CHAPTER THREE

A MODEL OF HOUSEHOLD MARKET PARTICIPATION UNDER TRANSACTION COSTS

3.1 INTRODUCTION

Many authors have recognised that analysis of smallholder market participation under transaction costs cannot be done by using standard economic models. Special theoretical and empirical models are required to understand the behaviour of smallholder farmers in market participation. This chapter provides a theoretical framework of market participation by resource poor households facing transaction costs. The empirical model is presented subsequently.

3.2 THEORETICAL MODEL

In this section a standard household model is constructed to determine the role of transaction costs in smallholder farming by specifying market participation (and hence revenue to access other goods) as choice variables. This follows largely on the recent work by Omamo (1998) and Key *et al* (2000). Their household models were an expansion of the model by de Janvry, Fafchamps and Sadoulet (1991) who were among the first authors to recognise the effect of market failures in smallholder farming. However, in constructing the model, elements from pioneering works in modelling smallholder market participation decision by Goetz (1992) and Strauss (1984) were also used. In constructing the model ideas from all of the mentioned studies were incorporated.

3.2.1 Market participation without transaction costs

Following Omamo (1998) and Key *et al* (2000), we consider a farm household maximising utility (u) by deciding on the consumption of k goods (c_k) production of k goods (q_k) and sales of k goods (s_k). That is, using i inputs for each product k (x_{ik}) the household can produce (q_k) which can either be sold (s_k) or consumed (c_k). Sales fits into the utility function through revenue generated from sales ($p_k s_k$), the sum of which is used to purchase other goods (represented by R_k). That is, the household will purchase an equivalent of R_k in other goods.

The neo-classical subjective equilibrium for a commercialising (or market participating) household will be given by the following:

$$\text{Max } U = u(c_k, R_k ; H_u) \qquad (1)$$

That is, household can either consume what it produces (c) or gain revenue to purchase other goods (R), given household characteristics (H_u). That is, H_u represents a set of factors shifting the utility function.

The utility maximisation is subject to:

$$\sum_{k=1}^{N}[p_k c_k + R_k] \leq \sum_{k=1}^{N}[p_k (q_k - s_k) + \text{E}] \qquad (2)$$

or full income constraint, implying that expenditure on all purchase must not exceed revenues from all sales and transfers (E),

$$p_k c_k + p_k s_k + p_i x_{ik} \leq p_k q_k + R_k + e_k \qquad (3)$$

or commodity resource balance, stating that for each of the N goods, the amount consumed, used as inputs, and sold is equal to what is produced and bought plus the endowment of the good (e),

$$G = g\ (q_k\ , x_{ik}\ ; H_q) \qquad (4)$$

or production technology that relates inputs (x_{ik}) to output (q_k), given the set of household characteristics (H_q) shifting the production function.

c_k, q_k, x_i, s_k, $R_k \geq 0$, where

$R_k = p_k s_k$, and

$s_k = f(c_k, q_k ; H_q, H_u, E)$ (5)

P_k (p_{ks} for selling price and p_{kc} for purchase price) and p_i are given market prices of good k and input i respectively. (6)

We can recap that E is exogenous transfers and other incomes (not from farming activities). The non-farm income is assumed to be exogenous since in South Africa it forms a major part of smallholder income, such that the small holder doesn't have to make decisions about it. More often when the household cannot generate such non-farm income itself there will be certain forms of transfers such as remittances or government grants. Then, e_k are endowments in good k. H_u and H_q are household and location-specific shifters in utility and production respectively, and G represents the production technology. It is noteworthy that c, R, s and q are defined and decided over k goods, where the set k covers all goods entering into production, consumption and the market (or commercial activity).

The household jointly makes its production, consumption and market participation decision subject to a number of constraints. The full income constraint (2) states that the equivalent of total expenditure on all purchases (or equivalent) must not exceed revenues from all sales and transfers. The resource equilibria (3) indicates that, for each k^{th} goods k, the value of what is consumed, sold, and used as inputs should not exceed the value of what is produced, bought plus the endowment of the good k. The production technology (4) relates inputs (x_i) required to produce output (q_k).

The Lagrangian associated with this optimisation problem to derive the supply and demand equations for a household participating in the market without transactions costs, is defined as:

$$\text{Max } L = u(c_k, R_k ; H_u)$$

$$+\mu_k\left[\sum_{k=1}^{N} p_k(q_k - s_k) - R_k - p_k c_k + E\right]$$

$$+ \lambda\,[p_k (q_k - s_k) - p_k c_k - p_i x_{ik} + R_k + e_k]$$

$$+ \phi\ G(q_k, x_{ik}; H_q) \qquad (7)$$

where μ, ϕ and λ are the Lagrange multipliers associated with the full-income constraint, resource balance equilibria, and technology constraint, respectively.

The optimal consumption, production, input use and market participation must, respectively, satisfy the following first-order condition (FOC), upon solving which the optimal supply and demand can be determined. These are the shadow prices of the constraint resource.

For consumption, the partial derivative of u (or L) with respect to c_k is:

$$\frac{\partial u}{\partial c_k} = \mu p_k + \lambda p_k \qquad (8)$$

For other purchased goods, the partial derivative with respect to R_k is:

$$\frac{\partial u}{\partial R_k} = \mu - \lambda \qquad (9)$$

For output, the partial derivative of G with respect to q_k is:

$$\phi\frac{\partial G}{\partial q_k} = -\mu p_k - \lambda p_k \qquad (10)$$

For inputs, the partial of G with respect to x_{ik} is:

$$\phi\frac{\partial G}{\partial x_{ik}} = -\lambda p_i \qquad (11)$$

For marketed goods, the partial derivative of G with respect to s_k is:

$$\phi \frac{\partial G}{\partial s_k} = -\mu p_k - \lambda p_k \qquad (12)$$

Using equations (8) and (9) subject to the full income constraint (2), we can solve for a system of demand equations for consumption, $c_k(p, I; H_u)$ and purchased goods $R_k(p, I; H_u)$. I is income redefined under full income constraint (Key *et al*, 2000).

Using equation (10) and (11) for profit maximisation, subject to (4), we can solve for output supply equations, $q_k(p; H_q)$ and inputs equations, $x_i(p; H_q)$.

Using equations (12) and (9) subject to constraint (5) we can solve for a system of market participation equations $s_k(p_k; H_q, H_u)$. This implies that market participation will be endogenously affected by prices, as well as by exogenously determined household characteristics. This supposes that participation in the markets is just a response to an observable price signal.

3.2.2 Market participation with transaction costs

As indicated earlier, market participation with exchange of output in the market is not cost free. The decision price faced by the farmer may differ from the observable price, due to the existence of transaction costs. These costs can be observed but are generally unobservable. However, the unobservable transaction costs can be explained by certain factors (such as assets and information) that can be observed. The transaction costs can vary with amount exchanged (variable transaction costs, TVC) or can be fixed regardless of amount exchanged (fixed transaction costs, TFC) (Key *et al*, 2000). Transaction costs in smallholder farming arise from a household's differential access to assets and information asymmetries, and different households face different transaction costs. Education and contact with extension, as proxies for information, represent fixed transaction costs, while ownership of arable land, livestock and transport facilities represent variable transaction costs.

The existence of transaction costs will lower the price effectively received by a seller - thus discouraging market participation on the one hand. On the other hand, they raise the effective value of production consumed by the household resulting in a higher level of consumption and a lower level of market participation. As such, the transaction costs tend to widen the price band (Minot, 2000) and if the decision price falls within the band, the household will not participate in the market (Sadoulet *et al*, 1995).

The objective function of the household under transaction costs becomes

Max $U_t = u_t(c^t, R^t; H_u)$ (13)

Subject to:

Full income constraint under transaction costs

$$\sum \tau_k^s [p_k - t_{vc}(h_t)](q_k - s_k) - \tau_k^s R_k^t - \tau_k^c [p_k + t_{vc}(h_t)]c_k - \tau_k^s t_{fc}(h_t) - \tau_k^c t_{fc}(h_t) + E \geq 0 \quad (14)$$

with the resource balance equilibria affected by transaction costs in the similar way, where $\tau_k^s = 1$ if $s_k > 0$ and $\tau_k = 0$ if $s_k = 0$. R_k^t is the revenue gained under transaction costs and $R_k^t = 0$, when $s_k = 0$, and $R_k^t \leq R_k$. The $\tau_k^c = 1$ if $c_k > 0$ and $\tau_k^c = 0$ if $c_k = 0$.

These conditions imply that when the household is not participating in the market variable transaction costs will not exist, and the fixed transaction costs (t_{fc}) will determine whether the household participates or not. That is, the household's response to transaction costs involves either switching from participating in one market to the other and/or from participating in the market to consuming.

We can then derive supply and demand equations conditional on market participation of household facing both fixed transaction costs (t_{fc}) and variable transactions costs (t_{vc}). The Lagrangian is defined as:

Max $L_t = u_t\ (c^t, R^t; H_u)$

$$+\ \mu \sum \tau_k^s [p_k - t_{vc}(h_t)](q_k - s_k) - \tau_k^s R_k^t - \tau_k^c [p_k + t_{vc}(h_t)]c_k - \tau^s t_{fc}(h_t) - \tau_k^c t_{fc}(h_t) + E$$

$$+\ \lambda\ [\tau p_k\ (q_k - s_k) - \tau p_k c_k - \tau p_i\ x_{ik} + \tau R_k + e_k]$$

$$+\ \varnothing\ G(q_k, x_{ik}; H_q) \qquad (15)$$

In this problem, the optimal solution cannot be found by solving the FOC since the presence of t_{fc} creates discontinuity in the Lagrange. This requires consideration of Kuhn-Tucker conditions (Instriligator, 1971; Silberberg, 1990, Nicholson, 1992). To be exact, the solution requires two steps as postulated in Key *et al* (2000). That is, we first solve for the optional solution on condition of market participation, and then choose the participation level leading to highest level of utility. When transaction costs can be specified as fixed cost (for example a credit constraint) then we can get a per unit shadow price (or the Lagrange multiplier) for that constraint.

The FOC for the equation 15) are:

For consumption of own production

$$\frac{\partial u^t}{\partial c^t} = \mu\tau^c (p_k + t_{vc}(h_t)) + \lambda\tau^c (p_k + t_{vc}(h_t)), \qquad (16)$$

For consumption of purchased goods

$$\frac{\partial u}{\partial R_k} = \tau_k^c \mu (p_k + t_{vc}(h_t)) - \tau_k^c \lambda .(p_k + t_{vc}(h_t)), \qquad (17)$$

For output produced

$$\phi \frac{\partial G}{\partial q_c} = -\mu\tau_k^s (p_k - t_{vc}(h_t)) - \lambda\tau_k^s (p_k - t_{vc}(h_t)), \qquad (18)$$

For inputs used in production

$$\phi \frac{\partial G}{\partial x_{ik}} = -\lambda\tau_k^s (p_{ck} - t_{vc}(h_t)) \qquad (19)$$

For marketed goods

$$\phi \frac{\partial G}{\partial s_k} = -\mu \tau_k^s (p_k - t_{vc}(h_t)) - \lambda \tau_k^s (p_k - t_{vc}(h_t)) \qquad (20)$$

The income constraint takes two forms:

When the household participates, the change in utility as a result of unit change in μ will be equivalent to income constraint in (14) which has both fixed and variable transaction costs. However, when the household is not yet participating

$$\frac{\partial L_t}{\partial \mu} = -\tau_k^s t_{fc}(h_t) - \tau_k^c t_{fc}(h_t) + E = 0 \qquad (21)$$

We can then solve for systems of demand equations under transaction costs

$$c_k^t = c_k^t (p_t + t_{vc}, I; h_u) \qquad (22.1)$$

$$R_k^t = R_k^t (p_t - t_{vc}, I; h_u) \qquad (22.2)$$

The systems of output supply equations under transaction costs;

$$q_k^t = q^t (p_t - t_{vc}; h_q) \qquad (22.3)$$

Input equations

$$x = x (p_i, h_q) \qquad (22.4)$$

and the system of market participation equations is given by

$$s_k^t = s^t (p - t_{fc}; h_q, h_u)$$

depending on whether τ_k^s = 0 or 1,

and

$$s_k^t = s^t (p - t_{vc} - t_{fc}; h_q, h_u)$$

when $\tau_k^s = 1$ (22.5)

Two points to note in this regard are that:

1) Transaction costs affect all systems of equations. For example, the utility maximisation under transaction costs is different from the one when transaction costs are assumed not to exist (Key *et al*, 2000). Under transaction costs more of the production will be consumed since producers will be valuing output consumed at $P_k + t_{vc} \geq P_k$, and they will be saving on a higher purchase price.

   On the other hand, less of other goods (R_k) will be consumed since there is less propensity to participate in the market. In a graph, these would be reflected by a twist in indifference curves and an inward shift of the full income constraint.

2) The household's market supply without transaction costs is a function of prices and household characteristics, i.e.
   $s_k = s\ (p, h_u, h_q)$

With transaction costs, the supply equation becomes (22.5), which is a function of fixed transaction costs when the households makes a decision to participate, but is affected by both fixed and variable transaction costs when the household effectively participates. That is, both the fixed and variable transaction costs will affect the magnitude of supply. They are likely to change the slope of the sales curve in the graph showing the quantity supplied and the revenue received or other goods acquired. However, the fixed transaction costs will shift the supply curve with respect to both R and Price - thus increasing the threshold at which market participation can take place, that is, when production under transaction costs is greater that what households would prefer to consume when the transaction costs are too high. Extremely high transaction costs (particularly fixed transaction costs) will lower the decision price considerably so much so that it might not be worthwhile to participate in the market.

It should further be noted that the consumption is a residual of production and market participation;

$q(p - t_{vc}, h_q) - s_k^t(p - t_{vc}, h_u, h_q) = c(p + t_{vc}, h)$

Thus market participation and consumption are inversely related. By determining one equation, the other equation is automatically determined in reverse.

Following Abdulai and Delgado (1999), the decision price for selling is the marginal value of household's commodity when all of it is allocated to consumption. It is obtained from equation (22.5) by setting the amount sold equal to zero (i.e. s = 0) and solving for $P_k = P_k^d$. The equation for shadow decision price will be given by

$$P_k^d = P_k^d(t_{fc}, p_k, h_q, h_u) \qquad (23)$$

3.3 EMPIRICAL MODEL

The econometric specification of the preceding model consists of market participation decision equations and market supply equations estimated separately for horticultural crops (k = 1), livestock (k = 2), maize (k = 3) and other field crops (k = 4). If the observed market price (P_k^m) of a commodity is greater than the shadow (decision) value (P_k^d), a positive amount of sales will be observed for the commodity.

Equation (22.5) shows that a decision to take part in the market depends only on fixed transaction costs, while the market supply (conditional on the market participation decision) will depend on both fixed and variable transaction costs. Thus, when fixed transaction costs are overcome (or a certain threshold is reached), positive values of supply (sales or market participation) will be observed for a particular commodity. Key *et al* estimated a structural model keeping separate the supply functions from the production threshold functions. In this study, we follow a standard unbiased estimation of the model based on the joint estimation of the reduced form of the market participation decision and supply function.

The empirical supply and transaction costs equation can be defined as a linear expression in parameters,

$q_k(p, h_q) = P_k\beta_{sk} + h_q\beta_q$

$t_{vc}^{s} = -h_t\, \beta_{vc}$, for variable transaction costs, and

$t_{fc}^{s} = -h_t\, \beta_{fc}$, for fixed transaction costs,

which leads to linear expressions for supply by sellers, s_k as;

$$s_k = P_k^s + h_t\, \beta_{vc} + h_t\, \beta_{fc} + h_q \beta_q \qquad (24)$$

where the h's are the household characteristics affecting transaction costs and production respectively. The market participation indicator variable (s_k^*) for commodity k can be defined as

$s_{ik}^* = 1$ if $P_k^m \leq P_k^d$

and

$s_{ik}^* = 0$ if $P_k^m > P_k^d$

The econometric specification is obtained by adding error terms to the supply equations and defining market participation with a zero threshold as following Kelly *et al* (2000);

$$s_k = P_k + h_t\, \beta_p + h_t \beta_{fc} + h_q \beta_q + \mu_{sk}$$

$$\equiv \beta_p^s x_{sk} + \mu_{sk} \qquad (25.1)$$

where x_{sk} is a vector of exogenous explanatory variables such as personal, household and location characteristics that influence market participation; and u_{sk} are random disturbance terms for the population of all the commodities. The probability of participating in the market can then be specified as:

pr(s* = 1) = pr($P_k^m > P_k^d$) = pr($P_k + h_t\, \alpha_{fc} + h_q \alpha_q > \varepsilon_{sk}$)

with a reduced form for probability of market participation;

pr(s* = 1) $\equiv \alpha_p^s x_{sk} + \varepsilon_{sk}$ (25.2)

This model is based on a dichotomous selection mechanism. This will then follow Heckman's two-stage estimation approach.

3.4 SUMMARY

The chapter has introduced the conceptual framework for analysing the effect of transaction costs in the commercialisation of smallholder farmers. Since the smallholders make both production and consumption decisions simultaneously, a utility maximization problem is applied in the decision of production, consumption and sales. Under transaction costs, the decision price is reduced which subsequently reduces the market participation. The household faces a two-stage decision problem. Firstly, the fixed transaction costs influence the household's decision to participate or not to participate. Secondly, when the household is participating, both fixed and variable transaction costs affect the level of participation.

The econometric model shows a specification of the market participation process for commodities with respect to a range of explanatory (and or policy) variables that encompass transaction costs factors as well as household characteristics that have a bearing on transaction costs. In the next chapter, the various variables are evaluated for consideration into the model specification. In the subsequent chapter, the specified models will be estimated.