Transaction costs, information technologies, and the choice of marketplace among farmers in northern Ghana

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Abstract

Using a transactions costs framework, we examine the impact of information and communication technologies (mobile phones and radios) use on market participation in developing country agricultural markets using a novel transaction-level data set of Ghanaian farmers. Our analysis of the choice of markets by farmers suggests that market information from a broader range of markets may not always induce farmers to sell in more distant markets; instead farmers may use broader market information to enhance their bargaining power in closer markets. Finally we find weak evidence on the impact of using mobile phones in attracting farm gate buyers.

Keywords: market behaviour, transaction costs, information technologies.

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

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I. Introduction

An understanding of factors influencing market participation in developing countries is important for supporting the economic inclusion of remote farm households and in ultimately increasing their welfare. Market participation is crucial to economic growth and poverty reduction in rural areas in two ways. First, it allows farmers to trade surpluses of goods in which they hold a comparative advantage in production. Second, it enables larger scale production, reduction of fixed production costs, and enhanced use of technology which all together leads to more rapid total factor productivity growth. Ultimately, market access allows expansion in choice sets of farm households and thus higher levels of welfare for potential participants. This paper aims to better understand how transaction costs affect marketing decisions of farmers in northern Ghana, and how the use of information communication technologies (ICTs) (namely, mobile phones and radios) impacts market participation behaviour.

Rural markets are often imperfect and transaction costs can be so high that farmers are unable to participate in markets (de Janvry et al., 1991). The variable and volatile nature of transaction costs has challenged researchers attempting to assess their impact on marketing decisions. At the same time, in the past twenty years governments and aid agencies have recognised the importance of developing agricultural markets, investing in infrastructure and implementing policies to improve market participation of small-scale farmers. However, a large part of the trade in agricultural commodities in Sub-Saharan Africa takes place within social networks and depends on personal relationships. Thus, one of the challenges faced by policy makers has been to bring about a shift from personal exchanges to impersonal ones in order to widen the trade network (Platteau, 1994). From the other side, farm households have adopted a number of strategies in order to be able to participate in markets or expand the trade network, such as creating and participating in cooperatives where costs and risks associated with transactions are minimised (Fafchamps, 2004). In an environment where transport infrastructure is often inefficient, a major obstacle to market participation is the scarcity of information exchange between the actors. The recent adoption of ICTs in rural areas of Sub-Saharan Africa can potentially

enhance the flow of information with direct benefits for farmers' welfare. Better information can improve farmers' bargaining position, reduce search costs, and give them the choice to travel to farther markets if prices there are higher. In addition, farmers can improve allocation of production factors and be better informed about the optimum timing of sales.

In this paper, we focus on the determinants that drive the farm household's decision regarding the place of sale of farm produce. In investigating transaction costs, we focus on the effects of recent diffusion of ICTs in rural areas and their impact on search costs. We first investigate why some transactions occur at the farm gate and others at the marketplace. That requires modelling not only the farmers' marketing behaviour, but also the role of itinerant farm gate buyers. Farm gate buyers play an important role in the agricultural marketing system of Ghana and many developing countries. Their role is to travel to the farm gate, buy the commodity and resell in markets farther from the production regions where they may derive larger profits. Often, they may buy after the harvest, and store the produce until prices at the market increase. However, small-scale farmers may decide to travel to the market if farm gate buyers are not available or if they expect a larger profit from a sale at the marketplace. In this case, they may have different markets to choose from. Examining what drives the decision to travel to a farther market or sell at a nearer market is the second objective of this study.

The current study encompasses two strands of research on market participation in agricultural markets: the first comprises studies devoted to investigating the role of transaction costs in market transactions; the second is a more recent strand that looks at the impact of information communication technologies (ICTs) in developing countries, focusing mainly on the use of mobile phones and radios.

In the first strand, most of the studies investigate transaction costs that serve as barriers to farmers in entering a market first, and subsequently influence the quantities they trade. Seminal work in this area was by Goetz (1992) who investigated the market behaviour of Senegalese grain farmers. Thereafter, major contributions came from Key et al. (2000) and Bellemare and Barrett (2006). Using a different analytical method, they introduced the distinction between proportional and fixed transaction costs. Proportional transaction costs are transaction costs that vary with the quantity traded. Often they are

associated with the unit transport costs or the time required to make a sale. Fixed transaction costs are independent of the quantity traded and include the costs of seeking information on prices, costs of setting up a sale transaction and monitoring costs (i.e. costs to ensure that the conditions of an exchange are met, for example enforcing the payment schedule). Only a few studies on transaction costs investigate their impact on market behaviour at the household level. Vakis et al. (2003) include the distinction between fixed and proportional transaction costs in a household framework to study the market participation decisions of Peruvian potato farmers. Fafchamps and Hill (2005) investigate why many Ugandan coffee growers do not sell their produce at the marketplace but instead wait for an itinerant farm gate buyer, resulting in lower profits. More recently, Shilpi and Umali-Deininger (2008) studied how market facilities influence marketing decisions of farmers in the Indian state of Tamil Nadu. An important obstacle that has limited empirical research on market behaviour is the variable and volatile nature of transaction costs which are not easily quantified and are very often not, or only partially, captured in surveys.

The second research strand that this study relates to looks at the impact of the recent diffusion in developing countries of ICTs, which has rekindled research on the role of transaction costs. The rationale is that the usage of mobiles and radios by farmers can potentially reduce fixed transaction costs, specifically search costs, and at the same time improve farmers' bargaining position with direct benefits for farm household welfare. The pioneering work of Jensen (2007) showed that the adoption of mobile phones amongst fishermen in the Indian state of Kerala was associated with a reduction of price dispersion and waste of fish caught. Goyal (2010) demonstrated that the diffusion of computer terminals providing market information in Central India brought about 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 agricultural markets in Niger. The former found that the advent of mobile phones reduced the price dispersion of grains between markets by at least 6.5 per cent, while the latter did not find any effect on average prices, although it did find a reduction in variation in prices. No evidence of differences in farm gate prices was found, in contrast to the findings of Svensson and Yanagizawa (2009) who found

that radio use did increase farm gate prices in Uganda. More recently, Fafchamps and Minten (2012) conducted a controlled randomized experiment to assess the impact of SMS-based agricultural information in the Indian state of Maharashtra and found no statistically significant average treatment effect on the price received by farmers. However, they found evidence that farmers that received price information via SMS were less likely to sell at the farm gate and more likely to travel to more distant markets. Finally, Lee and Bellemare (2013) analysed data from the Philippines and found evidence that the use of mobile phones is associated with higher crop prices received by agricultural producers, but only once the intra-household allocation of technology is taken into account.

This study attempts to contribute to the strand of studies on transaction costs that focus on market behaviour of small-scale farmers in developing countries. At the same time it makes use of data on the adoption and usage of ICTs to explore how they may affect fixed transaction costs and influence marketing decisions. We use a novel dataset that contains very detailed information on 313 sale transactions of grains made by 197 small-scale farmers in northern Ghana. The rich dataset allows us to explore aspects of transaction costs that often have not been taken into account in previous microeconomic studies, such as the actual use of ICTs to seek market information, including the combined use of different technologies, the sources of price information, the knowledge of prices in different markets, and trust amongst agents. Our data at the transaction level allows us to take into account the different factors influencing individual transactions, although the cross section nature does not allow us to establish the causal impact of ICTs on the choice of marketplace. The nature of the data collection exercise meant that use of instrumental variable techniques or propensity score matching that could have provided more robust inferences regarding causality were not feasible in our case. We report evidence on how ICT use and other factors affecting fixed and proportional transaction costs influence decisions to sell at the farm gate or the market and, in the case of the latter, the choice of the specific market for sale of produce.

II. The functioning of food markets in northern Ghana

The study area for this research was the northern part of Ghana, specifically the Northern, Upper West, and Upper East regions. The harsh climatic conditions that follow from having only one rainy season in a year, more severe degradation of soil than other parts of the country, and the inadequacy of infrastructure that renders transportation time-consuming and difficult, make this the less developed part of Ghana. For these reasons, since post-colonial times, the Ghanaian government with the support of international funders has implemented various development programmes to reduce the gap with the southern regions. Actions have spanned a wide range of areas, from enhancing agricultural productivity and infrastructure, to improving health and education. However, the gap compared to southern regions is still wide. Seventy per cent of the people in northern Ghana live under the national poverty line and three quarters of the households live in rural areas, where most of the inhabitants base their livelihood on agriculture, which is their main source of income (GSS, 2008). The efficiency of agricultural markets is thus a critical means to improve the welfare of producers.

The study focuses on food crops (cereals and legumes) which are widely grown in the region. Food markets in northern Ghana are not regulated, i.e. anyone can access markets and sell produce. In most of the communities there is a local market active every fortnight. Producers living in the community can sell marketable surplus, and at the beginning of the agricultural season, buy inputs from traders. Larger markets are held at the district capital. These usually have better infrastructure than markets in the communities and attract more buyers. For these reasons, producers may travel there to trade. Regional capitals in each of the northern regions (respectively Tamale, Wa, Bolgatanga) are better connected to transport infrastructure and their levels of market activity and trade volumes are larger than in district markets. In this setting, the prices at regional markets are higher than in district markets, while prices at community markets are the lowest. However, the costs to access farther away markets can, of course, be higher.

Farm gate buyers are important economic actors in the study area. These are traders that travel to the farm gate, buy the commodity and re-sell in markets farther from the production regions where they may obtain a larger profit. Often they travel from southern regions to northern regions and tend to buy after the harvest when prices are lower, and store the commodity until prices rise. Once farm gate

buyers leave the region, the main buyers during the remaining months of the season tend to be consumers or local buyers, who buy small quantities and re-sell within northern markets.

III Conceptual Framework

Our conceptual framework is based on Fafchamps and Hill (2005) as further developed in Shilpi and Umali-Deninger (2008). We expand the original model to include fixed and proportional transaction costs associated with sale in the market and farm gate sales. Farmers who sell at the farm gate also incur some transaction costs – they may need to look for a buyer and in some cases, where the household is located away from road access, transport the commodity to a nearby collection point. The inclusion of fixed and proportional transaction costs allows us to separate the components that affect the costs of participating in a market and identify the role of ICTs. This section is divided into two parts: the first covers the decision to sell the produce at the farm gate or take it to the market, while the second part models the choice of the market when the farmer opts for a market sale.

A. Sale at the farm gate or the market

We assume that farmers have the choice to sell their produce at the farm gate or take their produce to a market for sale. For a farm gate sale, the i^{th} farmer who has a quantity q_i to sell would receive a unit price p^f and incur associated transaction costs C_i^f, where f denotes that costs are specific to the farm gate sale. The total transaction cost C_i^f consists of two components – the fixed costs incurred by the farmer in setting up the transaction and the proportional costs which are related to the quantity of produce transacted. Therefore,

$$C_i^f = a_i^f + c_i^f q_i$$

where a_i^f is the fixed transaction costs and c_i^f is the per unit (proportional) transaction cost associated with a farm gate sale. For a market sale, the farmer would receive a price of p^m and incur associated transaction costs of C_i^m which would also consist of a fixed and proportional component such that:

$$C_i^m = a_i^m + c_i^m q_i$$

where a_i^m is the fixed transaction costs and c_i^m is the per unit (proportional) transaction cost associated with a farm gate sale.

The net revenue for the farm gate sale is:

$$p^f q_i - C_i^f = p^f q_i - (a_i^f + c_i^f q_i)$$

and the net revenue for the market sale is:

$$p^m q_i - C_i^m = p^m q_i - (a_i^m + c_i^m q_i)$$

The difference in net revenue between selling at the market and selling at the farm gate can be denoted by D_i:

$$D_i = (p^m q_i - C_i^m) - (p^f q_i - C_i^f) = q_i[(p^m - p^f) - (c_i^m - c_i^f)] - (a_i^m - a_i^f)$$

The farmer will choose to sell at the market if $D_i > 0$ and at the farm gate otherwise.

Following Fafchamps and Hill (2005) and Shilpi and Umali-Deninger (2005) we assume that farm gate buyers are itinerant traders who also incur fixed and proportional transaction costs C^b to set up the transaction and transport and sell the produce in the market. For the j^{th} buyer:

$$C_j^b = a_{ji}^b + c_j^b q_i$$

where a_{ji}^b denotes the fixed transaction costs incurred by the buyer. The i subscript denotes the farm household and as explained later, we assume that the fixed transaction costs faced by the buyer are specific to the farm household. If we assume free entry into itinerant trading, then in equilibrium:

$$p^f q_i = p^m q_i - C_j^b.$$

Therefore, the expression for D_i becomes:

$$D_i = q_i[(c_j^b + c_i^f) - c_i^m] - (a_i^m - (a_i^f + a_{ji}^b).$$

The farmer's decision to sell at the farm gate or at the market depends on the fixed and proportional transaction costs faced by the farmer and the farm gate buyer. We will observe a market sale if $D_i > 0$ and the farmer's choice can be modelled as a binary decision (y_1) such that:

$$y_1 = \begin{cases} 1 & if\ D_i^* = D_i + u \geq 0 \\ 0 & otherwise \end{cases}$$

where u is the error term. In our data set we do not observe the transaction costs faced by the farm gate buyers. To derive the empirical specification we make two assumptions regarding the transaction costs faced by farm gate buyers. First we assume that the proportional transaction costs faced by all the farm gate buyers (itinerant traders) are the same. This can arise in a situation where all the itinerant traders use the same type of transport and incur the same per unit costs of transporting the produce to the market. Second, we assume that itinerant traders are a relatively homogenous group (in terms of scale of operations and infrastructure) and that the fixed transaction costs incurred by them are largely determined by the characteristics of the farm household. For instance, the fixed costs of identifying a potential transaction and setting it up may be lower when the buyer deals with a farm household with a large farm holding that consistently produces surpluses for sale compared to small households that only occasionally produce surpluses for sale. Similarly, the costs of setting up a transaction may be lower for the buyer when dealing with a farmer who is reachable by mobile phone or is located close to road access. Based on these assumptions, we use an empirical specification for the farmer's decision to sell at the farm gate or at the market based on the seller's characteristics and transaction costs:

$$y_1 = \alpha + \beta_1 Q + \beta_2 W + \beta_3 \boldsymbol{PTC} + \beta_4 \boldsymbol{FTC} + \beta_5 \boldsymbol{Z} + u \quad (1)$$

where Q is the quantity sold, W is the wealth of the household, $\boldsymbol{PTC}$ and $\boldsymbol{FTC}$ are vector of proportional and fixed transaction costs for the seller respectively, and $\boldsymbol{Z}$ is a vector of household characteristics. We adopt a linear probability model to estimate the latent variable (D_i^*).[1]

We can now review the determinants affecting the choice of marketplace. The availability of large quantities to sell could induce the farm producer to sell at the farm gate *or* at the market – the effect on the choice of the place of sale is ambiguous because a number of opposing considerations are involved. Sales of large quantities can reduce unit transaction costs and, therefore, may incline sellers to travel to markets (Fafchamps and Hill, 2005). However in most communities of Northern Ghana access to transportation (trucks) is seldom available to farmers and multiple trips to the market with a cart may not be convenient. Additionally, public transport, of formal and informal nature, is irregular. Thus the local setting may contribute to different marketplace choices than typically found in previous studies. Moreover, large quantities increase bargaining power and may attract farm gate buyers. Owning vehicles suitable to transport large quantities, farm gate buyers may be able to reduce fixed transportation costs by procuring larger quantities from a few sellers.

Fafchamps and Hill (2005) suggest that wealthier households are more likely to wait for a farm gate buyer. The rationale is that they have a higher shadow cost of labour and means to enjoy leisure time. Wealth could also be a signal for farm gate buyers to recruit sellers, since wealthier farmers are likely to produces surpluses for sale. However, wealthier farmers may also have access to better transport, which may facilitate better access to markets. Therefore, the impact of higher household wealth on the likelihood of a farm gate sale or sale at the marketplace is difficult to predict.

Factors that influence proportional transaction costs are the distance to the market, the quality of transportation and market infrastructure, the number of transactions conducted, and ownership of transport means. Distance to the nearest market has been widely used in the literature on farm household market behaviour (Goetz, 1992; Key et al., 2000; Fafchamps and Hill 2005; Bellemare and Barrett, 2006) as a determinant of transaction costs, while the quality of the road has been used as a proxy for the overall quality of infrastructure. We can expect sellers living closer to the market to take advantage of market facilities, especially where infrastructure is better. However, farm gate buyers may not be prepared to travel to farther away areas, and this may force remote households to travel to markets. Finally, ownership of vehicles such as bicycles may allow farmers to more easily reach the market and influence the per unit transportation costs of the seller.

Unlike proportional transaction costs, fixed transaction costs are independent of the quantity sold. They include costs of obtaining information on prices in different markets, searching for buyers and setting up or negotiating transactions. These costs may be influenced by the technology and sources of information available to the seller and certain characteristics of the seller (e.g., negotiating ability). Given the nature of ICTs, we expect their use to mainly influence the choice of marketplace through their impact on fixed transaction costs. Radios and mobiles may influence transaction costs and marketplace choice via different mechanisms. Radios can be used to get information on prices which may help farm producers' decision on when and where to trade and possibly strengthen bargaining power, while mobile phones could lower search costs to find buyers. Equally, using mobile phones, buyers can reach potential sellers and reduce their fixed transaction costs. Other seller characteristics may also determine the choice of the marketplace. The choice of the marketplace may depend on whether the male head of the household or the female spouse handles the sale transaction, since traditionally women are considered to be the main actors in Ghanaian agricultural markets (Boserup et al., 2007). Relationships between sellers and buyers are also important factors in market transactions. We, therefore, include in the model a variable that aims to capture the trust between the two actors. Crop quality may also influence fixed transaction costs – lower crop quality may increase the cost of locating a buyer willing to accept the produce offered. This cost could differ across markets and influence the choice of the place of sale.

Finally, we control for household characteristics ($\mathbf{Z}$), such as the age of the head, household composition, level of education, the crop sold and regional dummies.

B. Choosing the marketplace

Farmers that decide to sell at the market face a choice regarding which marketplace to travel to. More distant markets may have better infrastructure, more buyers, and potentially higher profits; reasons that can urge households to transport their products to be sold there (Shilpi and Umali-Deininger; 2008). However, that would increase proportional transaction costs and possibly information on prices

may not be reliable adding uncertainty and risk to the transaction. Let us consider an additional market, n, with potentially better infrastructure and more buyers than market m, and located farther away from the farm household. In case no farm gate buyers are available or the seller reckons s/he can get a better price bringing the commodity to a marketplace, the farm household will face the following trade off

$$p^m q_i - (a_i^m + c_i^m q_i) \gtreqless p^n q_i - (a_i^n + c_i^n q_i)$$

in which the proportional transaction costs associated with a sale at the market closer to the production site are lower than with the sale at a more distant market ($c_i^m < c_i^n$), as are the fixed transaction costs ($a_i^m < a_i^n$). The decision to travel to the more distant market will then depend on the different magnitudes of proportional and fixed transaction costs, and the expected price in each market. Specifically, the difference (D_i) in the total net revenues from selling at the market m and n will determine the choice of marketplace:

$$D_i = [p^m q_i - (a_i^m + c_i^m q_i)] - [p^n q_i - (a_i^n + c_i^n q_i)].$$

When $D_i > 0$ the farmer will travel to market m, otherwise to the market n.

Because of its administrative units, in northern Ghana small-scale farmers can choose to sell their produce (ordered from the closer to the farther away market) at the community market (m), in the district capital (n), or at the regional market (z). Expanding Eq. 2 to include a farther away market (z), the choice of marketplace is represented by an ordinal variable (y_2) such that

$y_2 =$

$$\begin{bmatrix} 1 \;\; if\; D_i^* = D_i + u = [p^m q_i - (a_i^m + c_i^m q_i)] > [p^n q_i - (a_i^n + c_i^n q_i)] \geq [p^z q_i - (a_i^z + c_i^z q_i)] \\ 2 \;\; if\; D_i^* = D_i + u = [p^n q_i - (a_i^n + c_i^n q_i)] > [p^m q_i - (a_i^m + c_i^m q_i)] \geq [p^z q_i - (a_i^z + c_i^z q_i)], \\ 3 \;\; if\; D_i^* = D_i + u = [p^z q_i - (a_i^z + c_i^z q_i)] > [p^m q_i - (a_i^m + c_i^m q_i)] \geq [p^n q_i - (a_i^n + c_i^n q_i)] \end{bmatrix}$$

where D_i^* is a latent variable estimated with an ordered probit.[2] The econometric specification is in common with Eq. 1., such that:

$$y_2 \; = f(Q, W, \boldsymbol{PTC}, \boldsymbol{FTC}, \boldsymbol{Z}) + u \qquad (2)$$

Equation (2) shares most of the variables with (1). Again the role of quantity traded and wealth in the choice of the marketplace may be mixed. Larger quantities may be transported to farther away markets where prices are higher, but the costs associated with the transaction may be higher as well. As in the choice between a sale at the farm gate or at the market, the effect of wealth may operate in opposing directions. Wealthier households may prefer leisure time and therefore choose a closer market for a quicker transaction. However, they may also own vehicles which allows them to travel to farther away markets compared to poorer households. In fact the role of transportation has had a predominant role in the literature on market participation (Goetz, 1992; Key et al., 2000; Fafchamps and Hill 2005) and we expect the ownership of bicycles to be associated with travel to more distant markets.

ICT use may influence the choice of marketplace in a number of different ways. Some sellers may use the market information to reinforce their bargaining power in closer markets, others may be pushed to travel to farther markets where the returns can be higher (Aker, 2010). However, the choice of marketplace will also be based on the expected price and seller may travel to farther markets if they are certain of the return from the transaction. Equally, trusted buyers may reduce the uncertainty of a transaction in a larger market and push sellers to travel longer distances.

We carried out the analysis at the level of individual transactions, which means that household characteristics and wealth are in the nature of fixed effects and remain the same across different transactions made by a household. As a consequence, in the econometric estimation of both models, the standard errors are clustered at the household level.

IV. The Data

An important aspect of the data used in this study is the availability of detailed information on individual sale transactions that is seldom available in other household surveys. The data include the extent of market information available with each seller, the use of ICTs to gather market information, and the characteristics of the sale (place, transport means, who bargained the sale and how much the

buyer was trusted). We collected primary data in northern Ghana on all sale transactions (313) of 197 households 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.

For this analysis we focus on the marketing of cereals (maize, sorghum/millet, rice) and legumes (cowpea and groundnut), which are the main food crops in the region. Due to their common characteristics including non-perishability, transaction costs for marketing these crops are likely to be similar which makes market transactions in these crops comparable. However, in order to control for sources of unobserved heterogeneity in marketing behaviour related to different crops, we included crop dummies in each model.

The choice of the variables included in the models directly derives from the theoretical framework and Vakis et al. (2003). Extending the approach adopted in Vakis et al (2003), and as an innovative element in this study, we include several variables to capture the role of ICTs and different sources of information in influencing market participation behaviour via their effects on transaction costs. The proportional transaction costs are captured with the distance to the market, the means of transport, and the status of roads. The determinants of fixed transaction costs include sources of information accessed and ICT use, whether the spouse of the head of the household conducted the negotiation, the trust with respect to the buyer, and the extent of market information available to the seller at the time of the sale.

The descriptive statistics of the household characteristics and sale transactions are reported in Tables A1 and A2 respectively in online Appendix. On average each household made two transactions, which involved slightly less than 400 kilograms of a commodity. The majority of the transactions were made at the market (84%), to which farm households travelled on average around 10 kilometres.[3] Out of all the transactions at the market, 68 per cent were made in the community market, 26 per cent in the district market, and the remainder in the regional capital. As a proxy for the

availability of good infrastructure, we used the self-reported status of the roads to the local market. The vast majority of transactions were made in conditions of poor infrastructure, and only twenty per cent benefitted from good roads. A quarter of the transactions were negotiated by the female spouse alone. In the sample, most of the transactions occurred in a situation where the seller trusted the buyer.

In most of the transactions, sellers knew in advance the price prevalent in the market where the sale was made (60%) and on average at the time of the sale they had price information from more than one market. For each transaction we captured the use of ICTs to gather market information and the sources of information accessed. Radios and mobile phones were the main ICTs in the region (used respectively in 59 and 56 per cent of the households). In 33% of the transactions, sellers used mobile phones to gather market information, compared to 16 per cent that received market information from the radios and 38 per cent that obtained market information based on discussion with the informants ("word of mouth"). The government does air a weekly price bulletin in local languages broadcast via radio throughout the country. It covers market price information of outputs and (in the production season) inputs in the markets in the regional and districts capitals in which it is aired. The main sources of market information were neighbours (62%), followed by the extension officers (46%).

V. Results

A. Correction for Potential Endogeneity in the Models

Empirically, we have reasons to think the quantity traded could be endogenous to the choice of market. For example, farmers may decide to sell small quantities at the farm gate or closer markets, and larger quantities in distant markets (or *vice versa*). Similarly to Fafchamps and Hill (2005), we chose as instruments land characteristics of the crop sold: we have no reason to think that the plot size has an effect on the marketing decisions, except through the size of the harvest. In both models we tested whether the quantity traded was exogenous (Durbin-Wu-Hausman test), checked that the

instrument chosen was not weak (5% distortion from Wald test based on Stock and Yogo significance levels), and jointly estimated the model and the instrumental regression based on maximum likelihood. In the model of choice between selling at the farm gate or at the market we rejected the hypothesis of exogeneity of the quantity traded ($\rho = 0.02$) and the chosen instrument proved to be strong ($F = 24.82$, $\rho = 0.00$, Stock and Yogo=16.38). In the case of modelling which marketplace sellers choose to travel to, we failed to reject the exogeneity of the quantity traded ($\rho = 0.70$).[4]

It could also be argued that the use of ICTs to gather market information may be determined by the choice of market, confounding attempts to identify causation. Although we cannot definitely rule this out, anecdotal evidence from the qualitative research that accompanied our household survey suggested that price search may not pose a major endogeneity problem for the equations being estimated. Focus groups with farmers revealed that the vast majority of farmers have some sort of market information (none of the households in the dataset used is autarkic), and our data show that almost 80 per cent of transactions have been made with prior market information. Insights from the focus groups suggest that farm households do not gather price information on a specific market once they decide to sell their produce there. Rather, they are interested in learning about price differences across markets, to help them decide where the return from the sale is likely to be higher after factoring in transactions costs.

There is also no systematic association in the data between the place of sale chosen by a farmer and the specific source of price information or type of ICT used. All the three transmission technologies (radios, mobile phones and "word of mouth") are relevant for gathering information from a range of markets. The only exception is market price in community markets, which is not available via radio. Radios and mobile phones may be used in different ways in making marketing decisions – radios may provide information on broader price trends, while the two-way communication facilitated by mobile phones may be more useful for locating buyers, setting up transactions and negotiating prices. Nevertheless, we have no evidence that the use of a specific technology is driven by the choice of marketplace.[5] This also applies to different sources of information.

B. Selling at the farm gate or at the market

Coefficients of the linear probability model are reported in Table 1. A significant factor that drives the market relationship between farmers and the itinerant farm gate buyer is the quantity traded. Farm gate buyers travelling from community to community looking for crops to buy have high fixed transaction costs: bargaining and monitoring costs can be very high. As a consequence, to realise larger profits, they may seek sellers offering larger quantities. A 10% increase in the quantum of produce offered for sale increases the probability the sale occurs at the farm gate by 0.02. This is not a negligible increase, given that at the baseline the probability of selling at farm gate is 0.16, and given the very large variation in quantity sold in the sample.[6] It is worth noting that the effect of quantity traded on marketing decisions appears to vary across country/institutional settings. A study of market transactions amongst coffee growers in Uganda (Fafchamps and Hill; 2005) found that sellers of larger quantities were more likely to sell at the market instead of waiting for a farm gate buyer.

[Table 1 about here]

We find that remote farm households (furthest from local markets) are more likely to travel to the market. This may be the consequence of farm gate buyers not being prepared to travel to remote areas for which they may have to incur higher proportional transaction costs. Availability of infrastructure is also a critical factor that allows farmers to transport their produce with less effort and participate in markets (Shilpi and Umali-Deininger, 2008). As a proxy for availability of infrastructure we used the self-reported quality of the road to the market. Better roads indeed encourage farm households to sell to the market, a good quality road significantly increases the probability of trading at the market by 0.1, which is not negligible given the baseline probability of 0.84. Sale transactions negotiated by the female spouse in the household were more likely to occur at the market, confirming the pivotal role of women in the agricultural markets in Ghana (Boserup et al., 2007).

Broader market information, i.e., knowledge of prices in more markets, appears to push farmers to sell at the market. Prices in more distant markets at the district or regional level are generally higher and information on prices in these markets may persuade farmers that potential returns from transacting in some of these markets may be greater than that from farm gate sales even after factoring in higher proportional transaction costs. Knowledge of prices from more markets significantly increases the likelihood a household sells at the market by 0.12. This is a notable increase, given that at the baseline, probability of selling at the market is 0.84. Information sourced from extension officers appears to make the farmer more likely to sell at the market. Of the ICT variables, only the use of mobile phone alone is (weakly) significantly associated with an increased likelihood of farm gate sales. Two-way communication permitted by mobile phone use does not just allow the receipt of updated price information but also enables interaction with the informant and possibly affords better opportunity to negotiate the terms of the sale over the phone with the buyer. This is more likely our case, where most of the communications are carried out via voice. Using mobile phones can thus reduce fixed transaction costs for both the seller and the farm gate buyer, and in our case study significantly increases by 0.14 the likelihood that the sale takes place at the farm gate. Given the baseline probability of selling at farm gate is 0.16, c*eteris paribus* the use of mobile to gather market information has a marginal economic importance. This finding is at variance with Fafchamps and Minten (2012), who found that receiving SMS-Based agricultural information pushes Indian farmers to sell at more distant wholesale market and less likely to sell at the farm gate. Our finding suggests that the information received via mobile phone is not used by sellers to arbitrage across sales outlets, instead supports the view that market information is used by farmers to negotiate better prices with farm gate buyers.

We also attempted to explore the impact of using the combined use of radio and mobile phone to gather market information on the farm gate versus market choice. The results are reported in in the second column (2) in Table 3. The use of radios and mobile phones together has a highly significant association with increased likelihood of market sales – in sharp contrast to the effect of the individual use of radio and mobile phones noted above. This result suggests that there are strong

complementarities in the use of the two technologies. Market price information obtained through radio may be verified through the use of mobile phones improving the reliability of information. Simultaneously, mobile phones may make it possible for farmers to act on the information received and instigate contacts with buyers in specific markets. It must, however, be noted that the combined use of radio and mobile phones was observed in only eight per cent of transactions (n=25) and most of these were associated with sale at the market. A larger sample is needed to provide more robust estimates.

As robustness check, we estimated the same specifications with a probit model. The coefficients of the linear probability model are consistent with the marginal effects of the probit model (online Appendix Table A3)

C. Choosing the marketplace

In case no farm gate buyers are available, or if expected prices are higher at the marketplace, the sellers face making a decision regarding which market to travel to - community, district capital, regional capital or farther (i.e. other regional markets).[7] The model estimates are reported in Table 4.

[Table 2 about here]

Consistent with our expectations, bicycle ownership is associated with travel to farther markets, decreasing the probability of selling at the community market by 0.30, and with a substantial increase in the likelihood of selling at the district market (0.17). Given that the baseline probability of selling at the community market is 0.68, the ownership of a bicycle has a notable impact in empowering farmers to travel to further markets. We find no evidence that ICT use encourages farmers to travel to more distant markets. Sellers receiving market information through radio are more likely to sell at the closer community market. This suggests that information about market prices in more distant markets may not always induce farmers to participate in those markets. They may instead use that information to improve their bargaining power in negotiating prices in closer markets. The effects of receiving

information through mobile phones are similar to that of radio use (but the co-efficient is not significant). We also examined the effects of the combined use of radio and mobile phone on the choice of market by introducing a dummy variable capturing the combined use; the co-efficient was not significant and other coefficients are largely unaffected (results in online Appendix Table A4).

When market information is sourced from extension agents, sellers are more likely to travel to farther away markets.[8] This may be related to the perceived reliability of information provided by extension agents. If farmers trust the information sourced from extension agents, they may be more willing to incur higher proportional transaction costs in pursuit of higher returns in more distant markets. Trust in the buyer reduces the uncertainty associated with the transaction outcomes and can reduce screening/monitoring costs and the risk of default. Our results show that trust in the buyer induces farmers to travel to more distant markets. Crop quality that is below the average quality induces farmers to sell in closer (community) markets. Farmers with poor quality of produce to sell may not find it worthwhile to incur the increased proportional transaction costs of transporting it to the district or regional markets. Finally, at variance with the behaviour of coffee producers in Uganda reported by Fafchamps and Hill (2005), we did not find evidence that wealthier farmers exhibit different behaviour in the choice of market.

VI. Conclusion

We have explored some aspects of household market participation behaviour in developing countries that have so far not received much attention in the literature. Market participation decisions are strategic for small-scale farmers and they can have a remarkable impact on the welfare of the households, expanding their choice sets. Our analysis was possible thanks to a novel dataset containing detailed information on sale transactions of grains made by farmers from northern Ghana and their use of ICTs to gather market information.

We find that larger quantity transactions are associated with farm gate sales, which may be attributable to lower (per unit) fixed transaction costs incurred by farm buyers when larger quantities are procured at the farm gate. This is at variance with the results from some previous studies of cash crop marketing, such as Fafchamps and Hill (2005) for coffee growers in Uganda. These differences in findings suggest that market participation behaviour may be significantly influenced by country and institutional settings. An important addition to the current literature on the usage of ICTs is some evidence (albeit weakly significant) for an impact of mobile phones (possibly through reduction in the search costs for both sellers and buyers) facilitating transactions at farm gate, with potential benefit for both actors.

We also attempted to explore the impact of using mobile phones and radios in combination to gather market information. Results showed the complementary and the reinforcing effect of the use of the two ICTs, which is associated with an increase of sale at the market. Possibly the use of radio is used to gather updated and regular market information in nearby markets and the mobile is used to confirm prices or look for a buyer in a certain market. However a larger sample of households that use both technologies is needed to provide more robust estimates. Given the policy relevance of the potential impact deriving from the use of different technologies, further research is needed in this area.

Further, we find that in cases where farm producers decide to sell their produce at the market, the use of ICTs is not systematically associated with sale in more distant markets. This suggests that the principal effect of ICT use on market participation may not necessarily be through encouragement to farm producers to travel to more distant markets. ICT use may influence the choice of market by (1) providing a broader knowledge of prices in different markets, increasing the bargaining power of farm producers in closer markets; and (2) reducing the transaction costs associated with locating a buyer and setting up and negotiating a transaction in particular markets. Programmes to disseminate market information to small farm producers aimed at enhancing market participation need to be based on a clear understanding of how ICT use can affect transaction costs in specific settings and how information obtained through the use of different transmission technologies is likely to be used in marketing decisions.

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Notes

1. We are grateful to an anonymous reviewer for having pointed out how in this setting a probit model may give inconsistent results when instrumental variables are used to address the potential endogeneity of explanatory variables.

2. Instead of modelling as an ordered model, in some situations a truncated model of the distance travelled by the sellers to reach the sale point could be used (see Fafchamps and Hill; 2005). As in our case the distance travelled to reach a market varies by district and region, a similar approach would not be informative (e.g. the distance to reach a district market in the region A could have been the same distance needed to reach a community district in the region B).

3. Note that not all farm gate sales are physically made at the farm gate (i.e. the seller did not incur in any transport cost). In some cases (26 per cent of the farm gate sales), farmers had to transport their products to a point where a farm gate buyer collected the commodity (on average they travelled 450 meters).

4. As a robustness check we also estimated the model instrumenting the quantity traded. Results of the IV and non IV approach were nearly identical.

5. The ownership of the ICTs is not a reliable proxy either, since the ownership is not associated with a specific use and therefore would not be informative (Zanello, 2012).

6. The distribution of quintiles of quantity traded shows a similar pattern for farm gate and market sales, with lower quantities of produce relatively more frequently sold at farm gate (Graph A1 in the Appendix).

7. Since in this case we are modelling only the transactions processed at the market (262 out of 313 transactions), it could be argued that a selectivity issue is in place. As a robustness check, we jointly run the initial probit modelling the choice to sell at farm gate or at the market with the ordered probit on the marketplace choices and the ρ (the correlation parameter between the first and second stage) is highly insignificant ($p = 0.962$). We then conclude that the selection is due to observable factors.

8. The results of the previous model suggest that sourcing information from extension officers is associated with greater likelihood of market sale. It is possible that extension officers are more likely to visit more remote areas where there are few farm gate buyers, and this may account for the association of market sales. However, here we find that information sourced from extension officers pushes farmers to travel to further away markets rather than selling in the closest available markets.

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Table 1: Linear Probability Model: Selling at the farm gate (0) or at the market (1).

	(1)		(2)	
	Coeff.	Std. Err.	Coeff.	Std. Err.
Quantity sold (IV log)	-0.172**	0.083	-0.176**	0.085
Wealth	0.17e-4	0.16e-4	0.19e-4	0.17e-4
Proportional Transaction Costs				
Distance to the local market	0.21e-4*	0.12e-4	0.21e-4*	0.12e-4
Status road	0.101*	0.06	0.104*	0.059
Bike ownership	0.135	0.103	0.131	0.102
Fixed Transaction Costs				
Spouse bargaining	-0.123*	0.074	-0.118	0.073
Trust in buyer	-0.064*	0.036	-0.061*	0.036
Quality	0.112	0.094	0.124	0.096
Price market sale known	-0.059	0.068	-0.053	0.067
Market prices known	0.123**	0.062	0.125**	0.062
Receiving market information via mobile phone	-0.140*	0.08	-0.232**	0.114
Receiving market information via radio	-0.115	0.105	-0.270*	0.159
Receiving market information "word of mouth"	-0.145	0.11	-0.207	0.126
Receiving market information via neighbours	-0.045	0.08	-0.003	0.085
Receiving market information via ext. agents	0.151**	0.067	0.165**	0.071
Receiving market information via mobile + radio			0.257*	0.146
Constant	1.509***	0.517	1.513***	0.521
Household characteristics	YES		YES	
Crop and regional dummies	YES		YES	
R-squared	0.015		0.02	
Wald $\chi 2$	49.52***		51.08***	
Durbin-Wu-Hausman test	5.98**		5.87**	
F-Test on significance of instruments	35.383***		35.383***	

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. Stock and Yogo significance levels =16.38.

Table 2: Choosing the marketplace: community (C), district (D), or regional market (R)

	Coeff.	Std. Err.	M.E. (C)	M.E. (D)	M.E. (R)
Quantity sold	0.089	0.139	-0.020	0.002	0.019
Wealth	-0.11e-4	0.86e-5	0.25e-5	-0.20e-5	-0.23e-5
Proportional Transaction Costs					
Distance to the local market	0.27e-4***	0.58e-5	-0.63e-5	0.50e-5	0.58e-5
Status road	-0.383	0.303	0.098	-0.027	-0.071
Bike ownership	0.970**	0.400	-0.301	0.172	0.129
Fixed Transaction Costs					
Spouse bargaining	-0.264	0.373	0.064	-0.013	-0.052
Trust in buyer	0.571***	0.213	-0.130	0.010	0.120
Quality	-0.938**	0.424	0.292	-0.168	-0.124
Receiving market information via mobile phone	-0.264	0.397	0.063	-0.010	-0.053
Receiving market information via radio	-0.776*	0.435	0.221	-0.099	-0.122
Receiving market information "word of mouth"	-0.267	0.485	0.063	-0.010	-0.054
Receiving market information via neighbours	-0.468	0.343	0.101	0.004	-0.105
Receiving market information via ext. agents	0.545*	0.322	-0.125	0.010	0.115
Household characteristics	YES				
Crop and regional dummies	YES				
α_1	4.983***	1.428			
α_2	7.172***	1.392			
Log pseudolikelihood	-117.19				
Wald χ^2	68.17***				
Ratio correct prediction‡	2.22				

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.

‡ The ratio of correct prediction is a measure of goodness of fit. It is computed as the sum of the fraction of zeros correctly predicted and the ones correctly predicted (McIntosh and Dorfman, 1992). The model is considered robust if the ratio is greater than one.

Online Appendix

Additional data description

The descriptive statistics of the household characteristics and sale transactions are reported in Tables A1 and A2 respectively. On average, the head of the household was over 50 years old with just two years of formal education. Most were male, although in Ghana – as in most of Western Africa – the role of women in markets is critical. In general, men are responsible for the clearing and preparation of the land while women are responsible for planting, weeding, fertilizer application, harvesting, transportation to market centres, and marketing of the produce (Boserup et al., 2007). A quarter of the transactions were negotiated by the female spouse alone. We expected a higher share since in Ghana women are traditionally considered to be more active in agricultural markets than men. Trust is an important component in market transactions that derives from a history of successful exchanges. This has been captured asking the sellers how much they trusted the buyer in each specific transaction.

Only ten per cent of the households did not have mobile network coverage in their household location, whereas the radio signal covers virtually every part of the country. Generally, mobile phones are owned mainly by the younger generation, who are more inclined to adopt new technologies. However they are widely shared within the household. In the case of mobile phones, information was transmitted via voice in the great majority of cases (98%). At the time of data collection in the study area no programmes of market information diffusion via SMS services were being implemented. Therefore, farm households that used mobile phones to receive price information privately contacted (or had been contacted by) an informant.

The average wealth, computed as the value of all the non-land belongings of the household (including the depreciated values of livestock, farm equipment, and other household equipment), was GH¢ 1222.58, equivalent to GBP 553.83 or US$ 863.15.

The quintiles distribution of quantity traded at the farmgate and market is shown in Graph A1.

Table A1: Descriptive statistics: regional and crop dummies, and household characteristics (n=313)

Variable	Unit	Mean	Std. Dev.	Min	Max
Household Characteristics					
Male household head		0.94	0.24	0	1
Household head age	Years	51.22	14.57	24	95
Adult in the household (15-64)	Number	4.44	2.02	1	12
Household head education	Years	2.22	4.22	0	20
Household head experience of farming	Years	26.94	15.62	2	74
Total land	Hectares	2.39	1.1	0.4	7.2
Households wealth	GH¢	1222.58	1559.72	7.4	8995.29
Regional and crop dummies					
North region		0.43	0.5	0	1
Upper West region		0.09	0.29	0	1
Maize		0.24	0.43	0	1
Sorghum/Millet		0.16	0.37	0	1
Rice		0.12	0.33	0	1
Cowpea		0.09	0.28	0	1
Groundnut unshelled		0.24	0.43	0	1

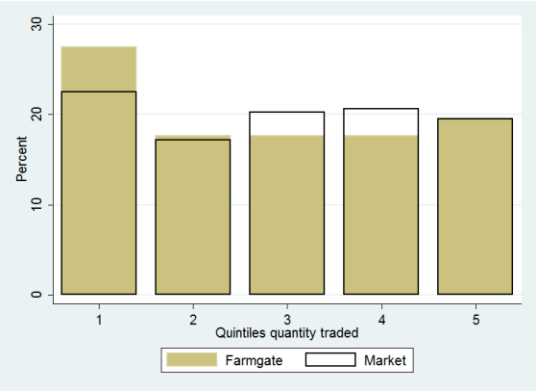
In case of dummy variable, the unit is not specified.

Table A2: Descriptive statistics: proportional and fixed transaction costs, instruments (n=313)

Variable	Unit	Mean	Std. Dev.	Min	Max
Proportional Transaction Costs					
Ownership of bicycle		0.87	0.34	0	1
Distance to the local market	Meters	3586.1	2452.59	50	9000
Good status of roads to the market		0.19	0.39	0	1
Fixed Transaction Costs					
Spouse alone bargained the transaction		0.28	0.45	0	1
Trust in the buyer	1=Very little 2=Little 3=Neutral 4=Much 5=Very much	2.26	0.9	1	3
Product below average quality		0.09	0.29	0	1
Market price sale known in advance		0.59	0.49	0	1
Market prices known	Number	1.15	0.61	0	3
Receiving market information via mobile phone		0.33	0.47	0	1
Receiving market information via radio		0.16	0.37	0	1
Receiving market information via mobile phone and radios		0.08	0.27	0	1
Receiving market information via “word of mouth”		0.38	0.49	0	1
Receiving market information from neighbours		0.62	0.49	0	1
Receiving market information from extension agents		0.46	0.5	0	1
Quantity traded, prices and selling locations					
Quantity sold	Kilograms	391.11	461.52	8	3500
Sale at the market		0.84	0.37	0	1
Market chosen (n=262)	0=Community market 1=District market 2=Regional market	1.38	0.6	1	3
Distance travelled to marketplace	Meters	9601.28	42977.3	0	450000
Instrument variable					
Plot size	Hectares	0.67	0.47	0.08	3

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

Graph A1: Distribution of quantity traded at the farmgate and market (quintiles).



Additional estimations

Table A3: Probit model: Selling at the farm gate (0) or at the market (1).

	(1)			(2)		
	Coeff.	Std. Err.	M.E.	Coeff.	Std. Err.	M.E.
Quantity sold (IV log)	-0.770***	0.162	-0.184	-0.781***	0.161	-0.191
Wealth	0.11e-4	0.06e-4	0.28e-4	0.11e-4	0.06e-4	0.28e-4
Proportional Transaction Costs						
Distance to the local market	0.09e-4**	0.04e-4	0.03e-4	0.10e-4**	0.05e-4	0.02e-4
Status road	0.418*	0.236	0.087	0.422*	0.232	0.090
Bike ownership	0.351	0.31	0.095	0.341	0.308	0.093
Fixed Transaction Costs						
Spouse bargaining	-0.523*	0.273	-0.139	-0.478*	0.265	-0.128
Trust in buyer	-0.300**	0.129	-0.072	-0.285**	0.129	-0.069
Quality	0.489	0.33	0.094	0.512	0.322	0.100
Price market sale known	-0.204	0.275	-0.048	-0.168	0.269	-0.040
Market prices known	0.454*	0.251	0.109	0.421*	0.241	0.103
Receiving market information via mobile phone	-0.750**	0.348	-0.201	-0.981**	0.397	-0.274
Receiving market information via radio	-0.289	0.408	-0.076	-0.910	0.59	-0.282
Receiving market information "word of mouth"	-0.618*	0.371	-0.158	-0.784**	0.398	-0.208
Receiving market information via neighbours	-0.190	0.302	-0.045	-0.049	0.3	-0.012
Receiving market information via ext. agents	0.558**	0.226	0.131	0.566**	0.233	0.135
Receiving market information via mobile and radio				1.032	0.659	0.156
Constant	4.041***	1.213		3.977***	1.205	
Household characteristics	YES			YES		
Crop and regional dummies	YES			YES		
Log-pseudolikelihood	-479.78			-478.22		
Wald χ^2	133.92***			142.96***		
Durbin-Wu-Hausman test	11.45***			11.66***		
F-Test on significance of instruments	35.38***			35.38***		
Ratio correct prediction‡	1.26			1.24		

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. Stock and Yogo significance levels =16.38.

‡ The ratio of correct prediction is a measure of goodness of fit. It is computed as the sum of the fraction of zeros correctly predicted and the ones correctly predicted (McIntosh and Dorfman, 1992). The model is considered robust if the ratio is greater than one.

Table A4: Choosing the marketplace: community (C), district (D), or regional market (R)

	Coeff.	Std. Err.	M.E. (C)	M.E. (D)	M.E. (R)
Quantity sold	0.089	0.137	-0.020	0.002	0.019
Wealth	-0.11e-4	0.86e-5	0.25e-5	-0.20e-5	-0.23e-5
Proportional Transaction Costs					
Distance to the local market	0.28e-4***	0.58e-5	-0.64e-5	0.50e-5	0.56e-5
Status road	-0.383	0.302	0.098	-0.027	-0.071
Bike ownership	0.970**	0.400	-0.301	0.172	0.129
Fixed Transaction Costs					
Spouse bargaining	-0.264	0.372	0.064	-0.013	-0.052
Trust in buyer	0.571***	0.213	-0.130	0.010	0.120
Quality	-0.939**	0.424	0.293	-0.168	-0.124
Receiving market information via mobile phone	-0.269	0.439	0.064	-0.010	-0.054
Receiving market information via radio	-0.784	0.637	0.224	-0.101	-0.123
Receiving market information "word of mouth"	-0.270	0.491	0.064	-0.010	-0.054
Receiving market information via neighbours	-0.465	0.349	0.100	0.004	-0.104
Receiving market information via ext. agents	0.545*	0.321	-0.125	0.010	0.115
Receiving market information via mobile and radio	0.016	0.716	-0.004		0.003
Household characteristics	YES				
Crop and regional dummies	YES				
α_1	4.983***	1.419			
α_2	7.171***	1.385			
Log pseudolikelihood	117.19				
Wald χ^2	68.47***				
Ratio correct prediction‡	2.23				

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.

‡ The ratio of correct prediction is a measure of goodness of fit. It is computed as the sum of the fraction of zeros correctly predicted and the ones correctly predicted (McIntosh and Dorfman, 1992). The model is considered robust if the ratio is greater than one.