Information sources, ICTs and price information in rural agricultural markets

Abstract

The spread and rapid uptake of mobile telephony in Sub-Saharan Africa has highlighted the potential role of ICTs in improving market participation and welfare outcomes for farm producers in agricultural produce markets. This paper explores the influence of different sources of information and transmission technologies on the quantum and reliability of market information flowing to farm producers, based on a survey of farm households in northern Ghana. Our results suggest that the principal role of radio broadcasts and mobile telephony is in providing a broader knowledge of markets by enhancing the quantum of market information flowing to farm producers. They do not, however, appear to have a significant impact on the quality/reliability of price information obtained by farmers for making marketing decisions. Information sources appear to be the chief determinant of the reliability of price information, with price information obtained from extension agents being the most credible. Our results provide some useful insights for the design and implementation of Market Information Systems aimed at encouraging market participation by rural farm producers in agricultural markets.

Keywords: market behaviour, transaction costs, information technologies.

JEL Classification: D82, D83, D84, O12, O55.

1 Introduction

The recent spread of Information Communication Technologies (ICTs) particularly mobile telephony in rural areas of Sub-Saharan Africa has highlighted the potential role of reliable market information flows in improving the welfare of farm producers (Aker and Mbiti, 2010). A better flow of market information can improve access to markets and reduce the barriers to market participation caused by a lack of efficient transport infrastructure. Reliable market information provided to farm producers at the right time can potentially improve their bargaining position, reduce searching costs, and give them the option of travelling to farther markets if these provide better returns. At the same time, the lack of reliable market information can impose a cost on farm producers. Inaccurate, out of date or unreliable information can push a farmer to travel longer distances to farther markets in vain or choose the wrong time for a sale. In this paper we explore how different sources of information and communication technologies affect the flow of market information to farm producers in a developing country context, with a focus on the role of ICTs (mobile phones and radios). An understanding of the factors that influence the quantum and quality of price information flowing to farmers can be useful for the design of public or private Market Information Systems (MIS) that utilise new technologies and support market participation by hitherto excluded remote farm households.

For this study we used a unique data set that includes information on the quantum and quality of price information available to individual transaction made by Ghanaian farm producers. We model the quantum and quality of price information obtained by farmers as a function of the different sources of information accessed and the technologies used along with other covariates. The quantum of price information associated with each transaction is the *number* of prices from different markets that the seller had obtained at the time of the sale. The quality or reliability of the price information is assessed by an *ex-post* indicator of whether the price realised in the transaction was greater than, equal to or less than the price expected by the farmer prior to the transaction. Price information obtained by the farmer was treated as "reliable" if the realised prices matched the expected prices. If the realised price exceeded the expected price, then the price information obtained by the farmer was treated as having a downward bias; if the realised price fell short of the expected price then the price information obtained had an upward bias.

Our results show that different sources of information and the use of ICTs do affect the quantum and quality of markets information flowing to farm producers. We found evidence that relative to the use of mobile phones and radios in isolation, the combined use of mobile phones and radios increases the quantum of price information obtained by farmers by 30%. Sourcing price information from neighbours increases the quantum of price information obtained, however, the reliability of the information obtained is low. Information sourced from neighbours reduces the probability that farmers will realise the expected price. Price information transmitted by extension agents is generally more reliable, but they are likely to be subject to a downward bias. However, we did not find particular technologies to be associated with more reliable price information, confirming that reliability depends principally upon the source and not on the channels of transmission.

The remainder of the paper is organized as follows. Section 2 contextualizes the study within the current body of literature. Section 3 gives background information on agricultural markets in Ghana and describes the data used in the study. Section 4 introduces the theoretical framework and Section 5 describes the empirical models. Section 6 discusses the results on the factors influencing the quantum and quality of price information flowing to farm producers with comments on the robustness of the estimates. Section 7 concludes with a brief discussion on policy implications.

2 Literature Review

Recent literature has found evidence of the positive impacts of ICTs on the market participation outcomes for farm producers in rural agricultural markets in developing countries. Goyal (2010) found that the diffusion of market information through computer terminal sharing in Central India brought an increase of 1-3 per cent in wholesale prices obtained by farm producers compared to areas where no comprehensive information diffusion systems were in place. Aker (2010) and Aker and Fafchamps (2013) analysed the impact of mobile phones in Nigerien agricultural markets. They found that the advent of mobile phones reduced price dispersion of grains between markets by six per cent. Moreover, producer prices of perishable crops were affected more than that of storable crops. The impact of market information through radio is investigated by Svensson and Yanagizawa (2009). They exploited a natural experiment in Uganda and concluded that in the areas where radio is used to receive price information, farm gate prices increased by 15 percent. However, the impact of radio and mobile phones can have different impacts in enhancing market participation. Zanello (2012) showed how in Northern Ghana the use of mobile phones to gather market information principally influences market entry/participation decisions, while radios have a larger impact on the quantity traded.

Despite evidence of the positive welfare impact of reliable market information on farm households, the factors influencing the quantum and quality of price information flowing to farm producers in a developing country context are not well understood. The effect of increased flows of market information due to diffusion of ICTs in developed countries has been studied (Baye and Morgan, 2001; Baye *et al.*, 2006), however there appear to be limited empirical studies carried out for rural agricultural markets in developing countries. Most of these investigate the impact of ICTs on prices obtained in the agricultural or other markets (Jensen, 2007; Aker, 2010; Goyal, 2010), while less evidence is available on how they influence market information flowing to sellers. We attempt to address this gap in this paper through an empirical study of agricultural produce sale transactions of smallholders in northern Ghana. Low agricultural productivity on account of limited rainfall (with only one rainy season in a year), soil degradation that is more severe than in other parts of the country, and the inadequacy of infrastructure that renders transportation time consuming and difficult, make it the less developed part of Ghana. As in most developing countries, despite the general inadequacy of infrastructure, rural areas are well covered by the radio network and the mobile phone network in Ghana has had a massive and rapid penetration in rural areas in the past ten years. It is estimated that in 2010 seven out of ten Ghanaians owned a mobile phone (ITU, 2010).[1] With the advent of mobile phones, it has become possible to design MIS tailored for individual areas or beneficiaries with sharply reduced costs for transmission and diffusion of information. The advantages of using mobile phones are twofold: Firstly, they enable price information to be transmitted to remote areas where communication and transport are very difficult; secondly, they offer a two-way communication technology which allows users to choose what information to receive.

In addition to the technology used, the source of information can be another important factor that may influence the quantum and the quality of price information flowing to farmers. There is very limited empirical evidence on how different sources influence price information flows. Ouma *et al.* (2010) examined how different sources of price information affect market participation in Central Africa and found that having neighbours as the principal source of price information reduced the probability of market participation. Zanello *et al.* (2013) analyse data from northern Ghana and found that when the sources of market information are extension agents, sellers are more likely to travel to farther away markets. The trust farmers have in extension officers may push them to invest more in transaction costs in pursuit of potentially greater profit at farther away markets. In this paper we consider the role of extension officers as well as neighbours in influencing the flow of price information to farm producers. Agricultural extension officers in rural areas in developing countries can potentially play a major role in linking farmers with markets. However, as a result of under investment in extension services, the evidence on the actual impact of extension agents in developing countries is mixed (Anderson and Feder; 2004).

3 Background and data

3.1 Agricultural markets and Market Information Systems (MIS) in northern Ghana

Agricultural produce markets in northern Ghana are not regulated, and are potentially accessible to all farm producers. In most rural areas there are community level markets which usually function once in a fortnight. Local producers living in the community can sell their marketable surplus in these markets and also buy inputs from traders at the start of the agricultural season. Larger markets function at the district headquarters. They usually have better infrastructure than community markets and attract more buyers, which may provide an incentive to producers to travel there to trade. Markets in regional capitals are better connected to transport infrastructure and their market activity and trade volume are larger than in districts markets. In this setting, in each region prices in regional markets tend to be higher than in districts markets, while prices in community markets tend to be the lowest.

Farm households' access to price information depends substantially on the information gathered from other farmers living in the same community (neighbours), extension officers, or through formal MIS via radio. Exchange of market information among farm households living within the same community is common. Most households have strong connections with neighbours and they rely on one another in meeting everyday needs. Extension Officers also support farmers' decisions on market participation. The provision of market information, mainly in terms of prices of agricultural inputs and outputs, is a service provided by extension agents in Ghanaian communities. MIS were introduced in many developing countries in the early 1990s to improve market efficiency; they were designed to provide a more complete flow of information for all actors in the market, and eventually reduce transactions costs (Shepherd; 1997). Collecting and disseminating relevant information is costly and MIS (especially those that transmit information publicly through radio or television) have public good characteristics (e.g., non-excludability). These systems have, therefore, been generally provided by governments. During the period of data collection (agricultural season 2008-2009), there was only one major active MIS in Northern Ghana. A weekly price bulletin was aired by the government and transmitted via radio throughout the country. It transmitted in local languages market information of outputs and (in production season) inputs in the markets in the regional and districts capitals in which it was aired. In Ghana the radio signal is widespread and every household with a radio is able to listen to these broadcasts. Because of the recent implementation of MIS that use mobile phones, currently most of the studies that investigate the impact of mobile phones in agricultural markets look at their usage within the social network of the users (an exception is Fafchamps and Minten; 2012).

3.2 Data

Our dataset on market transactions was derived from a farm household survey carried out in northern Ghana and collecting data on the agricultural season 2008-2009. We used multistage sampling, where we selected three districts in the northern regions of Ghana (Lawra in Upper West, Bongo in Upper East and Bunkpurugu-Yunyoo in Northern region), and within each district five communities were selected and thirty random households surveyed in each community. The survey focused on collecting detailed information on individual sale transactions that is seldom available in other household surveys. We also captured detailed information on the use of ICTs for agricultural marketing by farm producers.

For this analysis we focus on the marketing of grains (maize, sorghum/millet, rice) and legumes (cowpea and groundnut), which are the main crops in the region. Due to their common characteristics including non-perishability, unit transaction costs for marketing these crops are likely to be similar which renders market transactions in these crops comparable. The full sample included 319 sale transactions of grains and legumes made by 198 households and treated them as a cross-sectional dataset. Descriptive statistics of the sample are reported in Tables 2 and 3.

Most of the households are headed by males, who on average are more than 50 years old and have just two years of formal education. Dependency ratio is close to one, that is, the number of economically inactive household members (aged under 15 years or over 64 years of age) equal the economically active members (aged 15 to 64 years old). The average wealth, computed as the value of all the non-land assets of the household, was GHc 1220.9, equivalent to GBP 554.45 or US$ 864.05.[2] On average, at the time of sale, sellers had obtained information on the price in only one market, on which their marketing decisions were based. The most common way of obtaining market information was through discussion with the informant (what we call “word of mouth”), followed by the use of mobile phones and radios. At the time of the survey, in the study area there were no comprehensive government or non-governmental programs of market information diffusion via mobile phones being implemented. Therefore, farm households that used mobile phones to receive price information privately contacted (or had been contacted by) an informant. A weekly price bulletin aired by the government is transmitted via radio throughout the country. It transmits, in local languages, market information relating to agricultural produce in the regional and district markets for the region in which it is aired. The radio signal coverage is widespread and every household with a radio is able to listen to these broadcasts. As may be expected most of the price information was received from neighbours -nearly 60% of the sample households received information from neighbours while 45% received information from extension agents.

There is a growing interest in the measurement of perceptions and expectations in decision making developing countries, although the reliability of the data obtained through surveys is subject to debate (Attanasio; 2009). Given the uncertainties relating to price information in agricultural markets and the low level of education of most respondents, we opted for a measure of price information reliability based on a comparison of the realised prices (post transaction) and the stated expected prices of the respondents. Specifically, the respondents answered the question “Was the price received higher/lower/same compared to the expected price?”. In a little over half of the transactions (53%), the sellers received the price they expected; most of the others received lower prices than they had expected. Trust derived from a history of successful exchanges appears to be an important component of market transactions. In the sample, most of the transactions occurred in a situation where seller positively trusted the buyer. Finally, in 25 per cent of the cases, buyers and sellers knew each other before the transaction took place.[3]

Although most households in the survey were headed by males, there is a perception in Ghana that women are traditionally more active than men in rural agricultural markets. This is attributed to their being more knowledgeable about market conditions and their ability to better negotiate market transactions or exploit market opportunities. The survey, therefore, elicited information on whether each transaction was handled by the male spouse or the female spouse in the household. Contrary to the general perception, in our data set we found that only a third of the transactions were handled by the female spouse alone. However, we did find that the gender of the person handling the transaction did have a significant influence on the quantum of market price information collected prior to the transaction and on the probability of expected price being realised.

4 Theoretical framework

In the literature on the impact of mobile phones in markets in developing countries, several studies have used some variant of search models (Jensen, 2007; Aker, 2010). These models have been mainly used to test the hypothesis that the use of mobiles could improve farmers' access to markets and eventually reduce price dispersion across agricultural markets. Search models, however, do not allow to explore the determinants of market information available to sellers. Therefore, we used a simplified version of the model of demand for information by Keppo *et al.* (2008) and adapted it to the decision making of sellers participating in agricultural markets. Each seller is aware of a range of markets in which the produce can be sold and has certain prior beliefs about the prices prevalent in these markets. The flow of market price information from different sources of information and accessed via different transmission technologies allows the seller to update his/her prior beliefs about prices prevalent in different markets. The value of market information flowing to the seller depends on how the updated information influences the likelihood of different market outcomes, that is, obtaining a price greater than, equal to or less than the price expected by the seller. We hypothesise that the effect of different sources of information and transmission technologies (including ICTs) market outcomes arises through their influence on the updating process. To the best of our knowledge, such an approach does not appear to have been previously applied in a developing country context.

For the sake of simplicity, we assume that a seller can sell in two outlets or markets, A and B, in which the potential profits are respectively π_A^θ and π_B^θ depending on the market prices (θ) which equal H (if the price in market A is higher than price in market B) or L (when the price in market B is higher than the price in market A). Market B gives a larger profit if prices are H ($0 \leq \pi_A^H \leq \pi_B^H$), and the market A is best if prices are L ($\pi_A^L \geq \pi_B^L \geq 0$) (we could think of the case in which transport costs to market A are so high that it would provide lower profits even if prices are high ($\theta = H$)). If we then assume the seller has a prior belief (φ) that $\theta = H$, the expected profit function derived from the sale is

$$f(\varphi) = max\langle \varphi\pi_A^H + (1-\varphi)\pi_A^L , \varphi\pi_B^H + (1-\varphi)\pi_B^L \rangle. \quad (1)$$

If the loss of selling in the market B when $\theta = L$ equals M ($M = \pi_B^H - \pi_B^L$) and the loss of selling in market A when $\theta = H$ equals m ($m = \pi_A^H - \pi_A^L$), Eq. 1 becomes

$$f(\varphi) = max\langle \pi_A^L + m\varphi , \pi_B^L + M\varphi \rangle,$$

from which it is possible to derive the maximum profit/loss ($M - m$) from an incorrect marketing decision.

Before deciding where to sell the surplus, each seller can obtain any quantum of market price information ($p_n \geq 0$) about market prices in different outlets (θ). The seller with information p_2 will strictly know more about markets than does the seller with market information level $p_1 < p_2$. The ex-ante expected profit without market price information flows is $u(p,\varphi) = E[u(p,\varphi)|\varphi(0) = \varphi]$, and the value of information is $v(p,\varphi) = u(p,\varphi) - u(\varphi)$, which represents the expected increase in utility from acquiring more market price information. Let us assume that gathering price information comes with a marginal cost $c > 0$. The net profit given the level of market price information p is $v(p, \varphi) - cp$. This is maximised by choosing the information level $\tau(c, \varphi) > 0$ from which we can derive the demand for market information. Based on this framework, the effect of sources of information and use of ICTs on returns to sellers can be expected to occur through their impact on the quantum of information (p) and the reliability of information using which sellers update their prior beliefs (φ). We then draw two propositions of interest which we can empirically test:

Proposition 1: The mix of sources of information and transmission technologies used to gather market information affects the quantum of price information (number of prices in different markets) available to a farmer at the time of making a sale.

Proposition 2: The mix of sources and ICTs used to gather market information influences the reliability of price information available to a farmer. More reliable sources of information or better transmission technologies may provide farmers with better price information resulting in actual prices received being more closely aligned with the farmer's expectations.

It must be noted that while eliciting information on individual sale transactions in the survey, the respondents were asked separately about the sources of information on market prices and the methods of transmission (transmission technologies) used. Consequently, it was not possible to link the source of information with the transmission technology used for each transaction. The effects of different sources of information and transmission technologies may be confounded in our estimations, if there is a systematic association between specific sources of information and particular transmission technologies (e.g., if information from extension agents is always received through mobile phones). However, a correlation matrix of sources of information and transmission technologies suggests only a weak association between the two, which implies that potential confounding effects are likely to be limited.

The next section will describe the empirical models used to test Propositions 1 and 2.

5 Empirical models

We model the quantum and quality of price information obtained by the farm producer for each transaction as a function of the sources of information, the technologies used and other covariates that reflect the size of the transaction, ownership of bicycles (means of transport) and the accessibility to markets. The list of covariates used in the estimations are described in Tables 2 and 3.

Quantum of price information: The quantum of price information is the *number* of prices in different markets markets known to the seller at the time of the transaction and is, therefore, modelled with a count data model. The nature of the data is an important component in the correct choice of the count data model to adopt, and an initial inspection of the dependent variable (number of prices known) suggests that the variance is less than the mean. The model to be used should therefore be able to handle under-dispersion. A Poisson model or a negative binomial model may underestimate the standard errors and overstate the significance of the regression parameters. We, therefore, estimated a Generalized Poisson. Let Y_i be the random variable for the number market prices known by each farmer with a probability density function equal to

$$\left(\frac{\mu_i}{1+\varphi\mu_i}\right)^{y_i} \frac{(1+\varphi\mu_i)^{y_i-1}}{y_i!} exp\left(-\frac{\mu_i(1+\varphi\mu_i)}{1+\varphi\mu_i}\right), \quad y_i = 0,1,..., \tag{4}$$

with mean $E(Y_i = \mu_i)$ and variance $Var(Y_i) = \mu_i(1 + a\mu_i)^2$. The constant φ serves as distribution parameter with $\varphi < 0$ and $\varphi > 0$ denoting under- and over-dispersion respectively ($\varphi = 0$ reduces the model to the basic Poisson model).

Reliability of price information: We use an ex-post indicator of the reliability of price information obtained by the seller based on whether the realised prices are equal to, greater than or less than the price expected by the farmer. The underlying latent variable assumes the values of $y_i^* = x_i\beta + \epsilon$, where the $1 \times m$ row vector x contains the observed independent variables for the i^{th} decision maker. The observed categorical variable representing the accuracy of market information received (y_2) is based on ex-post prices realised (being p_i the price obtained and p_i' the price expected by the i^{th} farmer) and defined as

$$y_2 = e \begin{cases} 0 \Longrightarrow Price\ received\ lower\ than\ price\ expected & if\ p_i < p_i' \\ 1 \Longrightarrow Price\ received\ equals\ the\ price\ expected & if\ p_i = p_i' \\ 2 \Longrightarrow Price\ received\ higher\ than\ price\ expected & if\ p_i > p_i' \end{cases}$$

The model is then specified as:

$$P^e = Pr(y_2 = e|x_i) = F(x_i\beta_i^e) \text{ for } e = 0, 1, 2$$

where P^e denotes the probability that the price received by the seller is equal to e.

A multinomial probit model is used in order to relax the independence restriction built into the multinomial logit[4]. An alternative could have also been the use of an ordered probit model. However, it is not clear whether realising prices greater than expectations would always imply a “superior” outcome for the farmers – as the farmer may have foregone the opportunity to sell a larger quantity at the higher price realised. The multinomial probit addresses this problem model by treating the different outcomes as unordered.

6 Results

6.1 Robustness checks

Two potential issues could distort the estimation of the empirical models: the presence of equidispersion and a possible issue of endogeneity in the count data model. Following Cameron and Trivedi (1998), we formally run a test of the null hypothesis of equidispersion. We implemented the test by an auxiliary regression of the dependent variable (y), $\{(y-\hat{\mu})^2-y\}/\hat{\mu}$ on $\hat{\mu}$ without the intercept term, and performing a t-test to verify if $\hat{\mu}$ equals zero and whether it is positive (overdispersion) or negative (underdispersion). Results from the regression show a clear indication of underdispersion in the data ($\hat{\mu}=-0.572,\ p=0.000$), suggesting that the conditional variance is less than the conditional mean. The Generalized Poisson is then efficient and consistent.

It is possible that the quantity traded in each transaction may be influenced by the quantum of price information obtained and hence may be endogenous. That is, the farmer may decide on the quantity to be transacted depending on the quantum of price information available. We have, therefore, instrumented the quantity traded with the size of the plot where the crop was cultivated as has been done in other studies (Fafchamps and Hill; 2005; Shilpi and Umali-Deininger; 2008). While the size of the plot is likely to be correlated to the quantity traded, it is not likely to be influenced by the quantum of market information obtained by the farmer. We formally tested in the first model whether the quantity traded is indeed endogenous (Durbin-Wu-Hausman test) and checked whether the instrument chosen is not weak at 5% distortion based on the Wald test using Stock and Yogo significance levels (Stock and Yogo; 2002) (Table 1). We rejected the hypothesis (Table 1) of exogeneity of the quantity traded ($p=0.00$) and the chosen instrument proved to be strong (F=52.72, p = 0.00, Stock and Yogo at 5%=16.38). The IV Generalized Poisson model has been estimated in two steps (Mullahy; 1997). First the quantity traded is regressed with the size of the plot and then the predicted values are embedded into the Generalized Poisson model and the standard errors bootstrapped (250 repetitions).[5]

6.2 Determinants of diffusion (quantity) of market information

The estimated Generalised Poisson model was:

$$\begin{aligned} MKT\_PRICES &= \alpha + \beta_1 HEAD + \beta_2 AGE + \beta_3 RATIO + \beta_4 EDU + \beta_5 EXPERIENCE \\ &+ \beta_6 WEALTH + \beta_7 NORTH + \beta_8 WEST + \beta_9 FOOD + \beta_{10} QUANTITY \\ &+ \beta_{11} DIST\_MKT + \beta_{12} DIST + \beta_{13} SPOUSE + \beta_{14} BIKE + \beta_{15} ROAD \\ &+ \beta_{16} MOBILE + \beta_{17} RADIO + \beta_{18} RADIO\_MOBILE \\ &+ \beta_{19} WORD\_MOUTH + \beta_{20} NEIGHBOURS + \beta_{21} EXT\_AGENT + u \end{aligned}$$

where the dependent variable (MKT_PRICES) is the number of prices in different markets known to the respondents prior to the transaction, and the independent variables include household characteristics, quantity traded, sources and vectors of price information, and factors that affect marketing (see Tables 2 and 3). The estimated results are reported in Table 4.[7] The negative and significant φ value (over/under-dispersion parameter) supports the choice of a Generalized Poisson model. The results show how the use of different sources of information and ICTs influence the quantum of price information obtained by the sellers. Listening to the radio to obtain market information increases by 0.33 the number of prices obtained by the seller. Obtaining information through mobile phones has a slightly smaller impact, although it allows users to seek information specifically relevant to them at a time of their choosing (that is, they are not constrained by the fixed transmission slots as in the case of information transmitted over radio) and not being restricted to specific transmission times.

The combination between radios and mobiles has the highest impact, and increases the number of prices obtained by 0.39.

Among the different vectors of information (transmission technologies), “word of mouth” is less effective and increases the number of prices known to sellers only by 0.11. Among sources, neighbours (who are relied on by 60% of the respondents for price information), increase the number of prices known by 0.33. That is consistent with a priori expectation since communities are very integrated with daily interactions between neighbours. In transactions where the female spouse in the household negotiated the sale, the number of prices known was significantly higher. This highlights the role of women in northern Ghanaian markets, where traditionally they are perceived to be the main actors and, therefore, may be more experienced and more knowledgeable on market information. Moreover, more isolated households (i.e. the ones living farther away from the tarmac) on average obtain less price information, highlighting the fact that even in the era of ICTs, physical accessibility remains an important constraint to the flow of price information.

Finally the quantity traded in a transaction has an impact on the quantum of market information gathered. Farmers that trade larger quantities on average have knowledge of fewer prices in different markets. This may be because farmers with larger quantities to sell are sought out by buyers. The competition among buyers for large quantity transactions (which are advantageous to buyers as they reduce buyers’ fixed transaction costs) may imply that farmers with large quantities to sell may obtain fair prices even when they do not have a broader knowledge of prices in different markets.

6.3 Determinants of reliability (quality) of market information

The multinomial probit model shared most of the variables of the Generalized Poisson:

$$
\begin{aligned}
EXPECTATION \\
&= \alpha + \beta_1 HEAD + \beta_2 AGE + \beta_3 RATIO + \beta_4 EDU + \beta_5 EXPERIENCE \\
&+ \beta_6 WEALTH + \beta_7 NORTH + \beta_8 WEST + \beta_9 FOOD + \beta_{10} QUANTITY \\
&+ \beta_{11} DIST\_MKT + \beta_{12} DIST + \beta_{13} SPOUSE + \beta_{14} BIKE + \beta_{15} ROAD \\
&+ \beta_{16} MOBILE + \beta_{17} RADIO + \beta_{18} RADIO\_MOBILE \\
&+ \beta_{19} WORD\_MOUTH + \beta_{20} NEIGHBOURS + \beta_{21} EXT\_AGENT \\
&+ \beta_{22} BUYER + \beta_{23} TRUST + \beta_{24} MKT\_PRICES + \beta_{25} QUALITY + u
\end{aligned}
$$

where the dependent variable is an ordinal variable capturing the price expectation, taking a value 1 where the price received was lower than the price expected, value of 2 where the price received was equal to the price expected and a value of 3 where the price received was greater than the price expected. The independent variables are the same as the ones used in the Generalized Poisson model, however we also include factors that can affect transactions, such as the trust on the buyer, the number of market price known, whether there was a disagreement about the quality of the product sold or whether the buyer was known to the seller in advance (see Tables 2 and 3 for the variable descriptions). The results from the multinomial probit estimation are presented in Table 5. The quantum of information obtained by sellers is an important determinant of whether realised prices will match the farmers' expectations. A unit increase in the quantum of price information known to sellers decreases the probability of obtaining a higher than expected price by 0.08 and that of obtaining a lower than expected price by 0.02. Similarly, if the buyer is known in advance to the seller, the probability of getting a higher than expected price is reduced by 0.19 and that of getting a lower than expected price by 0.04. Higher than expected prices are less likely in transactions negotiated by the wife of the head of the household. Prices realised by more experienced farmers are more likely to match the expected price. Better transportation infrastructure and better road access make it more likely that realised prices will match farmers' expectation.

The relationship between sellers and buyers also influences the reliability of price information. Higher the trust on the buyer, the more likely it is that the price realised matches the expected price. Interestingly, the source of information appears to have an impact on whether farmers' expectations are realised. Sourcing information from neighbours appears to increase the probability of receiving a lower than expected price by 0.32. On the contrary, sourcing information from extension agents boosts the probability of receiving a higher than expected price by 0.11. The results suggest that the prices reported by neighbours are subject to an upward bias, while extension agents report prices more conservatively. Disagreements on product quality reduce the probability that the realised price will match expectations. Interestingly, in such cases there is also an increased probability of receiving a higher than expected price. This may be the result of asymmetric information in the bargaining process (the buyer has less information than the seller on the true quality of the product) or because sellers heavily discount the expected price in cases where the quality of the product is known to be poor.

Transactions involving larger quantities are associated with an increased probability of obtaining higher than expected prices. Again this may be the result of buyers competing for large quantity lots and being prepared to pay higher prices for them.

We do not find a significant impact of individual use of ICTs on the quality of the information received. Most notably the combined use of radios and mobile phones to gather market information increases the probability of obtaining a higher than expected price. Finally, receipt of information through "word of mouth" decreases the probability of receiving a lower than expected price. This may be attributable to "word of mouth" information being more current and up to date than information received through other sources or may reflect first hand information from actual market transactions.

6.4 Market information and price received

In the previous sections we presented evidence on how ICTs provide a broader knowledge of markets by enhancing the quantum of market information flowing to farm producers. However, they do not appear to have a direct impact on the quality/reliability of price information obtained by farm producers for making marketing decisions. Nevertheless, the quantum of market price information available to farm producers appears to be a strong determinant of whether farm producers receive the prices that they expect. We next analyse the quantum of information available to the farm producer and the price received in relation to the average prices received in the community. Figure 1 reports the results of the non-parametric regression in which the mark-up price was regressed on the amount of market information known at the time of the sale. Any value above zero on the vertical axis means that the price received in the transaction was greater than the average prices received for transactions of the same crop within the community (net of transport costs and in GH¢/Kg.). The comparison is, therefore, with the neighbours within the community rather than across markets (price dispersion across markets in different districts can be high).

The graphical representation of the kernel regression provides two clear indications: farmers that sell without prior market knowledge are worse off than more informed sellers; however, more information does not necessarily lead to a more profitable sale. This reinforces the importance of the accuracy of the market information obtained, rather than the quantum. But at the same time it also shows that more informed farmers have a higher variance in the prices they obtain (represented by the grey area in the graph). The higher variance in the prices received by better informed farmers may be related to the timing of sale transactions – better informed farmers may vary the timing of the sale after the harvest in an attempt to obtain better prices more than less informed producers. Anecdotal evidence from the fieldwork suggests that this may indeed be the case, but unfortunately we were not able control for this variable as it was not possible to collect reliable data on the exact timing of each sale transaction.

7 Conclusions

We investigated the role of different sources of information and ICTs on the quantum and quality of price information obtained by farm producers in northern Ghana. We found that radios and mobile phones have larger impact on quantum of price information obtained compared to the use of “word of mouth”. However, the source of information is more significant than the transmission technology used in its impact on the quality and reliability of the price information received. Price information reported by neighbours has an upward bias, while prices reported by extension agents are likely to have downward bias. The role of Extension Officers in disseminating market information is relevant. Farmers trust their advice and are prepared to invest more resources to travel farther when larger profits can be derived from sales in more distant markets. However, the prices reported by Extension Officers tended to be conservative. Investments in Extension Officers' training and integrating communication technologies with their work may strengthen their performance and provide farmers with a more prompt and updated flow of market information to with positive welfare impacts. In particular, technologies should facilitate connecting extension agents to local authorities and farmers. In most districts in Ghana, local governments monitor agricultural prices although Extension Officers do not have direct access to these data. Mobile phones could be be used to by Extension Officers to receive price information and this together with their knowledge may enable them to provide better support and advice to farm households. Moreover, extension visits could be followed up with SMS messages or information hotlines set up for farmers.

Some variables that are rarely captured in household surveys provided interesting insights into factors influencing the flow of market information. For example, when transactions are conducted by the wives of household heads, the quantum of price information obtained is significantly higher. This highlights the traditional role of women in northern Ghanaian markets and the advantages they have while participating in agricultural markets. The relationship between sellers and buyers play an important role in determining whether price expectations are realised. Knowing the buyer in advance increases the likelihood of receiving the expected price, possibly because the bargaining process with a known buyer may tend to be fairer. Lower trust in the buyer is significantly associated with lower than expected prices received by seller. Finally, when the quality of the product is subject to disagreements, sellers still have an increased likelihood of receiving higher than expected prices on account of asymmetries in information between the buyer and the seller.

This study was conducted in an area where there were no government or private MIS programmes in operation, other than transmission of price information through radio broadcasts. Our results provide some insights into the design of MIS programmes for enhancing market participation in agricultural markets in rural areas. The use of radio transmissions and mobile phones is principally useful for increasing the quantum of market information flowing to farm producers and providing them with a broader knowledge of markets where their produce could be traded. Mobile phones offer the advantages of allowing farm producers to seek information that is specifically relevant to them at a time of their choosing; although the lack of education and literacy may limit the use of SMS based provision compared to voice based provision. However, the flow of information on prices in different markets needs to be credible if it is to encourage market participation (especially among those previously excluded) and have a positive impact on farmers' welfare. Information from extension agents appears to be regarded as being the most credible in rural areas. It may be advantageous for MIS programmes to transmit price information through extension agents to build credibility. This would suggest integration of MIS programmes with the extension machinery.

Endnotes

[1] It is worth to noting that this refers to the number of subscribers and not to the actual number of users. In low-income countries, it is common for users to own more than one SIM card, to take advantage of the different fees and network coverage.

[2] The average exchange rate in 2009 was GHc 2.202/£ and GHc 1.413/$.

[3] We also elicited information on the nature of the relationship between the buyer and the seller in each transaction. The survey also included questions about whether: i) The seller knew the buyer in advance. ii) The seller trusted the buyer. iii) The transaction was negotiated by the male spouse alone, the female spouse alone or jointly.

[4] We have confirmed that the independence of irrelevant alternatives may have been problematic for the data in hand.

[5] As further robustness check we estimated the model clustering the standard errors at household level. The significance level did not change for any variable in the model.

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Table 1. Instrument variable (IV): Quantity sold (log) on plot size (ha)

	Coefficient	S.E
Size plot (ha)	0.511***	0.086
Constant	5.745***	0.081
R^2	0.1	
F statistics	34.97***	

***, **, *, stand for values statistically significant at 0.01, 0.05, 0.1 levels respectively. Standard errors clustered at household level.

Table 2. Descriptive statistics: Independent and instrumental variables, household characteristics, regional and crop dummies (n=319)

Variable	Acronym	Unit	Mean	S. D.	Min	Max
Independent variables						
Markets prices known	*MKT_PRICES*	Number	1.26	0.63	0	3
Price expectations	*EXPECTATIONS*	1=Lower 2=The same 3=Higher	1.74	0.63	1	3
Instrument variable						
Quantity sold	*QUANTITY*	Kilograms (log)	5.43	1.06	2.08	8.16
Size plot		Hectares (log)	-0.63	0.68	-2.53	1.1
Household Characteristics						
Male household head	*HEAD*		0.93	0.25	0	1
Household head age	*AGE*	Years	51.16	14.51	24	95
Dependency ratio	*RATIO*	Number	0.99	0.67	0	3
Household head education	*EDU*	Years	2.19	4.19	0	20
Household head experience of farming	*EXPERIENCE*	Years	26.99	15.59	2	74
Households wealth	*WEALTH*	GH¢	1220.9	1553.43	7.4	8995.29
Regional and crop dummies						
North region	*NORTH*		0.43	0.5	0	1
Upper West region	*WEST*		0.48	0.5	0	1
Food crop	*FOOD*		0.62	0.49	0	1

In case of dummy variable, the unit is not specified.

Table 3. Descriptive statistics: Transaction characteristics (n=319)

Variable	Acronym	Unit	Mean	S.D.	Min	Max
Distance to the market	*DIST_MKT*	Meters (log)	7.72	1.27	3.91	9.1
Distance to the tarmac road	*DIST_TAR*	Meters (log)	7.49	3.87	-11.51	9.67
Spouse alone bargained the transaction	*SPOUSE*		0.29	0.45	0	1
Ownership of bicycle	*BIKE*		0.86	0.35	0	1
Road status to the market	*ROAD*	1=Very good 2=Good 3=Poor 4=Very poor	3.18	0.81	1	4
Market information via mobile phone	*MOBILE*		0.25	0.43	0	1
Market information via radio	*RADIO*		0.08	0.27	0	1
Market information via mobile phone and radio	*RADIO_MOBILE*		0.08	0.27	0	1
Market information via "word of mouth"	*WORD_MOUTH*		0.38	0.49	0	1
Market information from neighbours	*NEIGHBOURS*		0.61	0.49	0	1
Market information from extension agents	*EXT_AGENT*		0.45	0.5	0	1
Known the buyer	*BUYER*		0.26	0.43	0	1
Trust on the buyer	*TRUST*	1=Very little 2=Little 3=Neutral 4=Much 5=Very much	3.38	1.65	1	5
Disagreement on product quality	*QUALITY*		0.09	0.29	0	1

In case of dummy variable, the unit is not specified.

Table 4. Quantity of market information: Generalized Poisson model (n=319)

	Coefficient	Std. Err.	M.E.
Quantity traded (IV)	-0.063*	0.035	-0.093
Distance to the market	0.018	0.022	0.031
Distance to the tarmac	-0.017**	0.007	-0.011
Spouse bargaining	0.177***	0.066	0.285
Bike ownership	-0.026	0.114	-0.185
Status road	0.064	0.043	0.037
Receiving market information via mobile phone	0.245**	0.102	0.291
Receiving market information via radio	0.315**	0.125	0.338
Receiving market information via radio and mobile phone	0.273**	0.123	0.39
Receiving market information via "word of mouth"	0.170*	0.104	0.112
Receiving market information from neighbours	0.196***	0.06	0.334
Receiving market information from extension agents	-0.075	0.065	-0.052
Constant	0.028	0.329	
Phi (φ)	-82.560***	15.222	
Log pseudolikelihood	-368.55		
Wald χ^2	186.07***		

Significance at the 10%, 5%, and 1% levels are indicated by one, two, and three asterisks, respectively. Standard errors bootstrapped (250 repetitions). The estimations include (not shown) household characteristics (age, gender and level of education of the head of the household, dependency ratio, and wealth) and regional and crop dummies.

Table 5. Quality of market information: Multinomial Probit (n=319)

	Lower Price			Higher Price		
	Coefficient	Std. Err.	M.E.	Coefficient	Std. Err.	M.E.
Quantity traded	-0.191	0.151	-0.045	0.350*	0.202	0.04
Distance to the market	-0.521***	0.173	-0.083	-0.075	0.22	0.014
Distance to the tarmac	-0.028	0.041	-0.006	0.043	0.067	0.005
Spouse bargaining	-0.421	0.421	0.000	-1.719***	0.576	-0.14
Status road	0.808*	0.257	0.114	0.463*	0.264	0.01
Receiving market information via mobile phone	-0.858	0.719	-0.129	-0.301	0.771	0.007
Receiving market information via radio	-0.102	0.930	-0.051	0.854	1.173	0.082
Receiving market information via radio and mobile phone	-0.688	0.898	0.339	-11.324***	0.923	-1.007
Receiving market information via "word of mouth"	-1.806***	0.671	-0.294	-0.057	0.767	0.067
Receiving market information from neighbours	1.957***	0.515	0.325	-0.078	0.573	-0.085
Receiving market information from extension agents	0.859*	0.444	0.078	1.588***	0.568	0.111
Known the buyer	-1.456***	0.513	-0.195	-1.101**	0.525	-0.042
Trust on the buyer	-0.413***	0.122	-0.072	0.102	0.156	0.026
Markets prices known	-0.629**	0.287	-0.081	-0.560*	0.306	-0.026
Disagreement on product quality	0.236	0.499	-0.01	1.218**	0.491	0.102
Constant	4.264	1.944		-5.275**	2.574	
Log pseudolikelihood	-178.74					
Wald χ^2	1905.41***					
Correctly Predicted (%)	65.52					

Significance at the 10%, 5%, and 1% levels are indicated by one, two, and three asterisks, respectively. Standard errors clustered at household level. The estimations include (not shown) household characteristics (age, gender and level of education of the head of the household, dependency ratio, and wealth) and regional and crop dummies.

Figure 1: Kernel regression with 95% confidence interval on the mark-up price and the amount of market information known at the time of the sale.