775*	0.0869*	0.0586
		(0.046)	(0.079)	(0.043)	(0.036)
HH belongs to an association		0.1070	0.0883	-0.0765	-0.0137
		(0.077)	(0.131)	(0.093)	(0.072)
HH received extension		-0.0388	0.0136	-0.0282	-0.0394
		(0.046)	(0.099)	(0.047)	(0.044)
Female heads HH		-0.0476	0.4026*	-0.0434	-0.0383
		(0.054)	(0.205)	(0.060)	(0.047)
Units used (0=liter tins, 1= kilogram bags)		0.0832	-0.0621	0.0711	0.0739
		(0.044)	(0.091)	(0.043)	(0.038)
Log of dist. to nearest road[1] (KM)		-0.0079		-0.0210	-0.0219
		(0.024)		(0.021)	(0.018)
Log of dist. to district headquarters		0.0004		0.0247	0.0206
		(0.029)		(0.029)	(0.024)

Table continued on the next page

Appendix 2 (Continued)

Variable Name	Basic Pooled OLS	Pooled OLS	Fixed Effects	Random Effects	Robust Regression
(1)	(2)	(3)	(4)	(5)	(6)
HH members between 15 and 59		0.0796	0.1349	0.1004*	0.0552
		(0.051)	(0.139)	(0.049)	(0.038)
Head had 1 to 4 years of formal education		0.0847*	0.1105	0.0549	0.0563
		(0.041)	(0.076)	(0.041)	(0.034)
log of quantity of maize produced (kg)		-0.0058	-0.0679	-0.0082	0.0222
		(0.025)	(0.054)	(0.022)	(0.018)
HH in Zambezia province (Yes=1, No=0)		-0.2431***		-0.2603***	-0.2445***
		(0.053)		(0.054)	(0.050)
HH in Manica province (Yes=1, No=0)		-0.1984*		-0.2044*	-0.2168**
		(0.096)		(0.080)	(0.074)
HH in Sofala province (Yes=1, No=0)		-0.2144*		-0.1810*	-0.2296**
		(0.084)		(0.080)	(0.074)
HH in low medium agro-ecological zone		-0.0000		-0.0751	-0.0879
		(0.076)		(0.067)	(0.056)
HH in medium to high agro-ecological zone		0.0124		-0.0587	-0.0556
		(0.080)		(0.063)	(0.053)
Log of drought days in main growing season		-0.0153	-0.0035	-0.0329	-0.0151
		(0.023)	(0.033)	(0.021)	(0.019)
Panel data year dummy	0.1960***	0.1480	0.0205	0.2043**	0.1352*
	(0.057)	(0.087)	(0.143)	(0.079)	(0.060)
Interaction of year and information dummies	-0.0662	-0.0600	-0.1004	-0.0608	-0.0486
	(0.078)	(0.080)	(0.145)	(0.075)	(0.066)
Constant	0.7494***	0.8744***	0.9453**	0.9028***	0.8100***
	(0.037)	(0.190)	(0.292)	(0.172)	(0.146)

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Appendix 2 (Continued)

Variable Name	Basic Pooled OLS	Pooled OLS	Fixed Effects	Random Effects	Robust Regression
(1)	(2)	(3)	(4)	(5)	(6)
Observations	836	833	833	833	833
R-squared	0.04	0.10	0.14		0.11
Adj. R-squared	0.03	0.07	0.12	.	0.09
Number of hhid			654	654	

Robust standard errors in parentheses; *** p<0.001, ** p<0.01, * p<0.05

Notes on Appendix 2

The random effects model assumes that the unobserved effects are random and puts them in the error term. The fixed effects model assumes the unobserved effects are correlated with the explanatory variables and is used to eliminate the unobservable fixed effects a_i explained in section 2.1.2. The unobserved effects a_i are eliminated by a fixed effects transformation (within transformation) that involves subtracting the means of treatments from individual observations for all variables. When there are only two time periods, as is the case in this model, fixed effects estimation and first differencing procedure become the same thing—they eliminate the unobservable fixed effects a_i—and produce identical estimates and inference (Wooldridge 2002). Therefore, there was no need to use both the fixed effects method the first-differencing method in this study.

The estimated coefficients on the interaction of year and information dummies in the restricted OLS, the unrestricted pooled OLS, and the fixed effects model are also referred to as the difference-in-difference (DID) estimators in program evaluation literature. Keeping everything else constant, these DID estimators measure the impact of the policy change—in this case of providing market information— on prices received, between households that received information (treatment or experimental group) and those that did not receive information (control group) (Wooldridge 2002) between 2002 and 2005. These coefficients (DID estimators) were not significant in all the models, implying that there was no significant change in prices received by households that received and did not receive market information between 2002 and 2005.

The Hausman's specification test failed to reject the null hypothesis that both the fixed and random effects models are consistent, but that the fixed effects model is more efficient than the random effects model. The alternative hypothesis under the Hausman’s specification test is that fixed effects model is less efficient than the random effects model. These results imply that the fixed effects model would be the model of choice.

Robust regression is used because the price data were suspected to be noisy, being observed household-specific survey data, and thus the need to compare results from other regression methods with those obtained from robust regression, which is considered to perform better when there are outliers and measurement errors in addition to heteroscedastic errors.

The econometric results from the five different model specifications shown Appendix 2 are consistent in several aspects. The estimated coefficients on reception of market information and on those factors which are significant in all of the models have, in general, the same signs, which indicate consistency of the models. The results obtained using robust regression have similar signs with those obtained using the random effects model (apart from quantity of maize produced). Also, the results obtained using robust regression have similar signs with those obtained using the random effects model and pooled OLS (apart from belonging to an association, and quantity of maize produced), suggesting that measurement errors in the price data are not a major problem.

The fixed effects model produces 4 coefficients with unique changes in signs (household has a radio (+), household received extension (+), female headed household (+), and units of measurements (-)) compared to the other three methods (pooled OLS, random effects, and robust regression). The fixed effects model by design drops all variables that are time-invariant such as distance variables, and provincial and agro-ecological zone dummies.

Overall, the models have weak explanatory power, as indicated by the low adjusted R^2s, which are 0.04 for the restricted pooled OLS model, 0.10 for the unrestricted pooled OLS model, 0.14 for the fixed effects model, and 0.11 for the robust regression. This implies that there is still a very large amount of unexplained variance in the data.

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