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Information sources, ICTs and price information in rural agricultural markets

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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, Market Information Systems, Sub-Saharan Africa.

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

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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 they 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 Inaccurate, out of date or unreliable information can push a farmer to travel longer distances to farther markets in vain or choose the wrong time for a sale.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. 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.

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 market information through computer terminal sharing in Central India brought an increase of 1-3 per cent in the wholesale prices compared to areas where no comprehensive information diffusion systems were in place. Aker (2010) and Aker and Fafchamps (2010) 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 at least 6.5 per cent. Moreover, producer prices of perishable crops were affected more than that of storable crops. Zanello (2012) showed how the use of mobile phones and radios has different impacts in enhancing market participation in Northern Ghana, with mobile phones principally influencing market entry/participation decisions and radios having a larger impact on the quantity traded.

Despite the 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 have been studied (Baye and Morgan; 2001; Baye et al.; 2006), however there appear to be no empirical studies carried out for rural agricultural markets in developing countries. 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) and 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 enables price information to be transmitted to remote areas where previously communication and transport were 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 and found that having neighbours as the principal source of price information reduced the probability of market participation. In this paper we consider the role of extension officers as well as a source of price information. 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 and a lack of resources, the evidence on the actual impact of extension agents in developing countries is mixed (Anderson and Feder; 2004). We examine how extension officers influence the flow of price information to farm producers.

The data set used in this study had information on the quantum and quality of price information available to the farm producer in relation to each individual transaction. In our empirical model, 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 had a downward bias; if the realised price fell short of the expected price then the price information obtained had an upward bias.

There is a growing literature that measures subjective expectations in developing countries (Delavande et al.; 2011). Most of the studies cover issues on health, education, and migration; this study attempts to analyse farmers' expectations in relation to agricultural market prices. Our results show that the different sources of information and the use of ICTs does affect the quantum and quality of markets information flowing to farm producers. We found evidence that the use of mobile phones and radios increases by 30 per cent the *number* of prices obtained by farmers. 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 farmer 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 that some technologies provide more reliable price information than others.

The remainder of the paper is organized as follows. Section 2 introduces the theoretical framework and Section 3 describes the empirical models. Section 4 gives background information on agricultural markets in Ghana describes the data used in the study. Section 5 discusses the results on the factors influencing the quantum and quality of price information together with comments on the robustness checks of the estimation strategy. Section 6 concludes with a brief discussion on policy implications.

2 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 food markets. Search models, however, do nott allow us 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 decides how much price information to obtain, and then decides where to sell the surplus. To the best of our knowledge, such an approach has not 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, and the market A is best if prices are $L: 0 \leq \pi_A^H \leq \pi_B^H$ and $\pi_A^L \geq \pi_B^L \geq 0$ (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

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

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

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

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

Before deciding where to sell the surplus, each seller can obtain any quantum of market information ($p \geq 0$) 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 $p_1 < p_2$. Before travelling to the market, the expected profit 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 selling at a certain market. Let assume that gathering price information comes with a marginal cost $c > 0$ The demand for market information will then be $p(c,\varphi) > 0$. From this, we draw two propositions of interest:

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.

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

3 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 markets whose prices are 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

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

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 (based on ex-post prices realised) (y_2) is defined as

$$y_2 = \begin{cases} 0 \Rightarrow downward\ bias\ prices\ (higher\ expectation) & if\ p_i < p_i^{'} \\ 1 \Rightarrow correct\ price\ (accurate\ expectation) & if\ p_i = p_i^{'} \\ 2 \Rightarrow upward\ bias\ prices\ (lower\ expectation) & if\ p_i > p_i^{'} \end{cases}.$$

The model is then specified as:

$$P^e = Pr(y_2 = e \mid x_i) = F(x_i \beta_1^e) \qquad for\ e = 0, 1, 2,$$

where P e denotes the probability that the price received by the seller is equal to e (e being downward bias, correct, or upward bias prices).

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.

4 Background and data

4.1 The functioning of agricultural markets and Market Information Systems 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 markets 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 MIS that have been established. MIS were introduced in developing countries in the early 1990s to improve market efficiency; they were designed to provide a more complete flow of information among all the 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. With the advent of mobile telephony, it has become possible to tailor market information to the needs of specific areas or individuals and transmit the information exclusively to subscribing individuals at a much lower cost than was possible hitherto. This has allowed the private sector to enter into the provision of MIS in agricultural markets. MIS can be broadly divided into four categories: public MIS (run by governments), private MIS, farm-organized MIS (such as cooperative), and MIS provided through NGOs projects. At the time of the survey, there were two major MIS in Ghana. The first was a weekly price bulletin 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. The second MIS was run by a private company Esoko[2]. They collected price information in a multitude of markets in the country and delivered price information via SMS to farmers who subscribed to the service. Farmers could also post an announcement looking for a potential buyer with details of crop, quantity to be sold, location, and price. During the agricultural season 2008-2009, Esoko was not active in northern Ghana.[3] Because of the recent implementation of MIS using mobile phones, currently most of the research 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).

4.2 Data

Our dataset on market transactions was derived from a farm household survey of 447 households in northern Ghana in the agricultural season 2008- 2009. We used multi-stage 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. Out of the full sample, we then used a sub-sample of 319 selling transactions of grains 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 belongings of the household, is GHc 1220.9, equivalent to GBP 554.45 or US$ 864.05.[5] On average, at the time of sale, sellers had obtained information on the price only in one market, on which their marketing decisions were based. The most common way of obtaining market information is 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 expected most of the price information is 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 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. Only a third of the transactions were negotiated by the female spouse alone; we expected a higher percentage since in Ghana women are traditionally more active in agricultural markets than men. Trust is an important component in market transactions that derives from a history of successful exchanges. In the sample, most of the transactions occurred in a situation where seller positively trusted the buyer. In 25 per cent of the transactions the sellers knew the buyer in advance.

5 Results

5.1 Robustness checks

Two potential issues could invalidate 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 $\hat{\mu}$ is equals to 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 from Wald test based on 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).[6]

5.2 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 table 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 dependent by the transmission time. 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, the "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 of the household head 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 the main actors and therefore can 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.

5.3 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, from 1 (price received was lower than the price expected) to 3 (price received was higher than expected), being the price received equals to the expected price assuming the value of 2. The independent variables are the same we found in the Generalized Poisson model, however we also include factors that can effects transactions, such as the trust on the buyer, the amount of market price known, whether there was a disagreement in the quality of the product sold or in case the buyer was known in advance (see Table 2 and 3 for the acronyms). The results from the multinomial probit 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 mobiles 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.

5.4 Market information and price received

In the previous sections we showed how we had evidence that ICTs are the main factors in providing 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 farmers for making marketing decisions. Nevertheless, the amount of market prices is a strong factor in obtaining the price farmer expect. The last step is then to analyse which relationship exists between the amount of market information at the time of the sale and the price received. The Fig. 1 reports the results of the non-parametric regression. Any value above zero on the vertical axes means that the transaction was more profitable than the average sale of the same crop within the community (net of transport costs and in GH¢/Kg.). The comparison is then with the neighbours within the community, since price dispersion in 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 seller and more information not necessary provides a more profitable sale. This reinforces the importance of the accuracy of the market information obtained, rather than the amount. But at the same time it also shows that more informed farmers have a higher variance in the price they received (represented by the grey area in the graph). It is likely that some of the more informed farmers are selling with higher profit and others aim to get better prices after harvest when more sellers are in the market and prices low. Anecdotal evidence from the fieldwork supports this behaviour, but unfortunately we cannot control for this variable since was not possible to collect reliable data on the exact time of the sale.

6 Conclusions

We investigated the role of 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 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 extension officers reported tended to be conservative. Investments in extension officers' training and integrating communication technologies within their work may strengthen their performance and provide farmers with a more prompt and updated flow of market information to with positive welfare impacts. Along this line, Aker (2011) argues that ICTs could support the work of extension in disseminating market information and she suggested different modalities by which this could be achieved.

Some variables that are rarely captured in 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] We have confirmed that the independence of irrelevant alternatives may have been problematic for the data in hand.

[3] Website: http://www.esoko.com.

[4] Therefore, when respondents of the questionnaire stated that they received price information via mobile phone we assumed that they privately contacted an informant or a relative/friend.

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

[6] 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.

[7] For the sake of brevity, we did not report the household and crop characteristics in the results.

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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	0.10	
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 instrument 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	1.10
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¢	1220.90	1553.43	7.4	8995.29
Regional and crop dummies						
North region	*NORTH*		0.43	0.50	0	1
Upper West region	*WEST*		0.48	0.50	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	9.10
Distance to the tarmac road	*DIST_TAR*	Meters (log)	7.49	3.87	-11.51	9.67
Spouse 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
Mkt information only via mobile phone	*MOBILE*		0.25	0.43	0	1
Mkt information only via radio	*RADIO*		0.08	0.27	0	1
Mkt information via mobile phone and radio	*RADIO_MOBILE*		0.08	0.27	0	1
Mkt information via "word of mouth"	*WORD_MOUTH*		0.38	0.49	0	1
Mkt information from neighbours	*NEIGHBOURS*		0.61	0.49	0	1
Mkt information from extension agents	*EXT_AGENT*		0.45	0.50	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	0.390
Receiving market information via "word of mouth"	0.170*	0.104	0.112
Receiving market information from neighbours	0.196***	0.060	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	0.040
Distance to the market	-0.521***	0.173	-0.083	-0.075	0.220	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	-0.140
Status road	0.808*	0.257	0.114	0.463*	0.264	0.010
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	-0.010	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.