The role of rural off-farm employment in agricultural development among farm households in low-income countries: Evidence from Zimbabwe

CORNILIUS CHIKWAMA*

Rural and Environment Research and Analysis Directorate, Scottish Government, Scotland

Abstract

This study examines the widely held view that earnings from rural wage employment can help farm households overcome constraints on farm investments. It uses a panel dataset of 359 randomly selected farm households from three resettlement areas in Zimbabwe over the period 1996/97 to 1998/99. It finds no evidence to support the hypothesis that income from rural wage employment contributes towards increasing farm investment for the sampled households, and it attributes this to very low savings rates on rural wage employment income. Further, it finds that levels of farm investment increase with the amount of labor and land used in farm production in the previous year, and for households with male and/or older household heads. It also finds an inverse relation between farm investment and farm capital stocks – evidence that households that had higher levels of farm capital stocks were disinvesting in agriculture over the period studied.

Keywords: rural off-farm wage employment; farm investment; agricultural development; sub-Saharan Africa; Zimbabwe

JEL codes: O12; O18; J40; R20

Cette étude examine l'idée largement soutenue que les gains issus des salaires en zone rurale peuvent aider les petits fermiers à surmonter les contraintes des investissements agricoles. Elle utilise un ensemble de données concernant 359 petits fermiers, choisis au hasard, dans trois zones de réimplantation au Zimbabwe, pour la période allant de 1996/97 à 1998/99. L'étude n'a trouvé aucune preuve capable de soutenir cette hypothèse que les salaires des zones rurales contribuent à augmenter l'investissement agricole pour cet échantillon de fermiers. Elle en justifie la cause par le taux d'épargne très faible sur les revenus issus des salaires en zone rurale. De plus, elle montre que les niveaux de l'investissement agricole augmentent par rapport à la quantité de main-d'œuvre et de terre utilisée pour la production agricole lors de l'année précédente, et pour les ménages où un homme et/ou des personnes plus âgées travaillent. L'étude révèle également une relation inverse entre l'investissement agricole et le capital agricole – preuve que les ménages dotés d'un niveau plus élevé en matière de capital agricole étaient en train de désinvestir dans l'agriculture au cours de la période étudiée.

* Correspondence: Cornilius.Chikwama@scotland.gsi.gov.uk

Mots-clés : *emploi rural rémunéré hors ferme ; investissement agricole ; développement agricole ; Afrique sub-saharienne ; Zimbabwe*

Catégories JEL : *O12 ; O18 ; J40 ; R20*

1. Introduction

Over the last three decades, it has become widely accepted in both academic and policy research that rural off-farm activities form a significant component of livelihoods in developing countries. Evidence from field surveys during the 1970s and 1980s across many of these countries shows that self-employment in household based enterprises and wage employment in rural labor markets are both widespread (Chuta & Liedholm, 1990). Furthermore, a large share of households' income comes from off-farm activities (Reardon, 1997; Bryceson & Jamal, 1997), and earnings from farm and off-farm activities are in fact positively correlated (Haggblade et al., 1989; Hazell et al., 1991).

The positive relationship between off-farm and farm income, in particular, has attracted considerable attention from researchers in this area. It is used in a number of studies to argue in favor of the widely held view that rural off-farm income is important for agricultural development as it helps households overcome cash constraints on farm investment.[1] If accurate, this view would be important for agricultural development in low-income countries where there is widespread evidence of institutional failures in rural capital markets. It is not surprising, therefore, that it attracts considerable attention from non-governmental organizations (NGOs) and development agencies when formulating policies to improve the agricultural potential of households in poor countries (Von Braun & Pandya-Lorch, 1991; Bernstein et al., 1992; Ellis, 2000). However, other studies and policy views have argued that expansion of the rural off-farm sector may have adverse effects on the development of household agriculture (Lipton, 1980; Low, 1986; Ellis, 1998). For instance, until the early 1990s households that had resettled on formerly white-owned farms in Zimbabwe in the early 1980s were prevented by the government from participating in off-farm activities in order to oblige them to concentrate on agriculture (Kinsey, 2002).

Although rural off-farm income may help to raise a household's farm investment, the above review suggests lack of consensus on the exact nature of the relationship between rural off-farm activities and the broader process of agricultural development (Lanjouw, 2001). In fact, Reardon et al. (1994) point out that studies in Africa have hardly, in any systematic way, explored for factors that influence the direction and nature of reinvestment of household income earned from the rural off-farm sector. Studies that examine the direction of influence in the positive relationship between farm and rural off-farm production observed in the literature on sectoral linkages in rural areas suggest that the expansion of off-farm production in the 1960s was due to productivity gains on the farms following the Green Revolution (Haggblade et al.,

[1] See Savadogo et al. (1994), Carter (1997), Barrett et al. (2001), and Lanjouw et al. (2001), for some insights, and Reardon et al., who point out that 'Non-farm income can be an important source of cash income, which can potentially improve farm productivity if it is used to finance farm input purchase or longer-term capital investment' (1994:1172).

1989; Hazell & Haggblade, 1993), which implies that the development of the rural off-farm sector depends on the growth of the agricultural sector, rather than the reverse.

It is against the above background that this study examines the effect of rural off-farm wage employment on households' farm investment. The study defines rural wage employment as all activities, regardless of sectoral classification, that households engage in away from their own farms in exchange for wages (Barrett et al., 2001). It focuses on rural wage employment because this is considered the easiest way that poor households in low-income countries can diversify into the off-farm sector (Hill, 1982; Barrett et al., 2000). Additionally, despite growing evidence that rural off-farm economic activities have become increasingly important in Africa and the rest of the developing world, there are hardly any studies that try to understand the rural labor market as a significant component of the rural off-farm sector (Rosenzweig, 1988; Jamal, 1995; Anderson-Schaffner, 1996; Reardon, 1997). Most of the studies that look at rural labor markets do so only to understand their role as sources of migration labor to urban areas (Lucas & Stark, 1985; Collier & Lal, 1986; Low, 1986; Rosenzweig, 1988; Bhattacharya, 1998, 2002).

The rest of this paper is organized as follows. Section 2 presents the standard agricultural household model, which includes unemployment in the household to explain labor allocation to farm production and rural wage employment, Section 3 introduces a farm investment perspective to the household model and establishes conditions for rural wage employment to raise investment on household farms, Section 4 presents the empirical specification of the farm investment model, Section 5 describes data collected from resettlement areas in Zimbabwe that are used in the analysis, Section 6 presents results from the analysis, and Section 7 concludes.

2. Rural wage employment and labor allocations

This section uses the standard neoclassical agricultural household model to analyze a household's labor allocation to farm production and rural wage employment (Low, 1986; Friis-Hansen, 1995; Bardhan & Udry, 1999). The model assumes that households maximize utility by choosing optimal levels of consumption (c) and leisure (l) subject to a full-income constraint – the sum of income from farm production and the sale of factor endowments. As a deviation from this standard model, this study assumes that households face incomplete markets for factors of production,[2] that rural labor is homogenous, and that a household's own labor can be perfectly substituted with that from the market.

The household's objective is to:

$$\text{Max}\, U(c,l), \tag{1}$$

[2] Evidence from studies in developing countries shows that rural factor markets, where they exist, do indeed function only imperfectly (Collier, 1983; Carter, 1984; Jacoby, 1993).

subject to

$$p_c c + wL^h \leq p_f F\left(L, E^A, E^K, \boldsymbol{\alpha}\right) + wL^M \ . \quad (2)$$

The household faces the labor constraint

$$E^L = L^f + L^M + l \ , \quad (3)$$

where

$$L^M \leq M \ . \quad (4)$$

The household's utility function ($U(\cdot)$) is increasing and concave in both consumption and leisure. On the left-hand side of (2) p_c is the price of consumption goods (c) and L^h is the amount of labor hired by the households at a wage w. On the right-hand side of (2), p_f is the price of farm output. $F(\cdot)$ is the farm production function, which is increasing and concave in $L = L^h + L^f$, E^K and E^A – the amounts of labor used on the farm, and the household's endowments for farm capital and land. $\boldsymbol{\alpha}$ is a vector of the household's plot characteristics. The household labor constraint (3) states that the household's labor can be allocated to farm production (L^f), or rural labor market (L^M), or consumed as leisure (l). Constraint (4) defines imperfections in the rural labor market, that is, there is a maximum amount of labor (M) that households can sell on the market.[3] The case when (4) is binding is more important in this study because evidence from most developing countries suggests high levels of rural unemployment. When (4) is binding there is excess labor in the households, which implies there is no need to employ outside labor (i.e. $L^h = 0$). Therefore, the full income constraint becomes:

$$p_c c \leq p_f F\left(L^f, E^A, E^K, \boldsymbol{\alpha}\right) + wM \ . \quad (5)$$

Assuming that c, L^f, E^A, E^K and M are positive, the solution to the first-order Kuhn Tucker conditions for the household's maximization problem given the presence of unemployment in the rural labor market will be $l^* = l^*\left(p_c, p_f, w, M, E^A, E^K, E^L, \boldsymbol{\alpha}\right)$ and $c^* = c^*\left(p_c, p_f, w, M, E^A, E^K, E^L, \boldsymbol{\alpha}\right)$. By choosing optimal demand for leisure, a household implicitly chooses its labor supply, which is $L^* = E^L - l^*$. The next step is to determine how households allocate labor between farm production and rural wage employment.

This study assumes risk-free farm production, and uses the supply/demand framework to explain the allocation of labor. The farm production function exhibits diminishing marginal productivity, thus for a given wage the household's labor demand schedule will have a kink where the wage is equal to the marginal revenue product of labor. Diminishing marginal returns to labor also imply that the first hours of work go to farm production, especially given the very low wages in rural areas in developing

[3] To simplify the analysis the study assumes M is exogenous.

countries. Once the opportunity cost of working on the farm is equal to the wage in the rural labor market, subsequent hours of labor are supplied to the rural labor market.[4] Whether the household's labor allocation to farm production equals the optimal level (L_*^f) depends on the size of labor supply (L^*) relative to the extent of unemployment in the rural labor market.

Figure 1 shows the effect of employment rationing in the rural labor market on the household's labor allocation.

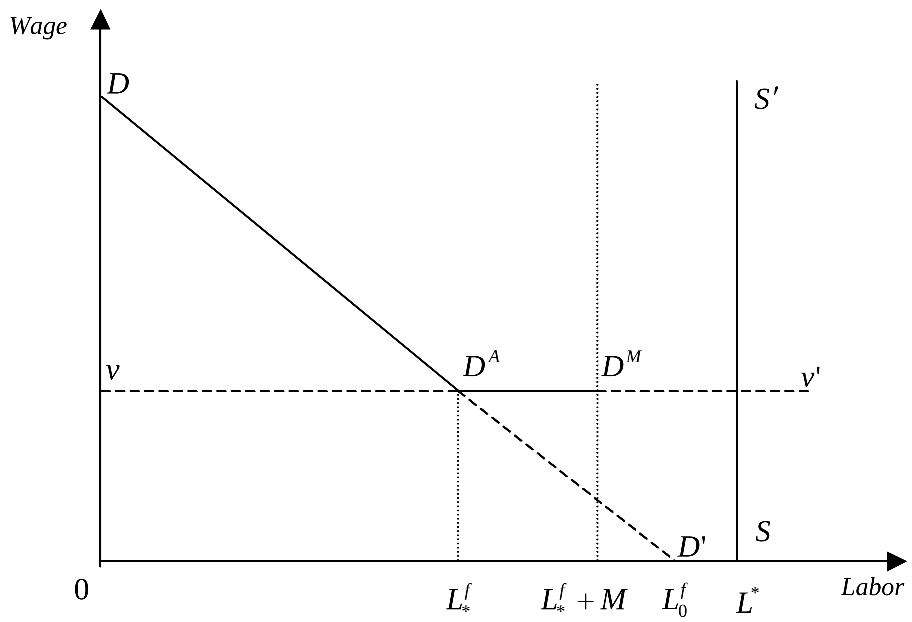

Figure 1: Allocation of household's labor between farm production and wage employment

If M is the maximum rural wage employment that a household gets, the labor demand schedule is DD^AD^M. Since (4) is binding, in Figure 1 the household's labor supply (L^*) exceeds the allocatively efficient level of farm employment plus the maximum level of employment in the rural labor market ($L_*^f + M$). Thus there is unemployed labor in the households, which is equal to $L^* - (L_*^f + M)$.[5] The unemployed labor, however, can contribute to the household's income if used on the farm beyond the

[4] Arayama (1985, 1986) and Nandkeolyar (1991) question this framework. They argue that for some agricultural households the marginal return to the first units of labor hours is higher in rural wage employment. They draw their evidence, however, from farm households in industrialized countries – Japan and the US, respectively.

[5] Other studies observe that wages in rural areas in developing countries do not fall despite high levels of unemployment. Minimum wage legislations, theories of efficiency and nutritional wages, imperfect information and resistance of workers to accepting low wages explain this phenomenon (Drèze & Mukherjee, 1989; Carter & Wiebe, 1990; Dasgupta, 1993; Datt, 1996; Lanjouw & Feder, 2001).

allocatively efficient level. Savadogo et al. (1998) refer to this as de facto agricultural intensification. Whether all the unemployed labor contributes to farm production depends on the level of unemployment relative to the difference between the efficient level of farm employment L_*^f and the point where the marginal productivity of labor on the farm falls to zero L_0^f. In fact, the magnitude of $L^* - (L_*^f + M)$ relative to $L_0^f - L_*^f$ can be used as a crude indicator of unemployment among agricultural households, where different levels of unemployment are defined as follows:

No unemployment $\quad L_*^f + M = L^*$

$$\text{Unemployment} \qquad L_*^f + M < L^* \begin{cases} L^* - M < L_0^f & \text{low unemployment} \\ L^* - M > L_0^f & \text{high unemployment} \end{cases} \qquad (8)$$

In a regime with low unemployment, all of the household's unemployed labor is used productively on the farm through de facto agricultural intensification. This implies that $0 < F_L < w$. Only a fraction of the household's unemployed labor can work on the farm through de facto agricultural intensification in a regime with high unemployment, so there will be 'idle labor' among households that fall into a high unemployment regime – $F_L = 0$.

The above definitions of household-level unemployment assume that households are indifferent as to whether they take up rural wage employment or work on their own farms. However, evidence from other studies shows that household farmers prefer to work on their own farms rather than take up rural labor market jobs, partly to avoid risks associated with the food market (Weiss, 1997; Corsi & Findeis, 2000). The above definitions are therefore imprecise, as they overestimate unemployment in the households. They are used in this study only to demonstrate, theoretically, that the effect on farm investment of increasing the household's rural wage employment depends on the level of unemployment in the households.

3. The household's farm investment perspective

A policy commonly used to achieve demand-side expansions of rural labor markets is introducing public works programs in rural areas or expanding them where they already exist. To understand how such policies affect a household's farm capital stocks, this section adds a simplified farm investment perspective to the household model. In particular, it defines the household's capital stocks at any period $t+1$ as:

$$E_{t+1}^K = (1-\theta)E_t^K + I_{t+1}, \qquad (10)$$

where $\theta \in [0,1]$ is the rate of depreciation of farm capital and I_{t+1} is the amount of investment in the farm in period $t+1$. This section assumes the amount of investment is equal to the household's savings in period $t+1$, so that,

$$I_{t+1} = S_{t+1}. \tag{11}$$

Further, it is assumed that the household's savings in period $t+1$ depend only on income earned in period t, that is,[6]

$$S_{t+1} = S_{t+1}\left[F(E_t^L - l_t^*(\cdot) - M_t, E_t^A, E_t^K, \boldsymbol{\alpha}) + w_t M_t\right], \tag{12a}$$

also expressed as

$$S_{t+1} = F(E_t^L - l_t^*(\cdot) - M_t, E_t^A, E_t^K, \boldsymbol{\alpha}) + w_t M_t - c_t^*(\cdot). \tag{12b}$$

Taking the total differential of (12a) and (12b) and rearranging gives

$$\partial I_{t+1}/\partial M_t = s'\left[w - F_L(l_M^* + 1)\right] \tag{13a}$$

and

$$\partial I_{t+1}/\partial M_t = \left[w - F_L(l_M^* + 1)\right] - c_M^*, \tag{13b}$$

which defines the effect of a demand-side expansion of the rural labor market on farm investment. To simplify the interpretation of (13a) and (13b), the study assumes that

[6] Although this is a strong simplifying assumption, it reflects in many ways some fundamental aspects of households' savings behavior in developing countries, in particular the somewhat myopic behavior. In Zimbabwe, this may be due to high rates of inflation, which have maintained negative real interest rates on savings. This, coupled with very high transaction costs because of institutional failures in rural financial markets, may explain why farm households do not make long-term savings.

leisure is a normal good so that l_M^* (the change in the household's optimal leisure when M_t changes) is positive.

[$w_t - F_L(l_M^* + 1)$] is the household's net marginal income gain from a demand-side expansion in the rural labor market. A marginal demand-side expansion in the rural labor market increases the household's wage income by w_t, but also reduces farm income by $F_L(l_M^* + 1)$. There are two components to the decline in the household's farm income. First, other things being equal, a demand-side expansion in the rural labor market is matched by a decline in farm employment – the factor 1 in (13a) and (13b). Second, an increase in the household's wage employment changes the demand for leisure and thus labor supply – the factor l_M^*. Alternatively, the effect of a demand-side expansion in the rural labor market on farm production can be thought of as having a substitution effect and an income effect. The substitution effect is the commutation of the household's farm employment with rural wage employment when jobs become available on the rural labor market. The income effect is the change in household farm employment when demand for leisure changes because of changes in the aggregate household income.

The sign of $\partial I_{t+1}/\partial M_t$ depends on the unemployment regime the household falls into as follows:[7]

Regime 1: No unemployment – $w = F_L$

In the absence of unemployment, households choose the allocatively efficient level of employment on the farm, where $w_t = F_{L_t}$. From (13a) and (13b), this means that $w - F_L(l_M^* + 1) < 0$ since leisure is assumed to be a normal good. The study assumes that $0 < c_M^* < 1$ (the marginal propensity to consume income from the rural wage income lies between zero and one), thus it is clear from (13b) that a demand-side expansion of the rural labor market will have a negative effect on farm investment. Alternatively, the study can assume in (13a) that s' (the marginal propensity to save) is positive. In this case, a demand-side expansion of the rural labor market also reduces farm investment. Therefore, when there is no unemployment in the households, a demand-side expansion in the rural labor market will lead to 'de-agrarianization'.[8]

Regime 2: Low unemployment – $0 < F_L < w$

In a regime with low unemployment, the marginal productivity of labor on a farm lies between zero and the wage in the rural labor market. The impact of a demand-side expansion in the rural labor market on farm investment in this regime is ambiguous because the net marginal income gain component ($w - F_L(l_M^* + 1)$) can be positive or

[7] See the definitions of unemployment in Section 2.

[8] This could also provide some micro foundations of the process of structural transformation as an economy grows. The early work by Clark (1940) and Kuznets (1966) argues that growth in the economy, a rise in incomes, results in a decline in the share of agriculture in both output and total employment.

negative depending on how close a household is to a regime with no unemployment or high unemployment. When a household is close to a high unemployment regime (when $w/F_L \rightarrow \infty$), a demand-side expansion in the rural labor market is most likely to result in a positive net marginal income gain and thus has a positive effect on farm investment if $w - F_L(l_M^* + 1) > c_M^*$ in (13b). On the other hand, when a household is close to a no unemployment regime (when $w/F_L \rightarrow 1$), a demand-side expansion in the rural labor market is most likely to result in a negative net marginal income gain. As in Regime 1, this leads to 'de-agrarianization'. The same results can be derived for (13a) as long as the assumption that $s' > 0$ is maintained.

Regime 3: High unemployment – $w > F_L$, $F_L = 0$

A regime with 'high unemployment' means that households have 'idle labor'. The net marginal income gain is equal to the wage in the rural labor market, and from (13b) farm investment increases when $w > c_M^*$. Alternatively, focusing on (13a), it is clear that $\partial I_{t+1}/\partial M_t > 0$ when $s' > 0$. In this regime, farm investment increases with the marginal propensity to save and the wage in the rural labor market.

The derivation of (12a) assumes that income from farm production and income from rural wage employment are fungible (and therefore factors out the savings rate). However, a survey of the literature on the fungibility of the household's incomes from different sources suggests otherwise (see Thaler, 1990). Ishikawa & Ueda (1984) argue that the household's fully expected income, such as that from wage employment, is consumed at a much higher rate than the less certain farm income. The difference in savings rates for farm income and wage income suggests that (12a) must be expressed as:

$$\partial I_{t+1} \big/ \partial M_t = s'_w \cdot w_t - s'_F \cdot F_{L_t}(l^*_{M_t} + 1) \qquad (14)$$

where s'_w is the savings rate on rural wage income and s'_F is the savings rate on farm income. Since wage income has a lower savings rate than farm income, the positive effect of a demand-side expansion of the rural labor market on farm investment is dampened. The extent to which this happens is an empirical question that this study addresses in Sections 4 and 5.

4. Empirical specification

The empirical specification of the farm investment model assumes households have no access to capital markets, and farm investment is financed entirely from the household's savings. Additionally, it assumes that savings are a linear function of income and distinguishes between savings rate on rural wage income and farm income. From (12a) this means:

$$I_{t+1i} = s_F \cdot F\left(L_{ti}^f, E_{ti}^A, E_{ti}^K, \boldsymbol{\alpha}_{ti}\right) + s_w Y_{ti}^W, \qquad (15)$$

where Y_{ti}^w is rural wage income ($w_t M_{ti}$) for household i in period t. The specification assumes that $\boldsymbol{\alpha}_{ti}$ represents observable and unobservable plot characteristics – $\mathbf{Z}_{ti}$ and $\boldsymbol{\varphi}_{ti}$, respectively, and thus (15) becomes:

$$I_{t+1i} = s_F \cdot F\left(L_{ti}^f, E_{ti}^A, E_{ti}^K, \mathbf{Z}_{ti}, \boldsymbol{\varphi}_{ti}\right) + s_w Y_{ti}^W. \qquad (16)$$

By taking the first-order linear approximation for the farm production function, the study obtains that

$$I_{t+1i} = \beta_1 L_{ti}^f + \beta_2 E_{ti}^A + \beta_3 E_{ti}^K + \beta_4 Z_{ti} + \beta_5 Y_{ti}^w + \psi_i + \varepsilon_{ti}, \qquad (17)$$

where

$$\psi_i = s_F \cdot \left[\overline{F} - F_L' \cdot \overline{L}_i - F_A' \cdot \overline{E}_i^A - F_K' \cdot \overline{E}_i^K - F_Z' \cdot \overline{\mathbf{Z}}_i - F_\phi' \cdot \overline{\boldsymbol{\varphi}}_i\right]^9 \qquad (18)$$

and

$$\varepsilon_{ti} = s_F \cdot F_\phi' \cdot \boldsymbol{\varphi}_{ti}. \qquad (19)$$

The coefficient $\beta_1 = s_F \cdot F_L'$, $\beta_2 = s_F \cdot F_A'$, $\beta_3 = s_F \cdot F_K'$, $\beta_4 = s_F \cdot F_Z'$ and $\beta_5 = s_w$. The parameter ψ_i represents all time-invariant unobserved household effects, and ε_{ti} is an idiosyncratic error term whose distribution follows that of time-variant unobserved household plot characteristics – $\boldsymbol{\varphi}_{ti}$.

[9] Note that, $\overline{F} = F\left(\overline{L}_i^f, \overline{E}_i^A, \overline{E}_i^K\right)$, where the 'bars' indicate mean values of inputs in the production function.

The marginal product of labor is equal to zero ($F_L' = 0$) when households fall into a high unemployment regime. Therefore, when the savings rate on farm income (s_F) is positive, the above empirical specification can detect whether households fall into a high unemployment regime by testing the null hypothesis that $\beta_1 = 0$. In this case, the model

$$I_{t+1i} = b_2 E_{ti}^A + b_3 E_{ti}^K + b_4 Z_{ti} + b_5 Y_{ti}^w + \psi_i + \varepsilon_{ti}' \qquad (20)$$

is observed. An alternative test for high unemployment will be to compare the distributions of ε_{ti} and ε_{ti}', where identical distributions suggest that households in a sample fall into a 'high unemployment' regime.

Depending on whether ψ_i is correlated with the observed explanatory variables, the estimation of (17) can be carried out using Generalized Least Squares – Random Effects (GLS-RE) or fixed effects models. GLS-RE estimation treats ψ_i as a component of the error term and uses serial correlation in the composite error term ($\psi_i + \varepsilon_{ti}$) to obtain efficient estimates of parameters of the model. However, GLS-RE estimates will only be consistent if the set of observed explanatory variables is exogenous (i.e. if they are not correlated with ψ_i). Where the observed explanatory variables are correlated with ψ_i consistent estimates can be obtained from fixed effects estimation since in the fixed effects model the explanatory variables are allowed to be arbitrarily correlated with ψ_i.

By definition, the components of ψ_i are most likely to be correlated with the observed explanatory variables. For example, it is reasonable to expect that within the sample $\overline{L}_i$, $\overline{E}_i^A$ and $\overline{E}_i^K$ are correlated amongst themselves and with the observed explanatory variables L_{ti}, E_{ti}^A and E_{ti}^K. Thus, the estimation of (20) uses a fixed-effects model. In fact, the Hausman (1978) test for choosing between the GLS-RE and fixed effects model favors the latter.[10]

5. Data

The estimations of the farm investment model in this study use a three-year panel dataset of 359 households drawn from three resettlement areas in Zimbabwe.[11] Data

[10] For example, for model (4) and (5) in Table 4 the Hausman chi-square statistics with nine degrees for choosing between the GLS-RE and fixed effects models are 55.66 and 45.29, which is evidence in favor of the fixed effects model.

[11] The resettlement areas are a result of Zimbabwe's land-reform program soon after independence in 1980. Starting in 1983, Dr Bill Kinsey collected data from a sample of 400 households that resettled on former white-owned commercial agricultural land. The 359 households analyzed in this study are those for which appropriate data is available.

are available for the periods 1983–1987 and 1992–1999. The analysis, however, only uses data collected for the 1996/97, 1997/98 and 1998/99 agricultural seasons. This is the period over which the rural off-farm sector became a more discernable feature of the resettlement areas' economic landscape following the relaxation of laws that restricted resettlement households' participation in off-farm sector activities until the early 1990s.

The resettlement areas covered in the surveys are Mpfurudzi, Sengezi and Mutanda, located in three of the country's five natural farming regions defined according to agricultural potential (see Table 1).

Table 1: Selected characteristics of surveyed resettlement schemes

	Mpfurudzi	**Sengezi**	**Mutanda**
Province	Mashonaland West	Mashonaland East	Manicaland
District	Shamva	Wedza	Makoni
Natural region	II	III	IV
Average annual rainfall	750–1000mm	650–800 mm	450–650 mm
Type of farming	Intensive crop and livestock farming	Livestock farming with marginal cultivation of maize and tobacco	Livestock farming and marginal cultivation of drought resistant crops
Year established	1980	1981	1981
No. of villages	18	8	29
No. of households	563	289	575
Sample households	230	100	70
Area	345 km^2	84 km^2	439 km^2

Dependent variable

The dependent variable, farm investment ($INVESTMT_t$), is the net change in a household's farm capital stock over the three agricultural seasons that are studied. During the 1995 round of surveys, households reported all their productive assets as well as their replacement values. In succeeding years, they only reported the purchase of new assets. Using the data, this study calculates the households' farm capital stocks following guidelines set out in the OECD manual for measuring capital (OECD, 2001). All the values are adjusted to 1999 prices using the Reserve Bank of Zimbabwe gross domestic product (GDP) deflators for the years analyzed. The study calculates farm investment as the difference in net values of households' farm capital stocks between successive years.[12]

Explanatory variables

The factors of production in the household's farm investment model are labor, capital and land. The amount of labor used in farm production is not observable from the surveys and thus a variable 'the number of household members above the age of 15 whose main economic activities are in the household's agriculture' ($AGRIWKERS_{t-1}$)

[12] Thus, farm investments in 1996/97 is the difference between the net values of farm capital stocks in the 1995/96 season and the 1996/97 season; in 1997/98 the difference between 1996/97 and 1997/98, and in 1998/99 the difference between 1997/98 and 1998/99.

is used as a proxy. The study uses value of farm productive assets and inputs held by the households ($FARMCAPITAL_{t-1}$) to measure capital endowments in the previous season. The total area sown by households in the previous season ($CROPAREA_{t-1}$) measures the amount of land used in farm production as there is no evidence that resettlement households in the sample face land constraints in their farm production (Chikwama, 2004).

Dummy variables for resettlement areas are used as proxies for household observable plot characteristics. The dummy variables included in the estimations are Mpfurudzi and Sengezi. Mutanda, the least suited for crop production, acts as a control region. It must be emphasized at this point that the dummy variables for the resettlement areas may also capture other settlement level characteristics that affect farm investment, such as local market prices and transport networks.

The total amount of cash receipts from rural wage employment earned in the previous season ($WAGEINCOME_{t}$) measures a resettlement household's rural wage income. The study ignores payments made to a household in kind from the definition of rural wage income since there is insufficient data to ascertain their values. Over the period that is studied, only about 40% of the households had at least one member engaged in rural wage employment. Although wage employment was varied, the majority (82.6%) of households in the sample had members working as agricultural laborers on farms run by other households or on nearby large-scale commercial farms. The proportions of households that had members in skilled manual employment or artisan jobs were very small – 4.7% and 0.5%, respectively.

The predominantly agricultural nature of rural wage employment among households in the resettlement areas suggests that wages were very low. Over the three years, average household cash income from rural wage employment was Z$756, which represented 4.1% of a household's total income. Further analysis shows that the rural wage income was much higher in Sengezi where it was Z$1,193 and represented 14.9% of a household's total income. In Mpfurudzi it was Z$575 and in Mutanda it was Z$720 – 2.6% and 5.9% of a household's total income, respectively. The variation in the share of rural wage income across the resettlement areas reflects the relatively limited agricultural potential in Sengezi, which compels households to rely more on paid work.

Variables included to capture the effects of a household's socioeconomic characteristics on farm investment are age ($HHAGE_{t}$) and gender ($HHMALE_{t}$) of household heads, total value of the household's livestock wealth ($LVSTVALUE_{t}$), size of the household's cattle herds ($CATTHERD_{t}$), a dummy variable for access to loans for farm production ($FARMLOAN_{t}$), and season dummy variables (YEAR1999) and (YEAR1998).

Table 2 and Table 3 present definitions of variables used in the estimations and their summary statistics.

Table 2: Variable definitions

Variable	Variable definition
$INVESTMENT_t$	Net change in value (Z$) of household farm productive assets at 1999 prices
$CROPAREA_{t-1}$	Total amount of land cultivated by household in previous agricultural season (in acres)
$FARMCAPITAL_{t-1}$	Net value (Z$) of household farm productive assets in the previous agricultural season at 1999 prices
$AGRIWKERS_{t-1}$	Number of household members above age of 15 whose main economic activities are in household's agriculture in previous agricultural season
$WAGEINCOME_{t-1}$	Total cash (Z$) earned by household from working in rural labor market in previous agricultural season at 1999 prices
$LVSTVALUE_t$	Value of household's livestock wealth at 1999 prices in current season
$CATTHERD_t$	Size of household's cattle herd in current season
$HHAGE_t$	Age of household head in current season
$HHSIZE_t$	Size of household in current season
$INPUTSTOCK_t$	Value of input stock from previous seasons
$HHMALE_t$	Dummy: equal to one if household is headed by a male in current season
$FARMLOAN_t$	Dummy: equal to one if household received a loan for farm production in current season
MPFURUDZI	Dummy: equal to one if household is located in Mpfurudzi resettlement scheme
SENGEZI	Dummy: equal to one if household is located in Sengezi resettlement scheme
YEAR1999	Dummy: equal to one for observations in year ending 1999
YEAR1998	Dummy: equal to one for observations in year ending 1998

Table 3: Summary statistics for variables used in estimations

	Variable means							
	1996/97		1997/98		1998/99		1996/97 – 1998/99	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
$INVESTMENT_t$*	4.40	4.91	-4.97	5.93	-0.34	4.53	-0.30	6.42
$CROPAREA_{t-1}$	8.29	3.48	8.43	3.31	8.05	3.68	8.26	3.49
$FARMCAPITAL_{t-1}$*	18.33	17.26	22.72	19.22	17.75	15.86	19.60	17.63
$AGRIWKERS_{t-1}$	4.53	2.59	3.52	1.53	4.04	2.51	4.03	2.30
$WAGEINCOME_{t-1}$*	0.14	0.74	1.36	8.74	0.62	3.16	0.68	5.39
$LVSTVALUE_t$*	42.51	43.67	44.97	46.10	38.70	36.74	42.06	42.39
$CATTHERD_t$	10.49	9.54	10.35	9.75	10.88	9.91	10.57	9.72
$HHAGE_t$	55.22	12.73	56.44	12.46	56.72	12.81	56.13	12.68
$HHSIZE_t$	13.14	6.22	14.70	6.96	15.27	7.18	14.37	6.85
$INPUTSTOCK_t$*	0.79	1.50	0.49	9.08	0.46	1.09	0.58	1.20
$HHMALE_t$	-		-		-		-	

$FARMLOAN_t$	-	-	-	-
MPFURUDZI	-	-	-	-
SENGEZI	-	-	-	-
YEAR1999	-	-	-	-
YEAR1998	-	-	-	-

Note: * Amount in Z$1000 at 1999 prices

6. Estimation results and discussion

Table 4 presents estimation results for the farm investment model. The estimation uses pooled Ordinary Least Squares (OLS) and fixed-effects methods. The pooled OLS estimates will be biased and inconsistent if unobserved effects (ψ_i in model (17) in Section 4) are correlated with the explanatory variables. However, because the fixed-effects method excludes all time-invariant variables, the pooled OLS estimates are important for understanding the effects of time-invariant variables on farm investment. (The t-statistics for each of the coefficients are reported in parenthesis and use the heteroskedasticity-robust-variance estimator.)

Table 4: Regression estimates for determinants of farm investment (in Z$1000)

Explanatory variables	Dependent variable: Household farm investment					
	(1)	(2)	(3)	(4)	(5)	(6)
	Pooled OLS	Fixed effects	Pooled OLS	Fixed effects	Pooled OLS	Fixed effects
YEAR1999	-3.8185***	-4.8788***	-4.4304***	-4.8417***	-4.4615***	-4.9721***
	(11.56)	(10.45)	(13.39)	(11.42)	(13.44)	(12.36)
YEAR1998	-7.9982***	-4.8135***	-8.6590***	-4.5823***	-8.6407***	-4.5452***
	(20.50)	(9.02)	(21.22)	(9.47)	(21.06)	(9.53)
MPFURUDZI	1.3543***	-	0.6097	-	0.5949	-
	(3.74)		(1.35)		(1.34)	
SENGEZI	1.6427***	-	0.5458	-	0.5486	-
	(5.18)		(1.60)		(1.61)	
$CROPAREA_{t-1}$	0.2778***	0.2097**	0.1274**	0.1586**	0.1237**	0.1493**
	(5.84)	(2.05)	(2.51)	(2.11)	(2.41)	(2.03)
$FARMCAPITAL_{t-1}$	-0.0746***	-0.9363***	-0.0809***	-0.9884***	-0.0812***	-0.9891***
	(3.98)	(5.99)	(4.20)	(8.59)	(4.20)	(8.61)
$AGRIWKERS_{t-1}$	0.3403***	0.2466	0.1085	0.2163	0.1070	0.2132
	(4.04)	(1.49)	(1.21)	(1.50)	(1.20)	(1.48)
$WAGEINCOME_{t-1}$	-0.0043	0.0137	0.0017	0.0125	-0.0005	0.0106
	(0.14)	(0.45)	(0.06)	(0.49)	(0.02)	(0.45)
$LVSTVALUE_t$	-	-	0.0053	0.0165	-	-
			(1.26)	(1.48)		
$CATTHERD_t$	-	-	-	-	0.0259	0.1039*
					(1.38)	(1.73)
$HHAGE_t$	-	-	0.0447***	0.0972	0.0449***	0.1028
			(5.09)	(1.34)	(5.14)	(1.41)
$HHMALE_t$	-	-	0.8211**	3.5852***	0.8140**	3.3943**
			(2.26)	(2.58)	(2.23)	(2.51)
$FARMLOAN_t$	-	-	0.5880	0.7214	0.5831	0.6708
			(1.26)	(1.55)	(1.23)	(1.46)
R-Squared	0.3688	0.6388	0.3922	0.6558	0.3924	0.6567
N	1077	1077	1077	1077	1077	1077

Note: *** significance at 1%, ** significant at 5%, * significant at 10%

The coefficient estimates for rural wage income ($WAGEINCOME_{t-1}$) are statistically not different from zero in any of the models. This suggests rural wage earnings have no effect on farm investment in the resettlement areas. From Section 4, this implies that the savings rate on the rural wage income is zero. Other studies note that when income from a particular source is very small relative to total income, it appears as 'current income' in a household's 'mental accounting' and thus it goes to finance consumption (Thaler, 1990). This may explain why rural wage employment fails to improve farm investments in this study. It is also possible that rural wage earnings among the resettlement households are not significantly different from zero and thus have no significant effects on farm investment. However, regarding the latter, further analysis shows that the contribution of rural wage employment to households' total income is statistically different from zero.[13]

Table 5 presents uses of rural wage income among households in the sample. It shows that such income goes largely to financing consumption purchases. Between the 1996/97 and 1998/99 seasons, only a very small proportion of households (2.5%) either saved or spent their rural wage employment earnings on investment related expenditures. The results are consistent with the literature on savings rates on incomes similar to those earned from rural wage employment – they are very low (Thaler, 1990).

Table 5: Uses for household's rural wage employment income (% of households)

	1996/97	1997/98	1998/99	1996/97–1998/99
Uses				
Food purchases	64.2	69.0	57.5	63.4
General purchases for household	47.7	51.9	49.3	49.5
Invested in a business	0.7	.08	0	0.5
Expenditures for children	0	0	0	0
Saved	4.6	0.8	0	1.9
Purchased livestock	0.7	0	0	0.2
Purchased other assets	4.6	3.9	3.4	4.0
Other	10.1	11.9	8.2	10.1

The coefficient estimates on the variable $CROPAREA_{t-1}$ are positive and significant. This suggests that households that sow large areas in the current season will invest more on the farm in the next season. From the specification of the farm investment model, this implies that the savings rate on farm income (s_F) and the marginal productivity of land in farm production (F'_A) are both positive.

$AGRIWKERS_{t-1}$ is positive and significant in the pooled OLS model, but only when variables for households' socioeconomic characteristics are omitted from the estimations. In the fixed-effects results, $AGRIWKERS_{t-1}$ has no effect on farm

[13] The results of this analysis are available to the reader on request from the author.

investment. Given that the savings rate on farm income has already been established as positive, this implies that the marginal product of labor on the farm is equal to zero. From Section 4, this suggests there is high unemployment in the resettlement areas – one of the necessary conditions for rural wage employment to improve farm investment. However, rural wage income fails to raise investment on household farms since it is saved at very low rates.

$FARMCAPITAL_{t-1}$ turns out to have negative and significant effects on farm investments in all the estimations. It would be counterintuitive to interpret this result as suggesting the use of capital on farms beyond the efficient level – until the marginal productivity is negative. The negative coefficient on farm capital could be a result of the actual rate of gross capital formation on farms being lower than the 5% rate of depreciation that this study applies on farm equipment. Therefore, although households that had previously had large farm capital stocks may have had higher levels of gross capital formation, this falls short of offsetting high levels of capital consumption on the farms. This means households were disinvesting on the farm and agriculture was declining in the resettlement areas.

Table 6: Pooled and random-effects Tobit estimates for determinants of expenditure on farm equipment and inputs (in Z$1000)

	Dependent variable: expenditure on farm equipment and farm implement purchases (Z$1,000)			
	Farm equipment		Farm inputs	
Regression estimates	Random effects	Pooled	Random effects	Pooled
YEAR1999	-1.477***	-1.477***	0.449***	0.452***
	(3.33)	(3.33)	(3.45)	(3.46)
YEAR1998	-0.713	-0.713	0.911***	0.915***
	(1.61)	(1.61)	(6.91)	(6.92)
MPFURUDZI	-0.757	-0.757	1.237***	1.231***
	(1.38)	(1.38)	(7.08)	(7.11)
SENGEZI	-0.635	-0.635	0.442**	0.441**
	(1.14)	(1.14)	(2.41)	(2.42)
$CROPAREA_{t-1}$	0.216***	0.216***	0.050***	0.050***
	(3.83)	(3.83)	(3.03)	(3.05)
$WAGEINCOME_{t-1}$	-0.061	-0.061	0.006	0.006
	(1.27)	(1.27)	(0.68)	(0.68)
$FARMCAPITAL_{t-1}$	0.025**	0.025**	0.014***	0.014***
	(2.35)	(2.35)	(4.63)	(4.61)
$AGRIWKERS_{t-1}$	0.064	0.064	0.024	0.023
	(0.63)	(0.63)	(0.84)	(0.81)
$HHAGE_{t}$	0.021	0.021	-0.014***	-0.014***
	(1.43)	(1.43)	(3.34)	(3.35)
$HHSIZE_{t}$	0.043	0.043	-0.014	-0.014
	(1.30)	(1.30)	(1.49)	(1.49)
$LVSTVALUE_{t}$	0.008**	0.008**	0.000***	0.000***
	(1.99)	(1.99)	(6.16)	(6.16)
$HHMALE_{t}$	-0.063	-0.063	-0.063	-0.065
	(0.14)	(0.14)	(0.49)	(0.51)
$FARMLOAN_{t}$	0.378	0.378	0.389***	0.386***
	(0.82)	(0.82)	(3.11)	(3.10)
$INPUTSTOCK_{t}$	-	-	0.126***	0.139***
			(3.01)	(3.34)
Constant	-4.976***	-4.976***	-1.646***	-1.647***
	(4.69)	(4.69)	(5.21)	(5.25)
chibar2	0.000	-	0.500	-
	(1.000)		(0.239)	
Pseudo R^2	.0227		.1328	

Note: *** significant at 1%, ** significant at 5%, * significant at 10%

Table 6 presents estimation results from examining the effects of $FARMCAPITAL_{t-1}$ on components of farm investment – expenditure on farm equipment and expenditure on farm inputs. Since a significant share of households in the sample had no expenditure on farm equipment or inputs, the models for this expenditure can only be linear for a narrow range of the explanatory variables. Thus, Tobit methods are used to estimate these models. An additional variable, 'the value of inputs held as stocks from the previous season' ($INPUTSTOCK_t$), is included in the estimations to control for a household's inputs remaining from the previous season. The results show that $FARMCAPITAL_{t-1}$ has positive and significant effects on components of gross investment. This supports the earlier argument that if households had relatively larger capital stocks in the previous season, they would in turn have relatively higher levels of gross capital formation in the next season. However, the high levels of gross capital formation fail to compensate for the corresponding high levels of capital consumption and thus in Table 4 negative coefficients are observed on $FARMCAPITAL_{t-1}$.[14]

Judging by the households' socioeconomic variables in Table 5 (column 3 to column 6), coefficients of $HHMALE_t$ are positive and significant in all estimations. The coefficients $HHAGE_t$ are positive, but only significant in the pooled OLS estimations (column 3 and column 5). The study notes, however, that age and gender of household head hardly change over the short period that is being analyzed here.[15] In the fixed-effects estimations, these variables are highly collinear with unobserved household effects and thus the pooled OLS estimates are more informative about their effects on farm investments. The age of household heads, very often, is correlated with the age composition of the households. The households with older heads would normally have more adult members, and this has a positive effect on a household's farm investment since it increases the demand for farm produce or the availability of resources to invest in the farm, or both. As for gender, male-headed households generally have better access to resources for financing farm investments than female-headed ones – especially in patriarchal societies in rural Zimbabwe.

Among proxy variables for household wealth, only $CATTHERD_t$ has positive and significant effects on a household's farm investment (column 6). Although $LVSTVALUE_t$ has positive effects, it is not statistically significant. $FARMLOAN_t$ has positive effects on farm investment but the coefficient is not statistically different from zero.

Compared with 1996/97, households' farm investments were significantly lower in the 1997/98 and 1998/99 seasons. In the 1996/97 farming season, Zimbabwe experienced a drought linked to the El Niño Southern Oscillation phenomenon that affected southern Africa. As a result, there was further rationing of cash resources to finance farm investment in successive seasons, especially given that the households

[14] Evidence on resettlement households' income distribution over the period analyzed also shows that *farm* income declined and became more equally distributed. This means the decline in farm income was greater among households that formerly earned more from farming – those that previously had larger capital stocks (Chikwama, 2004).

[15] The age and gender of the household heads only change when the head dies or moves away and someone else takes over the headship role. While such changes do occur, they are only isolated over a short period and do not induce significant unsystematic variations in these variables. Although ages of household heads change every year, this does not cause any unsystematic variation in the variable across time.

rely on farm income to finance future farm investments. During the 1998/99 farming season, farm investments could have recovered following a successful 1997/98 season, but the macroeconomic environment in Zimbabwe started to deteriorate very rapidly.

In the pooled OLS models, estimates of coefficients for the resettlement area dummy variables have the anticipated positive signs given the agro-climatic conditions described in Section 5. However, they are not significant once the estimations control for households' socioeconomic characteristics.

7. Conclusion

This study has examined the extent to which rural wage employment can help households in developing countries to overcome cash constraints on farm investment and thus contribute to agricultural development. Its analytical results show that the effects of rural wage employment on a household's farm investment depend jointly on the ability of rural wage employment to increase a household's savings and the availability of surplus labor in the household. The literature on households' marginal propensities to save incomes from different sources suggests that income such as that from rural wage income is less likely to be saved; instead it goes to financing consumption expenditure (Ishikawa & Ueda, 1984; Thaler, 1990; Carriker et al., 1993). Therefore, although rural wage employment raises households' income it may fail to raise farm investment.

When there is no surplus labor in a household, increased availability of rural wage employment leads to 'de-agrarianization'. A demand-side expansion in the rural labor market would cause the wage to rise and thus a household would allocate more labor to wage employment, away from farm production. However, when there is surplus labor in the household, a demand-side expansion of the rural labor market draws on idle labor and farm investment increases whenever the savings rate on wage income is positive.

Using households' farm level data, the study examines whether the above conditions are met in resettlement areas in Zimbabwe. It finds high levels of unemployment in the resettlement areas, which suggests that households have surplus labor. However, there is no evidence that rural wage employment helps the farm households to overcome cash constraints on farm investment. This is because the savings rate on rural wage employment is not significantly different from zero. Unlike agricultural income that has a positive savings rate, rural wage income goes almost entirely towards financing consumption expenditure. This implies, therefore, that policies to encourage rural households in developing countries to diversify into rural wage employment would not address cash constraints on households' farm investments. Rather, priority should be given to policies that improve institutional credit provision to rural households.

Acknowledgements

Work presented in this paper is part of the author's PhD thesis from Heriot-Watt University, Edinburgh, Scotland. The views presented in this paper are those of the author and not of the Scottish Government.

References

Anderson-Schaffner, J, 1996. Labor markets in developing countries: Policy relevant research agendas and implications for household survey design. World Bank Washington, DC.

Arayama, Y, 1985. Lifetime allocation of farm household. Noringyo Mondai Kenkyu 80, 116–23.

Arayama, Y, 1986. Time allocation of farm household. Journal of Rural Economics 58(3), 139–50.

Bardhan, P & Udry, C, 1999. Development Microeconomics. Oxford University Press, Oxford.

Barrett, CB, Bezuneh, M, Clay, D & Reardon, T, 2000. Heterogeneous constraints, incentives, and income diversification strategies in rural Africa. Report to USAID/BASIC CRSP. Cornell University and Michigan State University, US.

Barrett, CB, Reardon, T & Webb, P, 2001. Nonfarm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics and policy implications. Food Policy 26(4), 315–31.

Bernstein, H, Crow, B & Johnson, H, 1992. Rural livelihoods: Crisis and responses. Oxford University Press, London.

Bhattacharya, PC, 1998. Migration, employment and development: A three-sector analysis. Journal of International Development 10, 899–921.

Bhattacharya, PC, 2002. Rural-to-urban migration in LDCs: A test of two rival models. Journal of International Development 14, 951–72.

Bryceson, DF & Jamal, V, 1997. Farewell to farms: De-agrarianisation and employment in Africa. Ashgate, Aldershot.

Carriker, GL, Langemeier, MR, Schroeder, TC & Featherstone, AM, 1993. Propensity to consume farm family disposable income from separate sources. American Journal of Agricultural Economics, 739–44.

Carter, MR, 1984. Identification of the inverse relationship between farm size and productivity: An empirical analysis of peasant agricultural production. Oxford Economic Papers 36, 131–45.

Carter, MR, 1997. Environment, technology and social articulation of risk in West African agriculture. Economic Development and Cultural Change 45(3), 557–91.

Carter, M & Wiebe, K, 1990. Access to capital and its impact on agrarian structure and productivity in Kenya. American Journal of Agricultural Economics 72(5), 1146–50.

Chikwama, C, 2004. Rural off-farm livelihoods, agricultural development and models of farm households: Evidence from resettlement households in Zimbabwe. PhD thesis, Centre for Economic Reform and Transformation, Heriot-Watt University, UK.

Chuta, E & Leidholm, C, 1990. Rural small-scale industry: Empirical evidence and policy issues. In Eicher, C & Staaz, J (Eds), Agricultural Development in the Third World. Johns Hopkins University Press, Baltimore.

Clark, CC, 1940. Conditions for Economic Progress. Macmillan, London.

Collier, P, 1983. Malfunctioning of African rural factor markets: The theory and a Kenyan example. Oxford Bulletin of Economics and Statistics 45, 141–72.

Collier, P & Lal, D, 1986. Labor and Poverty in Kenya, 1900–1980. Clarendon Press, Oxford.

Corsi, A & Findeis, J, 2000. True state dependence and heterogeneity in off-farm participation. European Review of Agricultural Economics 27(2), 127–51.

Dasgupta, P, 1993. An inquiry into well-being and destitution. Oxford University Press, New York.

Datt, G, 1996. Bargaining Power, Wages and Employment: An Analysis of Agricultural Labor Markets in India. Sage, New Delhi.

Drèze, J & Mukherjee, A, 1989. Labor contracts in rural India: Theories and evidence. In Chakravarty, S (Ed.), The Balance between Industry and Agriculture in Economic Development. Macmillan, London.

Ellis, F, 1998. Household strategies and rural livelihood diversification. Journal of Development Studies 35(1), 1–33.

Ellis, F, 2000. Rural Livelihoods and Diversity in Developing Countries. Oxford University Press, Oxford.

Friis-Hansen, E, 1995. Seeds for African Peasants: Peasants' Needs and Agricultural Research: The Case of Zimbabwe. Nordiska Afrikanstitutel, Uppsala.

Haggblade, S, Hazell, P & Brown, J, 1989. Rural nonfarm linkages in rural sub-Saharan Africa. World Development 17(8), 1173–201.

Hausman, JA, 1978. Specification tests in econometrics. Econometrica 46, 1251–71.

Hazell, P & Haggblade, S, 1993. Farm-non-farm growth linkages and the welfare of the poor. In Lipton, M & Van der Gaag, J (Eds), Including the Poor. World Bank, Washington, DC.

Hazell, P, Ramasamy, C & Rajagopalan, V, 1991. An analysis of the indirect effects of agricultural growth on the regional economy. In Hazell, P & Ramasamy, C (Ed.), The Green Revolution Reconsidered: The Impact of High-Yielding Rice Varieties in South India. Johns Hopkins University Press, Baltimore.

Hill, P, 1982. Dry Grain Farming Families. Cambridge University Press, Cambridge.

Ishikawa, T & Ueda, K, 1984. The bonus payment system and Japanese personal savings. In Aoki, M (Ed.), The Economic Analysis of the Japanese Firm. North Holland, Amsterdam.

Jacoby, H, 1993. Shadow wages and peasant family labor supply: An econometric application to the Peruvian Sierra. Review of Economic Studies 60, 903–22.

Jamal, V, 1995. Structural Adjustment and Rural Labor Markets in Africa. Macmillan, London.

Kinsey, BH, 2002. Survival or growth? Temporal dimensions of rural livelihoods in risky environments. Journal of Southern African Studies 28(3), 615–29.

Kuznets, S, 1966. Modern economic growth: Rate, structure and spread. Yale University Press, New Haven.

Lanjouw, P, 2001. Nonfarm employment and poverty in rural El Salvador. World Development 29 (3), 529–47.

Lanjouw, P & Feder, G, 2001. Rural nonfarm activities and rural development: from experience toward strategy. Rural Strategy Background Paper 4, World Bank, Washington, DC.

Lanjouw, P, Quizon, J & Sparrow, R, 2001. Non-agricultural earnings in peri-urban areas of Tanzania: Evidence from household survey data. Food Policy 26, 385–403.

Lipton, M, 1980. Migration from rural areas of poor countries: The impact on rural productivity and income distribution. World Development 8, 1–24.

Low, A, 1986. Agricultural Development in Southern Africa: Farm Household Theory and the Food Crisis. James Currey, London.

Lucas, REB & Stark, O, 1985. Motivations to remit: Evidence from Botswana. Journal of Political Economy 93(5), 901–18.

Nandkeolyar, S, 1991. An Intertemporal Model of Farm Household: An Investigation of the Production, Investment and Labor Supply Decisions. PhD thesis, Pennsylvania State University, US.

OECD (Organization for Economic Co-operation and Development), 2001. Measuring Capital. OECD Manual, OECD Publications Services, Paris Cedex.

Reardon, T, 1997. Using evidence of household income diversification to inform study of the rural non-farm labor market in Africa. World Development 25(5), 735–47.

Reardon, T, Crawford, E & Kelly, V, 1994. Links between non-farm income and farm investments in African households: Adding the capital market perspective. American Journal of Agricultural Economics 76, 1172–6.

Rosenzweig, MR, 1988. Labor markets in low-income countries. In Chenery H & Srinivasan, TN (Ed.), Handbook of Development Economics, Volume 1. North Holland, Amsterdam.

Savadogo, K, Reardon, T & Pietola, K, 1994. Farm productivity in Burkina Faso: Effects of animal traction and nonfarm income. American Journal of Agricultural Economics 76, 608–12.

Savadogo, K, Reardon, T & Pietola, K, 1998. Adoption of improved land use technologies to increase food security in Burkina Faso: Relating animal traction, productivity and non-farm income. Agricultural Systems 58, 441–64.

Thaler, RH, 1990. Anomalies: Savings, fungibility, and mental accounts. Journal of Economic Perspectives 4(1), 193–205.

Von Braun, J & Pandya-Lorch, R, 1991. Income source of malnourished people in rural areas: Micro-level information and policy implications. IFPRI Working Paper on Commercialization of Agriculture and Nutrition 5, IFPRI (International Food Policy Research Institute), Washington DC.

Weiss, C, 1997. Do they come back again? The symmetry and reversibility of off-farm employment. European Review of Agricultural Economics 24(1), 65–84.

The impact of participation in Diversity Field Fora on farmer management of millet and sorghum varieties in Mali

MELINDA SMALE*

Oxfam America, Washington, DC

(during the implementation of this research, Senior Research Fellow, International Food Policy Research Institute (IFPRI), Washington, DC)

LAMISSA DIAKITÉ

Institut d'Économie Rurale, Bamako, Mali

AMADOU SIDIBÉ

Institut d'Économie Rurale, Bamako, Mali

MIKKEL GRUM

Bioversity International, Maccarese, Rome, Italy

HANNAH JONES

International Food Policy Research Institute (IFPRI), Washington, DC

ISSA SENI TRAORE

Aide au Sahel et à l'Enfance Malienne (ASEM), Hamdallaye, San, Mali

HAMIDOU GUINDO

Institut d'Économie Rurale, Bamako, Mali

Abstract

Malian farmers have been cultivating millet and sorghum for millennia, but they are slow to adopt and develop modern varieties because it is difficult to observe the difference in yields in their fields, given the challenging local growing conditions. Farmer participatory approaches are therefore recommended. This paper applies an instrumental variables method to survey data from Mali to evaluate the impacts of Diversity Field Fora, a type of farmer field school which aims to boost millet and sorghum yields by showing farmers how to manage diverse varieties. Impact indicators are expected and recalled millet and sorghum yields, the total number of unique attributes of millet and sorghum varieties stocked as seed, and the relative

* Corresponding author: msmale@oxfamamerica.org

deprivation of the household farm with respect to these indicators. The findings suggest the project has had results at one of two sites where it has been implemented with the same local leadership and more intensively over a longer time frame.

Keywords: farmer field school; sorghum; millet; landraces; participatory crop improvement; Mali

Les fermiers maliens ont cultivé le millet et le sorgho pendant des millénaires, mais ils ne sont pas pressés d'utiliser et de développer des variétés modernes parce qu'il leur est difficile d'observer une différence dans leurs récoltes étant donné les conditions difficiles de l'agriculture locale. Par conséquent, des approches participatives des fermiers sont conseillées. Cet article applique une méthode de variables instrumentales aux données des enquêtes du Mali pour évaluer les impacts des Champs de Diversité, un type d'école pour fermiers spécialisée dans la culture visant à stimuler les récoltes de millet et de sorgho en apprenant aux fermiers la façon de gérer différentes variétés. Les indicateurs d'impact sont les récoltes de millet et de sorgho que les fermiers attendent et celles dont ils se souviennent, la somme totale des attributs uniques de variétés de millet et de sorgho stockées en tant que graines, et une privation relative pour les exploitations agricoles familiales par rapport à ces indicateurs. Les conclusions suggèrent que le projet a porté ses fruits dans un des deux sites, là où il fut mis en place sous la même direction locale et de manière plus intensive sur une période de temps plus longue.

Mots-clés : *école pour fermiers spécialisée dans la culture ; sorgho ; millet ; variétés traditionnelles ; amélioration des récoltes grâce à la participation ; Mali*

1. Introduction

Malian farmers have accumulated knowledge of millet and sorghum management that spans millennia. Pearl millet and sorghum are known to have been domesticated in multiple locations scattered across the Sahel – then savanna and now the border of the Sahara (Harlan, 1992). Archaeological evidence suggests that economies based on cattle, goats, sorghum and pearl millet were established in this region between 5,000 and 3,000 years ago (Smith, 1998).

Sorghum and millet are still the major crops of Mali, grown by subsistence oriented producers in an agricultural sector that is almost entirely rainfed. National average yields for both crops are less than one ton per hectare (Touré et al., 2006). For the Malian agricultural sector in general, the most binding constraint is the infertility and unsuitable structure of the soil, which in turn impedes moisture retention in zones with limited rainfall. The first devastating drought in a series occurred from 1968 to 1973. The 1982–1993 period was persistently dry and marked by another severe drought from 1982 to 1984. Although there was more rainfall during the 1994–2003 decade, conditions remained far drier than they had been from 1930 to 1965 (Anyamba & Tucker, 2005).

Low yields are often attributed in part to low rates of adoption of improved seed. The most recent draft Agricultural Census reports that the proportion of the area under cereals with improved seed does not exceed 10%. By contrast, 89% of the area is under industrial crops with improved seed (BCRA, 2006). Improved varieties of sorghum have been more widely adopted than improved varieties of millet (BCRA, 2006).

Low adoption rates have in turn been blamed on poor performance of the formal seed system. Despite an ongoing process of seed sector reform, liberalization of seed markets for sorghum and millet has not advanced as rapidly as liberalization of grain markets (Vitale & Bessler, 2006; Diakité et al., 2008). The formal seed sectors for sorghum and millet continue to be largely state run, with some participation by registered farmer cooperatives in multiplying seed. So far, commercialization of farmer-produced seed on more than a pilot scale has posed an insuperable challenge.

Surpassing the performance of farmers' own millet and sorghum landraces is not easy. International and national research centers accelerated breeding efforts from 1973, but new cultivars in the dry savannas made little impact on yields (Sanders et al., 1996). Of the improved varieties that performed well on research stations during that period, few performed better than landraces on farms, for several reasons. To start with, the imported breeding material was unsuitable. Initially, an emphasis was placed on material that was successful in India but was not adapted to the high soil temperatures in the Sahel (Matlon, 1987). Local sorghum and millet varieties also have photoperiodicity, which enables plants to adjust the length of the growth cycle to synchronize with the length of the rainy season. Unfortunately, early selection programs, combined with the effects of drought, led to the gradual elimination of photoperiodism in favor of a range of varieties with short, fixed cycle lengths (Vaksmann et al., 1996).

These shortcomings have since been overcome by international and national breeding programs (Weltzien et al., 2006), but challenges remain. Attaining more than marginal changes in yield is difficult without hybrids, but while promising materials are in the pipeline, none have yet been released for either sorghum or pearl millet. The tremendous variation in climate, soils and production systems means that the degree of plant stress is not only high but also extremely variable within and among fields in close proximity. It takes time for farmers to recognize whether or not a new variety has advantages, which is one argument for farmer participation in testing and evaluation. In addition, decreasing public funds have meant that no breeding is conducted for some agro-ecologies, including that of Douentza, where part of this survey was conducted.

Thus there is no consensus about whether it is lack of effective demand or supply that constrains farmer use of certified sorghum and millet seed. Because the private sector has not taken responsibility for seed distribution, and the public sector has failed to supply improved seed in reasonable quantities, some researchers have also called for strengthening the informal seed system (De Vries & Toenniessen, 2001), but knowledge about how this may be done is only beginning to emerge. Diakité et al. (2005), Bazile (2006) and Weltzien et al. (2006) recommend greater involvement of farmer and community organizations in testing and evaluating improved varieties, coupled with decentralized seed production to reduce the time lag between variety development and adoption, and to reach more remote areas.

The purpose of this paper is to evaluate the impact of one such participatory research effort. Diversity Field Fora, which bear some similarities to farmer field schools, have been launched in Mali on a pilot scale. Given the small scale and brief history of the Diversity Field Fora in Mali, and the statistical approach we use to address possible biases, this analysis focuses on measurable, short-term impacts. The findings shed light on the potential of the approach, but should not be understood as a comprehensive evaluation. The next section summarizes key features of the project and Diversity Field Fora, Section 3 describes the methodology used to evaluate impact, Section 4 interprets the findings, and Section 5 concludes.

2. Project description

Background

The project entitled 'Empowering Sahelian farmers to leverage their crop diversity assets for enhanced livelihood strategies'[1] was funded by the International Fund for Agricultural Development (IFAD) from 2005, coordinated by Bioversity International (previously, the International Plant Genetic Resources Institute, IPGRI) and implemented by a combination of local, national and international organizations. This second phase built on an earlier IFAD-financed project, conducted from 1999 to 2002 in Mali and Zimbabwe, which focused on the development of participatory strategies for on-farm (in situ) conservation of millet, sorghum and other crops. In the interim, IFAD also funded some farmer field school activities in the village of Boumboro, which became the locus of the San/Tominian project site during the second phase.

The goal of the second phase was to support the livelihood strategies of poor farmers in Mali by strengthening their capacity to manage their plant genetic resources. The findings of the earlier project demonstrated the importance of plant genetic resources in the livelihoods of Sahelian farmers. These farmers must be able to meet their staple food needs directly from their harvests in an exceedingly challenging growing environment – or migrate. Well-adapted, diverse local landraces supply them with a range of consumption attributes that are important for preparing local dishes and other end uses, and enable them to match their varieties to heterogeneous moisture and soil conditions and to smooth labor needs over the growing season. Genetic diversity also helps combat the risk of crop losses from biotic and abiotic stresses – the most pressing of which is the variability of rainfall and dry periods at critical points of plant growth.

Diversity Field Fora

In the first phase of the project, several activities were identified to support the management of crop genetic resources in farming communities. The most sustained and comprehensive of these was the notion of Diversity Field Fora (*Champs de Diversité*, or DFF), which built on the concept of farmer field schools.

[1] *« Projet de renforcement des capacités des agriculteurs sahéliens pour une meilleure gestion des ressources phylogénétiques en vue d'améliorer leurs conditions de vie »*

Farmer field schools are an adult education method developed and widely promoted in Asia to teach integrated pest management practices to groups of farmers. While there is considerable variation in form and content, the basic approach involves teaching farmers how to solve problems, set priorities and conduct experimental research through facilitated, hands-on sessions in fields allocated by the farming community for study. Reviews of the evidence for the impacts of farmer field schools suggest that they have not translated into changes beyond local communities, that they tend to favor the more privileged farmers in those communities (Davis, 2006), and that they provide an unlikely basis for sustained, group activity (Tripp et al., 2005). Tripp et al. (2005:1718) express concern that the assessment of farmer field schools has been 'insufficient', and Van der Berg and Jiggins (2007) explain that the methodology for evaluating their impact is still under development, and is characterized by a tension between statistical rigor, which implies a narrow focus, and comprehensiveness, which leads to a diversity of impact indicators and definitions of impact.

In this project, experiments in enhancing knowledge of crop genetic resources were designed and conducted by villagers, with technical support from the project staff, on land distributed for that purpose by villagers. Farmers studied both modern varieties and landraces. As defined in project documents, DFF encompass a combination of educational activities, action research and training. They aim to strengthen the capacity of farmers to understand, analyze and manage their own plant genetic resources, by creating a physical space that facilitates the exchange of ideas among farmers, extension agents and researchers and stimulates farmer experimentation.

The choice of project sites was guided by two fundamental criteria of location: they had to be in the drier savannas and in an area served by an IFAD investment program. Other criteria for village selection included considerations of feasibility, such as road access to the villages, willingness of farmers and leaders to participate in the project, social cohesion and availability of plots for experimental purposes. These criteria generate an obvious, but unavoidable, placement bias that limits the extent to which findings from this study can be generalized.

The two project sites studied here are separated by at least 400 km along a northeast transect on the main road from the capital city of Bamako into the Sahara. Each is located in a unique agro-climatic zone and cluster of ethno-linguistic groups. The village of Boumboro, Commune of Mandiakuy, Cercle[2] of Tominian, Region of Segou, is situated in a semi-arid, tropical climate with annual rainfall levels of 450 to 600 mm, which places it in the Sahelo-Sudanian zone. Variation in vegetative cover is linked to variation in soils, and the landscape is a mosaic of cultivated woodland savanna, heavily populated by shea nut trees (*karité*). Bambara and Bobo are the major ethnic groups at this site.

The village of Petaka, Commune of Petaka, Cercle of Douentza, Region of Mopti, is located in the Sahelian agro-climatic zone, which places it within the 200 and 400 mm isohyets. The zone is composed of a series of rocky plateaus and outcroppings, interspersed with sandy plains, forest cover, cultivated areas and pasture. Villages are

[2] In Mali, a *cercle* is an administrative unit in a region, followed by the categories of commune and village.

located on both the rocky plateaus and the plains. The major ethnic groups in this region are Dogon, Peulh and Sonrhaï.

Location is also related to the development of infrastructure and services, which generally declines with distance from Bamako. Boumboro is well served by a nexus of feeder roads linked to the city of San on the main tarmac road. This site is closest to Bamako and has a higher density of large weekly markets and other types of physical infrastructure. The closest town to Petaka is Douentza, which is commercially linked to a nexus of smaller-scale weekly markets that are dispersed in villages with more restricted physical infrastructure.

3. Methods

Evaluating impacts

The economics literature about evaluating project impacts emphasizes the importance of establishing the appropriate counterfactual. As it is often described, the problem is essentially one of missing data: differences between those who participated in a program and those who did not are observable, but it is not possible to observe the status of project participants in the absence of the project. Consequently, differences due to the influence of the project are easily confused with pre-existing differences between participants and non-participants.

The term 'selection bias' is often applied to the errors in estimation that result from this dilemma. Several types of selection bias occur. When participation is voluntary, factors that influence the likelihood of participation might also affect the outcome of participation. For example, farmers with more income, assets and access to information may be more likely to decide to participate in a project, and attain higher yields whether they participate or not. In other cases, projects or programs deliberately target certain individuals according to their characteristics, such as income. As noted in this case, projects or programs may also be placed in certain zones or sites because of agro-ecology or infrastructural characteristics.

To reduce selection bias, economists have proposed a class of statistical approaches that are commonly referred to as treatment models. Ravallion (1994) categorizes methods for evaluating project impact in terms of five basic approaches. Each approach involves an attempt to construct a treatment and a control group in such a way that they differ only with respect to the program, mimicking an experimental situation. The treatment group represents participants. The control group represents the status of participants in the absence of the program, and is composed in such a way that it matches or represents the test group as closely as possible – with the exception that its members did not participate.

Each of the five statistical techniques has advantages and disadvantages. With the randomized approach, individuals in each group are chosen at random. This technique eliminates statistical bias but is not always acceptable from a political or social standpoint. After selection, individuals may opt not to participate in ways that are non-random. The matching approach is employed to compose test and control groups by estimating the propensity of individuals to participate based on their characteristics. Scores are sensitive to the model used to construct them, and while individuals may be well matched on observable characteristics, they may still differ in those that have not been recorded, or in unobservable characteristics. Bias caused by differences in unobservable characteristics can be addressed through the double-difference approach, which compares treatment and control groups before and after the treatment. This technique eliminates the effects of unobservable characteristics by comparing net changes in variables between two time periods. Reflexive controls compare the same group before and after the program, but ignore changes induced by factors outside the project, which can lead to false attributions. The instrumental variable approach relies on econometric methods to separate the effects of project participation from those of other factors that influence impact. Identifying valid instrumental variables is the major challenge associated with this method. Valid instrumental variables are those that determine participation but only influence impact through participation.

Only the matching and instrumental variables methods are feasible in the context of this study. An experiment could not be designed given that related project activities in Boumboro were already in the process of implementation, from 2002. The data on which the analysis is based were collected as a statistical baseline with a relatively small sample size and single-period survey because of cost constraints, which precluded either the reflexive or double difference approaches. While feasible, the matching approach is not well-suited to analyzing the impact of this project because specific socioeconomic groups were not targeted. In addition, the impact indicators we use, which are based on the management and use of crop genetic resources, are complex. Handa and Maluccio (2007) conclude that matching is more promising as an approach for evaluating easily measured outcomes, such as those related to child schooling and health, than it is for more complex outcomes, such as expenditures.

Sample design

The conceptual approach implies a sample design. The test and the control villages must be as similar as possible with respect to agro-ecology and overarching social, economic and institutional conditions. At each site, both test and control villages are located within the scope of an IFAD project. The same non-governmental organization (NGO) that is active in the test village of a site is also active in the control villages. Ethnic representation is also broadly similar.

An additional feature of this project is that one means of addressing its goal was to introduce farmers to new cultivars (both landraces and improved varieties) and to facilitate their own experimental processes as well as their informal exchange of seed and seed-related information. Customarily, farmers at the project sites depend on their own harvests or other nearby farmers for their millet and sorghum seed (Sperling et al., 2006; Diakité et al., 2008). Seed transactions most often follow ties of kin and clan, and are shaped by social and cultural norms.

An effective DFF would lead to dissemination of materials from the locus villages[3] to other villages where farmers have social ties. Of the two locus villages, Boumboro has the longer and more extensive history of project activities. Here, staff reported that surrounding villages have been influenced by the project through farmer visits to diversity fields cultivated by participants and farmer-to-farmer exchanges of information and seed. In their study of the effects of health programs designed to reduce intestinal worms in school children, Miguel & Kremer (2004) refer to such patterns as 'treatment externalities'.

To address these externalities, we included in the treatment group nearby villages from which farmers had been invited to observe DFF conducted by farmers in Boumboro. Farmers sampled from these villages were not considered to be participants, however. At the Douentza site, all farmers in the treatment group are from the village of Petaka because DFF activities were much more recent and had not yet involved other villages.

In 2006, in the test villages of Boumboro and Petaka, where DFF had been established, all farmers who were active participants were interviewed. Farmers in other influenced villages near Boumboro were sampled. These and the DFF participants constitute the 'treatment' group. Non-participants in both Boumboro and influenced villages were also sampled at random; these constitute the 'control' group. Other than the census of participants, farmers were selected at random until we had a sample of 150 per site, roughly split between control and treatment groups. The control groups include at least three villages per site that had not been invited to demonstrations or field days.

Characteristics of households, farms, seed management, market participation and social capital were collected during 2006, along with yield information by variety. Data on variety attributes and additional yield data were elicited in 2007, when household demographic information was also reconfirmed. Among those households remaining in the sample, there were only a few with significant changes in composition (births and deaths).

Sample attrition, particularly at the San site, and missing responses on some variables, led to an operational sample size for this analysis of 131 farmers (62 treatment; 69 control) at the San site and 149 (56 treatment; 93 control) at the Douentza site, for a total of 280 farmers. Unfortunately, the San sample originally included some farmers from temporary populations who seek permission from longer established groups to resettle in the area. However, we posit that the remaining sample is representative of the more permanent population.

In order to simplify the text below, 'San site' or 'San' is used to refer to the clusters of test and control villages in the Cercles of San/Tominian and the 'Douentza site' or 'Douentza' refers to the parallel clusters in the Cercle of Douentza.

[3] The locus village is the village where the DFF were held. Test villages include these and villages indirectly affected by the DFF.

Impact indicators

Since the goal of the project is to strengthen the management of crop genetic resources, we defined impact indicators related to these resources (Table 1). Stronger management of sorghum and millet varieties is expected to enhance yields and contribute to more diverse crop genetic stocks held in farming communities. We use as indicators 1) expected yields of millet and sorghum in the presence and absence of drought, 2) two-year average yields based on farmer recall, and 3) the total count of the unique production and consumption attributes supplied by the millet and sorghum varieties held in stock at the time of the survey. In addition, we construct measures of relative deprivation based on these variables. An indicator of inequality, relative deprivation, compares the standing of participants relative to others.

Table 1: Definition of impact indicators

Indicator of impact	Definition
Expected yields	$=\sum_i \alpha_i[\delta_i^1((a^1+b^1+c^1)/3)+(1-\delta_i^1)((a^0+b^0+c^0)/3)]$ Where i indexes variety grown, α is the proportion of the crop area planted to the variety, δ is the probability the variety is affected by drought, and a,b and c are the parameters of the triangular distribution (the minimum, maximum and mode) variety yields. The superscript 1 refers to a drought year and 0 to a year without drought. See Hardaker et al. (2004).
Stock of attributes	Count of unique production and consumption attributes of all millet and sorghum varieties held in stock in 2006
Relative deprivation of farm household j with respect to variable Y	$=AD(Y_j)\ P(Y_j)$, where $AD(Y_j)$ is the mean of the variable Y for all farm households in the site with values higher than household j, and $P(Y_j)$ is the proportion represented by those households. Y in this study = expected yield of millet and sorghum, and stock of attributes. See Stark & Taylor (1989) and application by Edmeades et al. (2008).

The first two outcome variables are yield measurements. Expected yields are calculated from triangular distributions. The triangular distribution is often used as a subjective description of a population for which there is only limited sample data, and especially in cases where the relationship between variables is known but data is scarce. Elicited in terms of only three parameters (the minimum, maximum and mode), the triangular distribution is the simplest approximation to a normal distribution and has been widely applied in analysis of farmer decision making under risk (Hardaker et al., 2004). Yields are highly variable from year-to-year in this growing environment, and expected yields have the advantage that they include the history of the farmers' experience with variety. Although these are subjective rather than objective measurements of yields (typically undertaken by weighing the harvest of the crop cut from subplots placed in the field), social scientists often argue that it is the perception of the farmer that drives his or her decisions and is thus the relevant point of reference. This project is focused heavily on farmers' perceptions and knowledge systems. Furthermore, low heritability in this production environment also means that a yield measurement taken in one field or point in time will provide limited information. The survey team also elicited yields that were based on farmers' recall of 2006 and 2007 harvests, but these were not thought to be representative. Yields in Douentza, for example, were extremely low due to locust infestation in some villages. Nonetheless, we have also included these as outcome variables.

Each farmer surveyed was asked, for each variety grown, the minimum, maximum and mode production from all plots under that variety, in years with and without drought. These were divided by plot area to obtain minimum, maximum and mode yields. To estimate the probability of drought stress, farmers were asked to report the number of years they had grown each variety and the number of years of drought stress during that period. The minimum, maximum and most frequent (mode) yields were then elicited for years with and without drought stress. Unconditional expected yields were calculated on the basis of the probabilities of each type of year and corresponding yield estimates. The average unconditional expected yield per farm was calculated by multiplying each variety's unconditional expected yield by that variety's proportion of total crop area (see equation in Table 1).

The third outcome variable, the count of unique production and consumption attributes, is a rough indicator of the perceived 'richness' of traits and uses embedded in the seed stored on the farm at the time of the survey. Farmers were asked to list all millet and sorghum varieties in stock and, for each variety, to list production characteristics and consumption uses. From farmers' responses, a common 'spanning set' of production traits and consumption uses was identified. For millet and then for sorghum, each was counted only once for all varieties stocked by each farm household. This indicator recognizes that subsistence oriented farmers manage a set of varieties to address a complex combination of needs and constraints and that, typically, no single variety meets all their needs (Bellon, 1996). Thus, researchers have hypothesized that farmers with multiple objectives, and particularly those who cannot easily achieve their objectives by trading in markets, will manage more diverse varieties.

Other indicators are based on the concept of relative deprivation – a measure of inequality that has been applied in studies of migrant laborers (Stark & Taylor, 1989). Recently, this concept was applied in a study of hybrid banana adoption by Edmeades et al. (2008). An index was constructed for expected millet yields, expected sorghum yields, and the count of unique variety attributes. The index compares the status of each farm in the sample to all other farms at that project site, and is constructed by weighting the mean of all individuals with higher status by their sample proportion. The larger the number, the greater the relative deprivation of a farm with respect to the characteristic in question.

Econometric model

Instrumental variables regression can be used to explain variation in impact indicators among household farms while controlling for the effects of underlying observable and unobservable factors. Instrumental variables models are special cases of simultaneous regression models in which the causality of the relationship is recursive but the interrelationship among the error terms of the two equations is explicit. In this case, participation affects outcome variables but outcome variables do not affect participation.

The general form of the instrumental variables model is

$$y_i = \mathbf{x_{1i}}\boldsymbol{\theta_1} + \mathbf{x_{2i}}\boldsymbol{\theta_2} + v_i \quad (1)$$

$$z_i = \mathbf{x}_{1i}\boldsymbol{\beta}_1 + y_i\beta_2 + \mu_i \quad (2)$$

where the dependent variables include y, which measures participation, which is an endogenous regressor, and z, which measures the impacts of participation. The vector $\mathbf{x}_1$ represents a set of explanatory variables that influence both participation and impacts, and the vector $\mathbf{x}_2$ includes instrumental variables that explain participation only. The error terms of the equations, v and μ, have means of zero but are correlated.

In this analysis, participation is a dichotomous variable (1=participation, 0 else). Angrist (1999) has shown that in models with dummy endogenous variables and non-negative outcome variables, if the focus of the analysis is to estimate the causal effects of treatment rather than the magnitude of structural parameters, a number of simple strategies, such as two-stage least squares, can be applied. Two-stage least squares produces consistent estimators of the 'local average treatment effect' that are less sensitive to assumptions about functional form than probit or logit (Angrist & Krueger, 2001:77). To improve the efficiency of estimation when heteroskedasticity is present, the generalized method of moments is recommended. Standard diagnostic statistics include tests of a) the endogeneity of the first-stage dependent variable, b) the relevance of the instruments, and c) model identification.

Explanatory variables ($\mathbf{x_1}$) that are common to both the participation and impact equation represent components of the 'asset pentagon', as conceptualized in the project according to the basic livelihoods framework. Human capital is measured in terms of the ratio of economically active persons to the total number of persons in the farm.[4] The age limit for the numerator was arbitrarily set at 12 years of age (adulthood). The total value of livestock and material assets inventoried by the patriarch of the farm is the indicator of farm physical capital. Variables for human capital and farm physical capital were both highly correlated with total land area, suggesting that farm production is based on fairly fixed proportions of these three critical inputs (use of purchased inputs is negligible). Financial capital is represented by per capita cash income, calculated as the total annual expenditures for the farm divided by farm size. In this type of agricultural economy, where savings are in the form of land, livestock or other material assets, eliciting cash expenditure is thought to generate less bias than eliciting income. Enumerators asked the patriarch of the farm to report expenditures by category. The total number of unique associations to which any member of the farm belongs is used as an indicator of social capital.

[4] All human capital variables were inter-correlated (age and education of the household head, number of adult women, number of adult men, number of household members with any education), and the active ratio was the least correlated with other explanatory variables.

Other key explanatory factors are those related to treatment, site and orientation of production. The site variable represents major differences in agro-ecology, ethnicity and social structure, but also in market infrastructure. The treatment variable controls for indirect effects of the project in the locus villages and other test villages.[5] Specialization of production in one target crop rather than another is expressed in the share of target crop area allocated to millet. Target crops include millet, sorghum and cowpea. The target crop area was summed over plots where these crops were the principal or sole crop. Very few plots were planted to cowpea as the principal or sole crop.

The last variable related to orientation of production is the number of markets in which household members buy or sell millet or sorghum. Since these are not commercial farming operations, no certified seed is sold in markets, and other purchased inputs are rarely used, the count of markets has no direct relationship to expected yields. In a commercial farming system, a direct relationship between variety choice (a modern variety, for example) and market involvement might be expected. Nevertheless, we hypothesize that market involvement may relate to the desire of household members to procure and test new materials in DFF, either because they sell, or because they are food-deficit, i.e. they produce less than their food requirements, or because there are unobservable factors that cause a farmer to seek information, whether in village markets or in project activities.

Instrumental variables ($\mathbf{x_2}$) are those that affect participation but have no effect on impacts other than through participation, and are uncorrelated with the error terms of the impacts equation. These variables are 1) whether or not the patriarch has a Koranic education (instead of, or in addition to, public school attendance), and 2) the binary variable 'treatment' which controls for the indirect effects of the project. The variable 'Koranic education' is not highly correlated with any of the outcome variables (correlation coefficient range from -.02 to 0.37).

Explanatory variables are defined in Table 2, and means and standard deviations of explanatory variables are shown in Table 3. The null hypothesis that variable means are equal between test and control villages cannot be rejected at the 0.05 level of significance, although p-values are significant at the 0.10 level for total asset value and number of markets at the San site, and millet share and number of markets at the Douentza site. Additional comparisons of sample characteristics in the project baseline document[6] indicate few statistically significant differences with respect to human, farm physical, financial and social capital between the treatment and control groups, with important differences between sites.

Differences in outcome variables by treatment and control group are pronounced at the San site for all outcome variables except average millet and sorghum yields in 2005–06. At Douentza, statistically significant differences are apparent only for expected millet yields and relative deprivation with respect to millet yields. The 2005

[5] Although it would have been preferable to estimate separate models for the direct and spillover effects of the DFF on farmers, it was not possible for the survey team to identify the individual farmers from other villages who had procured seed when visiting Boumboro. This would have required close monitoring over time by a member of the DFF, which must be built into the original research design.

[6] Available from the authors.

season was an outlier due to heavy locust infestation, and these farmers (primarily Dogon) are quintessential millet growers.

Table 2: Definition of explanatory variables

Explanatory variable	Conceptual variable	Operational variable
Site	Agroecology, Ethnicity, Market infrastructure	0=San site 1 =Douentza site
Treatment	Experimental design	0=Control village 1=Treatment village
Active ratio	Human capital	Ratio of economically active persons (>12 years of age) to total number of persons in the production unit
Asset value	Farm physical capital	Total value of livestock and material assets (FCFA)
Millet share	Specialization in millet vs other target crops	Proportion of total crop area planted to millet
Per capita income	Financial capital	Total expenditures per year in FCFA in production unit divided by total number of persons
Association membership	Social capital	Total number of associations in which a members of production unit participates
Markets	Market participation	Number of markets in which members of production unit sell or purchase millet or sorghum
Koranic education	Instrument	Whether or not the patriarch of the production unit has a Koranic education, either instead of or in addition to a public school education

FCFA = *Franc Communauté Financière Africaine*

Table 3 : Comparison of means, explanatory and outcome variables, by site, treatment and control villages

	San site			Douentza site		
	Mean (control village)	Mean (test village)	P-value	Mean (control village)	Mean (test village)	P-value
Explanatory variables						
Active ratio	0.596	0.633	0.3896	0.5970	0.620	0.2434
Total asset value	737700	879888	0.0928	485178	558901	0.4588
Millet share	0.529	0.523	0.6785	0.867	0.891	0.0772
Per capita income	33892	37435	0.5098	23814	26130	0.2260
Association membership	1.55	1.64	0.1326	2.26	2.07	0.3669
Markets	1.16	1.27	0.0880	2.33	2.04	0.1081
Koranic education	0.318	0.258	0.4541	1.92	2.44	0.1543
Outcome variables						
Expected millet yields	331	609	0.0001	107	57.3	0.001
Expected sorghum yields	607	874	0.0141	194	216	0.5081
Mean millet yield 2005–6	908	1114	0.7106	766	799	1.000
Mean sorghum yield 2005–6	771	795	0.9926	241	314	0.589
Stock of attributes	25.8	30.0	0.0001	25.9	25.9	0.1305
Relative deprivation (expected millet yields)	200	364	0.0001	72.81	40.5	0.0001
Relative deprivation (expected sorghum yields)	535	433	0.0147	134	126	0.4995
Relative deprivation (stock of attributes)	18.5	11.4	0.0001	13.6	15.7	0.1665

Note: P-value refers to difference of means t-test for active ratio and Kruskall-Wallis test for other variables.

4. Findings

Instrumental variables regression

The findings of the first-stage regressions are presented in Table 4 for millet growers.[7] As expected, given the higher rates of participation at the San site and longer project involvement, location at the Douentza site reduces the chances that a farm household will include a DFF participant. Economically active human capital in the farm household bears no direct relationship to DFF participation. Farm households that are wealthier in terms of farm physical capital are more likely to participate. Greater specialization in millet than in sorghum increases the chances a farmer will participate in a DFF. This may be because millet was more widely grown at both sites, or because fewer improved millet varieties than sorghum varieties have been released at the sites – with the result that farmers are in search of new materials and means of improving their own. Social capital positively influences participation – these farm households have a propensity to engage in local associations. Similarly, participants sell or purchase the target crops in a larger number of markets than non-participants, other factors being held constant. The first-stage regression is the same regardless of the outcome variable, since DFF included both sorghum and millet related activities.

Table 4: First stage regression results, determinants of DFF participation

	Coefficient	Standard error	P value
site	-0.2126	0.0452	0.0000
active ratio	-0.0183	0.0918	0.8420
asset value	0.0000	0.0000	0.0870
millet share	0.2546	0.0909	0.0060
per capita cash income	0.0000	0.0000	0.1090
numassoc	0.1068	0.0242	0.0000
markets	0.0739	0.0177	0.0000
edukoran	-0.0035	0.0060	0.5620
treatment	0.2701	0.0357	0.0000
constant	-0.1664	0.1105	0.1330
		Test statistic	P value
F(9, 255)		12.06	0.0000
Centered R2		0.30	
Uncentered R2		0.37	
Root MSE		0.25	
Shea partial R2 of excluded instruments		0.18	
F(2, 255) of excluded instruments		28.8	0.0000
Anderson canonical correlation coefficient		48.9	0.0000

[7] Probit and linear probability first-stage regressions are shown in the Appendix. They are similar with respect to statistically significant causal factors (site, total asset value, per capita cash income, markets).

Second-stage regression results for each impact indicator are displayed in Table 5. Taking into account underlying observable and unobservable factors that predict participation in DFF, participation influences all the outcome variables with a high degree of statistical significance except average recalled sorghum yields.

Location at the Douentza site offsets estimated yield impacts, but augments stock of attributes and further reduces relative deprivation. The pervasive harshness of this environment, combined with the social structure of the Dogon, is a strong leveler of inequality. The greater degree of self-reliance makes it important for farmers to stock the varieties with attributes that span both their consumption and production needs.

While being wealthier enhances the likelihood of participation, it has a negative impact on yields per hectare once participation has been considered – perhaps because these factors are associated with a more extensive operation and crop area that are harder to manage as effectively. As expected, specialization in millet positively influences recalled millet yield, and negatively influences recalled sorghum yield and the total stock of attributes. Per capita cash income is statistically significant only in the recalled millet yield regression, and social capital is insignificant in explaining outcomes once DFF participation has been taken into account. Market participation is significant only in the expected millet yield and deprivation model.

In all except the expected millet yield and attribute stock regressions, the null hypothesis of homoskedasticity was rejected and the regression was estimated with GMM (Generalized Method of Moments), so that robust standard errors are reported. The Hausman test led to rejection of the hypothesis that DFF participation is exogenous in all cases except the regressions for expected sorghum yields and the relative deprivation with respect to the stock of attributes. The Anderson canonical correlation statistic based on the first-stage regression is highly significant, supporting the relevance of the instruments. The values of the Sargan statistic (in the presence of homoskedasticity) or Hansen J statistic (in the presence of heteroskedasticity) results in failure to reject the null hypothesis for each of the outcome equations. Thus, the instruments in the first-stage regression are uncorrelated with the error term in the second-stage regression. Rejection of the null hypothesis would have indicated either a misspecification of the second-stage regression or an invalid instrument.

Three caveats are important to remember in interpreting findings. The first is that while we assert that use of longer-term, subjective yields is more reliable than actual recent yields, it is evident that these variables measure primarily changes in perceptions. They are not highly correlated with average yields based on recall, which is to be expected given the year-to-year variability in rainfall conditions and the fact that 2005 was an outlier season at the Douentza site. In Boumboro, the project has been operational from 1999 – but not so in Petaka – where project impacts are not evident for either expected and recalled yields once other variables have been taken into account.

In addition, it is important to recognize that unobservable factors may explain both the decision to participate and yield expectations, which would contribute to an upward bias in estimated coefficients. Finally, the wide variation in average yields among villages, combined with the fact that most long-term participants live in Boumboro, means that the coefficient on DFF impact transmits a strong village-specific effect.[8] As recommended by Angrist, it is the significance of the coefficient (causality) rather than its magnitude that should be emphasized when interpreting the regression results.

[8] The descriptive statistics shown in the Appendix suggest that while the only explanatory variable that differs between Boumboro and other treatments villages is market participation, most of the outcome variables differ significantly.

Table 5: Second stage regression, impact of farm household participation in DFFs on crop genetic resource management

	Expected millet yield	Expected sorghum yield	Mean millet yield (2005-06)	Mean sorghum yield (2005-06)	Stock of attributes	Relative deprivation (millet)	Relative deprivation (sorghum)	Relative deprivation (attributes)
cd	364	543	463	321	5.76	-205	-212	-8.01
	0.0000	0.0040	0.0040	0.1060	0.0060	0.0000	0.0020	0.0220
site	-331	-683	-539	-409	1.61	-347	-462	-5.27
	0.0000	0.0000	0.0000	0.0000	0.1780	0.0000	0.0000	0.0010
active ratio	-155	-162	-39.0	2.660	0.949	63.9	47.2	-0.154
	0.1190	0.3380	0.8680	0.9850	0.6310	0.1090	0.4020	0.9570
asset value	-0.0000388	-0.0000558	-0.0004070	-0.0001920	-0.000000253	0.0000167	0.0000179	0.000000367
	0.1000	0.0800	0.0000	0.0000	0.5580	0.1050	0.1000	0.4510
millet share	-55.0	209	659	-682	-8.21	33.5	-74.1	10.2
	0.6270	0.2660	0.0040	0.0000	0.0000	0.4650	0.2230	0.0000
per capita cash income	0.000937	-0.001096	-0.004770	-0.001720	0.0000317	-0.000414	0.000197	-0.0000810
	0.4410	0.5820	0.0640	0.2570	0.1950	0.3770	0.7510	0.0250
numassoc	14.70	29.5000	5.80	-1.1400	-0.075	-5.47	-7.94	0.321
	0.4100	0.3270	0.9210	0.9730	0.8790	0.4620	0.4460	0.6490
markets	-36.9	-11.1	72.3	13.6	-0.390	18.2	2.1	0.272
	0.0110	0.6210	0.1700	0.6600	0.3780	0.0060	0.8070	0.6490
Hansen J statistic	1.4430	0.032	0.7010	0.594	0.908	0.988	0.154	0.958
or Sargan test	P=0.2246	P=0.8573	P=0.4024	P=0.441	P=0.3407	P=0.3203	P=0.6950	P=0.3278
Uncentered R2	0.6548	0.6284	0.6902	0.7081	0.958	0.8511	0.8774	0.7848
Hausman test	P= 0.00296	P=0.14226	P=0.05202	P=0.07029	P=0.05583	P=0.00013	P=0.04773	P=0.26991

Note: In all cases except mean yields and stocks of attributes, the null hypothesis of homoskedasticity was rejected and the regression was estimated with GMM. For GMM, standard errors are robust. P-values are reported under the estimated regression coefficient.

Post-estimation

Figure 1 compares the cumulative density function (cdfs) of predicted values of expected millet yields. Predicted values account for selection bias by incorporating the effects of factors that explain why DFF participants participate. As compared to the mean values shown in the regression results, the cdfs portray project impacts over the full range of predicted values. The graphs support the hypothesis that conditions are less risky for farmers in treatment villages than in control villages. For every predicted value of expected millet yields, the probability that a farm household will harvest less is lower in treatment villages than in control villages. Expected millet yields in treatment villages dominate in the first-order stochastic sense: any farm household in a treatment village, whether neutral to or averse to risk, is better off.

Similar comparisons were made for predicted values of relative deprivation with respect to expected yields. In this case, households are worse off with higher values, which imply greater relative deprivation. A cdf lying entirely to the left for test as compared to control villages suggests that the probability of being more deprived relative to other households is always less in test villages – an improvement in status. The cdfs of relative deprivation dominate stochastically in the first-order sense for expected millet yields in treatment villages of the San site (Figure 2), but not for expected sorghum yields; at the Douentza site, they dominate for sorghum yields in the treatment villages but not for expected millet yields. For both crops at both sites, from the perspective of farmers' yield expectations, conditions are not always better in treatment villages than in control villages.

Figures were not reported for all outcome variables because of space limitations. In the case of sorghum, while the cdfs for expected yields do not cross, they lie tangent to one another at some points. First-order stochastic dominance is also evident for the total count of attributes. For each predicted total count of attributes, the chances are smaller that a farm household in a treatment village will possess fewer attributes.

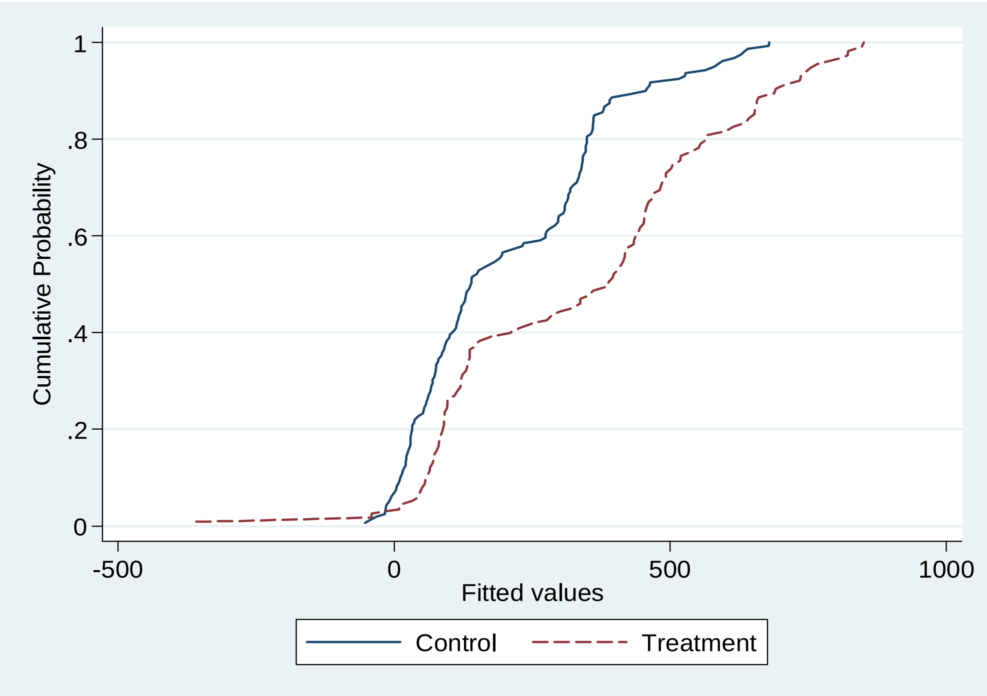

Figure 1: Cumulative density function of predicted values of expected millet yields, in the presence and absence of drought

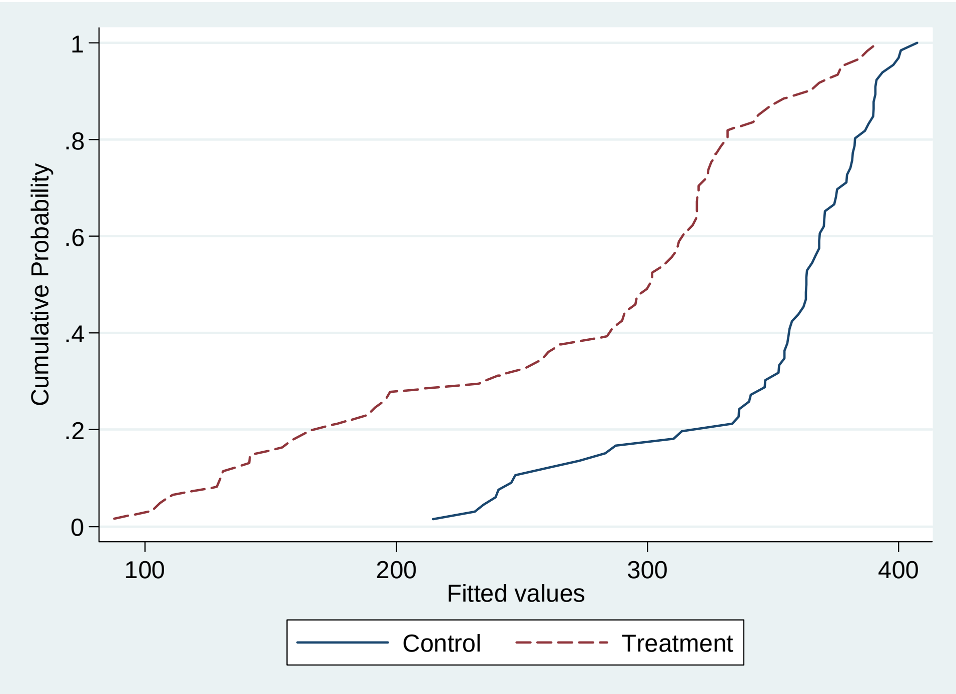

Figure 2: Cumulative density function of predicted values of relative deprivation with respect to expected millet yields in the San site

5. Conclusions

Despite continued progress in breeding improved sorghum and millet varieties, and the gradual process of seed sector reform, adoption rates are often considered to be relatively low in Mali – a nation whose rural population has depended on sorghum and millet for millennia. Some researchers have recommended more involvement of farmers themselves in evaluating and disseminating promising varieties. This paper has evaluated a pilot effort to involve farmers through Diversity Field Fora, which build on the concepts of farmer field schools. DFF aim to strengthen farmers' capacity to manage diverse millet and sorghum varieties, thereby improving productivity.

Regression results concur with previous assessments of farmer field schools in demonstrating that participants in DFF are more likely to possess more social and farm physical capital than non-participants. Participation has a positive impact on expected sorghum and millet yields, recalled millet yields and the stock of variety attributes, enhancing participants' standing relative to other farmers at the project site with respect to these impact indicators. Farmers in treatment villages are better off in terms of expected yields and attribute stocks throughout the range of predicted values. A significantly higher probability of participation at the San site, combined with the regression and descriptive results, indicates that the impacts of DFF were principally observed at this site in the village of Boumboro, where local field staff have been continuously engaged for a much longer period of time. However, inequality with respect to millet and sorghum crop genetic resources appears to be greater at the San site than at Douentza.

Two policy points with respect to DFF emerge from these findings. First, long-term commitment to fostering local leadership and capacity is likely to be a key factor in achieving impacts with this type of extension approach. The local leader at the San site has been trained on site and abroad, and has established his own NGO in surrounding communities. Second, for precisely this reason, it will be difficult to scale up impacts from one village to many without supporting, coordinated investments by national public institutions and donors.

This analysis has focused on statistical methods that reduce bias and the measurable, immediate impacts of DFF. Although farmer selection bias associated with participation has been taken into account, the findings cannot be generalized to other communities unless these communities conform to the criteria used to select sites. A more comprehensive evaluation, which would require the application of additional analytical approaches over a longer time period and in multiple locations – is not yet justified by the amount of funds invested in DFF nationwide. As more participatory research efforts are undertaken in Mali, however, these evaluations will be crucial.

References

Angrist, J, 1999. Estimation of limited-dependent variable models with dummy endogenous regressors: Simple strategies for empirical practice. MIT Economics Department Working Paper 99-31. Massachusetts Institute of Technology, Cambridge, US.

Angrist, JD & Krueger, AG, 2001. Instrumental variables and the search for identification: From supply and demand to natural experiments. Journal of Economic Perspectives 15(4), 69–85.

Anyamba, A & Tucker, CJ, 2005. Analysis of Sahelian vegetation dynamics using NOAA_AVHRR NDVI data from 1981–2003. Journal of Arid Environments 63, 596–614.

Bazile, D, 2006. State-farmer partnerships for seed diversity in Mali. Gatekeeper Series 127. IIED (International Institute for Environment and Development, London.

BCRA (*Bureau Central du Recensement Agricole*), 2006. *Recensement General de l'Agriculture 2004. Ministère de l'Agriculture, Ministère de l'Élevage et de la Pêche, Ministère du Plan et de l'Amenagement du Territoire*, Bamako, Mali.

Bellon, M, 1996. The dynamics of crop infra-specific diversity: A conceptual framework at the farmer level. Economic Botany 50(1), 26–39.

Davis, K, 2006. Commentary. Farmer field schools: A boon or bust for extension in Africa? Journal of International Agricultural and Extension Education 13(1), 91–6.

De Vries, J & Toenniessen, G, 2001. Securing the harvest: Biotechnology, breeding and seed systems for African crops. CAB International, Wallingford, UK.

Diakité, L, Sidibé, A & Diakité, S, 2005. *Enquête pour l'identification des paysans semenciers dans les zones et villages propices à la production semencière. Rapport final. Services d'Experts pour les Ressources Naturelles et l'Environnement au Sahel* (SERNES), Bamako, Mali.

Diakité, L, Sidibe, A, Smale, M & Grum, M, 2008. Seed value chains for sorghum and millet in Mali: A state-based system in transition. IFPRI Discussion Paper 749. IFPRI (International Food Policy Research Institute), Washington, DC.

Edmeades, S, Nkuba, J & Smale, M, 2008. The impact of hybrid use on the vulnerability and deprivation of smallholder banana growers in Tanzania. Manuscript. Environment and Production Technology Division, IFPRI (International Food Policy Research Institute), Washington, DC.

Handa, S & Maluccio, JA, 2007. Matching the gold standard: Evidence from a social experiment in Nicaragua. Manuscript. Department of Economics, Middlebury College, Middlebury, Vermont, US.

Hardaker, J, Huirne, R, Anderson & Lien, G (Eds), 2004. Coping with Risk in Agriculture. CAB International Publishing, Wallingford, UK.

Harlan, JR, 1992. Crops and Man. Second edition. American Society of Agronomy and Crop Science Society of America, Madison, Wisconsin, US.

Matlon, P, 1987. The West African semi-arid tropics. In Mellor, JW, Delgado, CL & Blackie, MJ (Eds), Accelerating Food Production in Sub-Saharan Africa. Johns Hopkins University Press, Baltimore.

Miguel, E & Kremer, M, 2004. Worms: Identifying impacts on education and health in the present of treatment externalities. Econometrica 72(1), 159–217.

Ravallion, M, 1994. Poverty comparisons. Fundamentals of Pure and Applied Economics. Volume 56. Harwood Academic, Chur, Switzerland.

Sanders, JH, Shapiro, BI & Ramaswamy, S, 1996. The Economics of Agricultural Technology in Semiarid Sub-Saharan Africa. Johns Hopkins University Press, Baltimore, Maryland, US.

Smith, BD, 1998. The Emergence of Agriculture. Freeman, New York.

Sperling, L, Weltzien, E, Sangaré, MB, Shines, JSc, Salla Boré, S, Bamba, A, Traoré, Keita, CO, Ag Hamada, M, Ballo, M, Sangaré, F, Kanouté, M, Sanogo, B, Guindo, H, Konta, B, Sanogo, S, Traoré, A, Loeffen, M & Dembélé, A, 2006. Seed System Security Assessment (SSSA), Douentza, Northern Mali. Final Report (June). Catholic Relief Services, Mali, and Partners, Bamako, Mali.

Stark, O & Taylor, E, 1989. Relative deprivation and international migration. Demography 26, 1–14.

Touré, A, Sanogo, O, Diakité, L & Sidibé, A, 2006. Program for Africa's Seed Systems (PASS). Country Report: Mali, *Institut d'Économie Rurale*, Bamako, Mali.

Tripp, R, Wijeratne, M & Hiroshini Piyadasa, V, 2005. What should we expect from farmer field schools? A Sri Lanka case study. World Development 33(10), 1705–20.

Vaksmann, M, Traoré, SB & Niangado, O, 1996. *Le photopériodisme des sorghos Africains*. *Agriculture et Développement* 9, 13–18.

Van der Berg, H & Jiggins, J, 2007. Investing in farmers: The impacts of farmer field schools in relation to integrated pest management. World Development 35(4), 663–86.

Vitale, J & Bessler, B, 2006. On the discovery of millet prices in Mali. Papers in Regional Science 85(1), 139–62.

Weltzien, E, Christinck, A, Touré, A, Rattunde, F, Diarra, M, Sangaré A & Coulibaly, M, 2006. Enhancing farmers' access to sorghum varieties through scaling up participatory plant breeding in Mali, West Africa. In Almekinders, C & Hardon, J (Eds), AgroSpecial 5: Bringing Farmers Back into Breeding: Experiences with Participatory Plant Breeding and Challenges for Institutionalisation. Agromisa Foundation. Wageningen, The Netherlands.

Appendix: Additional statistics

A. Probit and ordinary least squares regressions explaining DFF participation

Determinants of DFF participation, probit regression

Variable	Coef.	Std. Err.	P>z
Site	-1.8142	0.4309	0.0000
Active ratio	0.0240	0.7109	0.9730
Total asset value	0.0000	0.0000	0.0820
Millet share	0.7461	0.7198	0.3000
Per capita cash income	0.0000	0.0000	0.1060
Association membership	0.2040	0.1726	0.2370
Markets	0.5497	0.1402	0.0000
Koranic education	0.0439	0.0481	0.3610
Constant	-0.6355	0.8339	0.4460
Number of obs	265		
LR chi2(8)	37.67		
Prob > chi2	0.0000		
Pseudo R2	0.2274		
Log likelihood	-63.970473		

Determinants of DFF participation, ordinary least squares regression

	Coef.	Std. Err.	P>t
Site	-0.2320	0.0498	0.0000
Active ratio	0.0387	0.1011	0.7020
Total asset value	0.0000	0.0000	0.0190
Millet share	0.1133	0.0983	0.2500
Per capita cash income	0.0000	0.0000	0.0540
Association membership	0.0368	0.0247	0.1370
Markets	0.0783853	0.0195788	0.0000
Koranic education	0.0040264	0.0065585	0.5400
Constant	0.1531561	0.112754	0.1760
Number of obs	265		
F(8, 256)	5.26		
Prob > F	0		
R-squared	0.1412		
Adj R-squared	0.1143		
Root MSE	0.2756		

B. Comparison of means of outcome and explanatory variables, locus and other treatment villages, San site

	Boumboro	Other treatment	P-value
Expected millet yields	660	529	0.3318
Expected sorghum yields	1014	673	0.0258
Mean millet yield 2005-6	999	791	0.0263
Mean sorghum yield 2005-6	822	705	0.3598
Stock of attributes	30.74	29.46	0.032
Relative deprivation (expected millet yields)	273	310	0.3308
Relative deprivation (expected sorghum yields)	418	535	0.0258
Relative deprivation (stock of attributes)	9.26	13.20	0.0389
Explanatory variables			
Active ratio	0.609	0.651	0.3776
Total asset value	1135337	859970	0.4561
Millet share	0.605	0.518	0.1281
Per capita income	36657	38035	0.8703
Association membership	1.89	1.63	0.1418
Markets	2.04	1.04	0.0001
Koranic education	0.556	0.029	0.1203

Poverty, property rights and land management in Uganda

PATRICK BIRUNGI[1]

United Nations Development Program (Uganda Country Office), Kampala, Uganda

RASHID HASSAN

Centre for Environmental Economics and Policy in Africa (CEEPA), University of Pretoria

Abstract

This study investigates the impact of poverty, social capital and land tenure on the adoption of soil fertility management (SFM) and conservation technologies in Uganda. Considering four land management technologies (fallowing, terracing and inorganic and organic fertilizers), the study estimates a multinomial logit model to link farmers' characteristics to the choice of technologies. The findings show that investments in land management are driven by factors such as land tenure security, level of poverty and participation in community organizations (social capital), and, most importantly, that household level poverty reduces the probability of adoption of most of the technologies, while social capital and land tenure security increase it. The findings suggest that more efficient government efforts to reduce poverty would enhance the adoption of SFM technologies. Other policies that would enhance the adoption of sustainable land management practices are infrastructure development, tenure security through a more efficient system of land registration, and investment in and use of social capital institutions.

Keywords: poverty; social capital; property rights; soil fertility management; Uganda

Cette étude examine l'impact de la pauvreté, du capital social et du régime foncier dans l'adoption d'une gestion de la fertilité du sol (SFM, en anglais) et les technologies de conservation en Ouganda. Prenant en considération quatre technologies de la gestion foncière (jachère, étagement, engrais biologiques et inorganiques), l'étude évalue le modèle logit multinomial pour relier les caractéristiques des fermiers au choix des technologies. Les conclusions montrent que les investissements en gestion foncière sont guidés par des facteurs comme la sécurité du régime foncier, le degré de pauvreté, la participation au sein des organisations communautaires (capital social) et, d'abord et avant tout, que le degré de pauvreté des ménages réduit la probabilité de l'adoption de la plupart des technologies, alors que le capital social et la sécurité du régime foncier l'augmentent. Les conclusions suggèrent que de plus amples efforts de la part du gouvernement, efficaces et destinés à réduire la pauvreté, encourageraient l'adoption de technologies SFM. D'autres politiques sont capables d'inciter l'adoption de pratiques en matière de gestion

[1] Corresponding author: pbirungi2000@yahoo.com

foncière durable, à noter le développement de l'infrastructure, la sécurité foncière, grâce à un système plus efficace d'enregistrement des terres, et l'investissement dans et l'utilisation des institutions du capital social.

Mots-clés : *pauvreté ; capital social ; droits liés aux biens immobiliers ; gestion de la fertilité du sol ; Ouganda*

1. Introduction

Reduction of poverty has become the major challenge for the international community over the coming few years (World Bank, 2001). While poverty is a global phenomenon, it is particularly pervasive in sub-Saharan Africa where in 2005 more than 46% and 70% of the population lived on less than $1 and $2 a day, respectively (World Bank, 2005; UNDP, 2005). As in many other developing countries, poverty is one of the major challenges facing policy makers in Uganda. Although poverty (measured in head count below the poverty line) in Uganda fell from 56% in 1992 to 35% in 1999, more recent estimates indicate a national increase in poverty by four percentage points, reaching 39% in 2002 (Appleton & Sewanyana, 2003). About half of the rural households are classified as poor and poverty is more acute for crop farmers than for those practicing non-crop agriculture such as livestock and fishing (GoU, 2004). The fact that agriculture remains the key economic activity in Uganda (contributing 40% of the GDP, 85% of export earnings and 80% of employment) and the main source of livelihood for the vast majority of the population, especially in the large subsistence segment, indicates the importance of this sector's performance for food security and poverty reduction (NEMA, 2002; GoU, 2004).

Recent studies show that the major cause of low incomes in the rural areas of Uganda has been stagnating agricultural production (Deininger & Okidi, 2001). One major constraint to improved agricultural productivity in Uganda, as in many of the sub-Saharan African countries, is land degradation. There is ample evidence of widespread land degradation in Uganda (NEMA, 2002; GOU, 2004), as manifested in high rates of soil nutrient loss, soil erosion and compaction and water logging (Nkonya et al., 2004). More than 85% of water contamination and more than 15% of biodiversity and topsoil loss have been attributed to soil erosion and deforestation. The extent of land degradation, however, varies between regions. For instance, while the Arua and Kapchorwa districts experience relatively fewer soil and land degradation problems, other districts such as Kabale and Kisoro are heavily eroded (GOU, 2002). The densely populated and extensively cultivated highlands and the overstocked cattle corridors of the severely de-vegetated drylands of Uganda are identified as the most fragile ecosystems in the country (NEMA, 2002).

Exacerbated by poverty, a fast growing population, and inadequate tenure security, land degradation poses a threat to national and household food security and the overall welfare of the rural population in Uganda (Nkonya et al., 2004). Poverty acts as a constraining factor on households' ability to invest in mitigating land degradation. Poor households are unable to compete for resources, including high quality and productive land, and are hence confined to marginal land that cannot sustain their practices, which perpetuate land degradation and worsen poverty

(Kabubo-Mariara, 2003). The poor and food insecure households may contribute to land degradation because they are unable to keep land in fallow, make investments in land improvements or use costly external inputs (Reardon & Vosti, 1995). Due to credit constraints, inadequate tenure security and weak institutions, poverty can also cause farmers to take a short-term perspective, which limits incentives for long-term investments in soil conservation (Holden et al., 1998; Shiferaw & Holden, 1999).

Access to land, the key productive asset for the rural population in Uganda, is extremely limited because of the very high fertility and population growth rates, which averaged 3.5% per annum over the past decade. Moreover, high degrees of uncertainty over tenure security prevail under some of Uganda's key land tenure systems, and this reduces incentives to adopt land conservation practices and protect soil fertility by terracing, fallowing and applying manure and fertilizers. For example, the bulk of the land in Uganda is under customary systems governed by communal rules enforced by elders and clan leaders.

Land degradation and poverty are bound to continue worsening in Uganda unless sound intervention policies are put in place. Designing appropriate intervention programs requires proper understanding of the factors that determine the adoption of land conservation practices. It is of particular interest to understand the role of poverty in land degradation. Given that government resources for eradicating poverty are limited, a more rational and effective way to allocate them would be to target specific aspects of poverty that critically limit farmers' ability to invest in soil conservation and enhance agricultural productivity. In order to design appropriate interventions, it is also necessary to gain a deep understanding of the social and institutional environments in which policies to curb land degradation operate, as this will facilitate knowledge transfer, encourage cooperation, help to coordinate and monitor public service delivery, and make it easier for farmers to access credit, markets and farm equipment, all of which are important for the adoption and diffusion of agricultural technologies (Isham, 2000; Nyangena, 2005).

In Uganda, studies investigating how social structures that vary from one village to another may affect the diffusion and adoption of SFM and conservation technologies are nonexistent despite the country's wide heterogeneity of tribal affiliations and formal and informal social organizations. Very few attempts have so far been made to investigate the impact of poverty on adoption of soil conservation practices in Uganda. The only available studies (Nkonya et al., 2005) used binomial decision models, which treat adoption choices as being independent of each other and exclude useful economic information contained in the interdependence and simultaneity of adoption decisions.

Applying a multinomial logit model (MNL) to a dataset purposefully collected by the World Bank and the International Food Policy Research Institute (IFPRI), this study analyzes the way land tenure, property rights, social capital and poverty influence the adoption of SFM and conservation practices.

A short survey of relevant theoretical and empirical literature is presented in Section 2. Section 3 presents the analytical model used to estimate the determinants of SFM conservation practices in Uganda. Section 4 presents the data and discusses the choice of variables and the empirical implementation of the MNL model. The MNL results are presented in Section 5, and Section 6 concludes the paper with some policy implications.

2. The links between poverty, tenure security, social capital and land degradation

Poverty and land degradation

Many theoretical studies have conceptualized the connection between rural poverty and the environment as a 'downward spiral', where poverty coupled with population growth leads to environmental degradation and thus worsens poverty (Mink, 1993, Dasgupta, 1995; Scherr, 2000). Some of these studies argue that poor farmers are limited to labor intensive production strategies, as they are unable to use external inputs such as fertilizers to support sustainable intensification and are therefore destined to contribute to natural resource degradation. Even if it is endowed with some natural resource assets, a household may be poor if it lacks complementary assets such as human capital or physical and financial farm assets. Some attempts have been made to study the factors that reduce poverty and at the same time increase investment in land management (Reardon & Vosti, 1995; Duriappah, 1996; Barrett et al., 2005).

Land tenure security and investment in SFM and conservation

The literature also tends to suggest that incomplete property rights reinforce the poverty-environment vicious circle (Duriappah, 1996; Scherr, 1999). This line of argument proposes that insecure tenure rights to land and the imperfect functioning of land markets tend to reduce incentives for smaller rural farmers to invest in long-term conservation measures such as planting trees, and soil conservation structures.

Surprisingly, despite the well-thought-out theoretical links, the results from studies that link tenure security and investment in conservation activities are contradictory and inconclusive. For instance, some studies argue that tenure security is not important for conservation (Migot-Adholla et al., 1991; Brasselle et al., 2002), while others argue that it is (Shiferaw & Holden, 1999; Place & Otsuka, 2000; Gabremedhin & Swinton, 2003; Kabubo-Mariara, 2003). These different findings are the result of differences either in the way tenure security is measured or in the way the relationship between investments and tenure rights is empirically conceptualized (Kabubo-Mariara, 2003).

Social capital and investment in SFM and conservation

Empirical studies show that greater social capital, acquired through information sharing and collective action, results in improved adoption and diffusion of technology (Isham, 2000; Nyangena, 2005). Reid and Salmen (2000) found that while all aspects of trust were important in explaining the level and extent of technology adoption, social cohesion in the form of attending social and church meetings and cooperating in providing public goods creates the ground for external inputs such as agricultural extension to take root. Women's organizations were also found to be consistent diffusers of information and technology (Reid & Salmen, 2000).

Isham (2000) showed that in rural Tanzania tribal-based social affiliations act as a form of social capital in the adoption decision. A household in a community within which there is greater ethnic homogeneity and greater member participation in decision making is more likely to adopt.

Other factors that influence investment in SFM and conservation

Many studies have found a strong association between household assets and environmental problems (Reardon & Vosti, 1995; Swinton & Quiroz, 2003). The characteristics of the natural resource base are also important in explaining the pathway from poverty to environmental degradation. The agricultural landscape for each different agro-ecological zone is typically quite distinct, and each therefore carries its own distinct risks of resource degradation, and offers its own distinct opportunities for intensification, diversification and land improvement (Scherr, 2000). In Ethiopia, for example, Bekele and Drake (2003) found that slope of the plot has a positive correlation with all types of conservation structures.

Lack of farmer awareness has been found to be a significant constraint to positive adaptation to environmental changes and also to making appropriate investments in land for conservation, especially where degradation effects are not easily observable and where resource degradation is not a local concern but a negative externality to outsiders, such as downstream sedimentation (Scherr, 2000).

3. The analytical framework for modeling farmers' decisions to adopt SFM and conservation practices

Many previous studies have modeled the decision to adopt conservation technology as a binary choice process (Place & Otsuka, 2000; Kabubo-Mariara, 2003, 2005; Pender et al., 2004; Nkonya et al., 2005). Using such bivariate models excludes useful economic information contained in the interdependent and simultaneous adoption decisions (Dorfman, 1996; Wu & Babcock, 1998; Bekele & Drake, 2003). It is therefore important to treat adoption of soil conservation measures and adoption of soil nutrient enhancing technologies as multiple-choice decisions made simultaneously.

Multinomial probit (MNP) and multinomial logit (MNL) models provide alternative approaches to analysis of land management decisions because such decisions are usually made jointly. They can also be used to evaluate the alternative combinations of management practices, as well as individual practices (Wu & Babcock, 1998). MNP models are, however, not commonly used, since it is difficult to compute the multivariate normal probabilities for any dimensionality higher than two, i.e. more than two (bimodal) choices (Greene, 2000).

In the present study, farmers' adoption of land management practices is modeled using an MNL model. Zilberman (1985) used this model to examine choices of irrigation technologies in California and Bekele and Drake (2003) used it to examine choices of soil and water conservation practices in Ethiopia.

Households' adoption of soil conservation and nutrient enhancing technologies can be evaluated on the basis of alternative decision choices, which can easily be linked to utility. According to Greene (2000), the unordered choice model could be motivated by a random utility framework, where for the i^{th} household faced with *j* technology choices, the utility of technology choice *j* is given by

$$U_{ij} = \beta_j^{'} X_{ij} + \varepsilon_{ij} \tag{1}$$

where U_{ij} is the utility of household *i* derived from technology choice *j*, X_{ij} is a vector of factors that explain the decision made, and $\beta_j^{'}$ is a set of parameters that reflect the impact of changes in X_{ij} on U_{ij}. The disturbance terms ε_{ij} are assumed to be independently and identically distributed. If farmers choose technology *j,* then U_{ij} is the maximum among all possible utilities. This means that

$$U_{ij} > U_{ik}, \forall k \neq j \tag{2}$$

where U_{ik} is the utility to the i^{th} farmer from technology k. Equation (2) means that when each technology is thought of as a possible adoption decision, farmers will be expected to choose the technology that maximizes their utility given available alternatives (Dorfman, 1996). The choice of *j* depends on X_{ij}, which includes aspects specific to the household and plot, among other factors. Following Greene (2000), if Y_i is a random variable that indicates the choice made, then the MNL form of the multiple choice problem is given by:

$$\Pr ob(Y_i = j) = \frac{e^{\beta_j^{'} X_{ij}}}{\sum_{j=1}^{j} e^{\beta_j^{'} X_{ij}}}, j = 0, 1, 2. \tag{3}$$

Estimating equation (3) provides a set of probabilities for *j*+1 technology choices for a decision maker with characteristics X_{ij}. The equation can be normalized by assuming that $\beta_0 = 0$, in which case the probabilities can be estimated as

$$\Pr ob(Y_i = j) = \frac{e^{\beta_j' X_{ij}}}{1+\sum_{K=1}^{j} e^{\beta_j' Z_{ij}}} \text{ and:} \qquad (4)$$

$$Pr\, ob(Y_i = 0) = \frac{1}{1+\sum_{j=1}^{j} e^{\beta_j' X_{ij}}} \qquad (5)$$

Normalizing on any other probabilities yields the following log-odds ratio:

$$\ln\left[\frac{p_{ij}}{p_{ik}}\right] = x_i'(\beta_j - \beta_k) \qquad (6)$$

In this case, the dependent variable is the log of one alternative relative to the base/reference alternative.

The coefficients in an MNL model are difficult to interpret, so the marginal effects of the explanatory variables on the choice of alternative management strategies are usually derived as (Greene, 2000)

$$m_j = \frac{\partial P_j}{\partial x_i} = P_j\left[\beta_j - \sum_{k=0}^{j} P_k \beta_k\right] = P_j\left[\beta_j - \overline{\beta}\right] \qquad (7)$$

The sign of these marginal effects may not be the same as the sign of respective coefficients as they depend on the sign and magnitude of all other coefficients. The marginal probabilities measure the expected change in the probability of a particular choice being selected with respect to a unit change in an independent variable (Long, 1997; Greene, 2000). Also important to note is that in an MNL model the marginal probabilities resulting from a unit change in an independent variable must sum to zero, since the expected increases in marginal probabilities for certain options induces a decrease for the other options within a set.

4. Data and empirical methods

This study used two datasets. First, we had access to data from a survey conducted in 2002 by IFPRI in collaboration with the World Bank and the Uganda Bureau of

Statistics to provide an understanding of the links between natural resource management and poverty in Uganda. The IFPRI survey covered rural areas in eight districts in Uganda: Arua, Iganga, Kabale, Kapchorwa, Lira, Masaka, Mbarara and Soroti (Table 1). The districts were chosen to represent a wide range of social, economic, environmental and institutional circumstances. The IFPRI survey collected information on plot and household characteristics as well as these households' participation in agrarian associations.

The IFPRI data, however, did not cover key variables such as education and gender and did not collect information on household expenditure. This information was therefore obtained from a second dataset, the 2000 Uganda National Household Survey (UNHS), since the two datasets had common identifiers. The UNHS covered all districts surveyed under the IFPRI project. A sample of 9,711 households was randomly selected from 972 enumeration areas (565 rural and 407 urban) in proportion to the population density of each district. The IFPRI data on the other hand covered a subsample of 851 households from 123 enumeration areas (all rural, given the focus of their study). Many of the observations had missing values and a large number of questionnaires were left out since they had incomplete or unreliable information (a high percentage of outliers), with the result that there were only 2110 usable data units.

4.1 Choice of explanatory variables and model implementation

Controlling for the effect of poverty

This study uses the level of per capita household expenditure to construct appropriate measures of poverty. This is one of the most widely used approaches to measuring poverty (Geda et al., 2001; Mukherjee & Benson, 2003). To compute this variable the study uses data from the 2002 Uganda National Household Survey (UNHS). The per capita household expenditure is expressed in real terms, normalized using 1989 as the base year.

Using the generated per capita household expenditure, the households in the sample are classified into two categories (poor/non-poor) using the standard national poverty lines (calculated on the basis of the people's food calories requirements adjusted by a mark-up for non-food requirements). Different poverty lines are used for different regions to take into account differences in staple foods consumed, tastes and consumption preferences, and price differences (Appleton & Sewanyana, 2003).

The literature postulates that poverty and adoption of various land management technologies are reciprocally interrelated. On the one hand, poverty determines the level of adoption of particular technologies. On the other, however, the level of adoption may have implications for land productivity and consequently for poverty. Introducing poverty on the right-hand side therefore introduces an endogeneity problem. Treatment of endogeneity in non-linear models cannot be pursued using the instrumental variables approach, as commonly used in linear models. Two-stage least-squares probit and logit models have been widely used to correct for endogeneity in the literature (Lee et al., 1980; Hassan, 1996) as described in Section 4.2.

Controlling for social capital impacts

The study uses one critical component of social capital, namely participation in agrarian associations such as production, supra-community and social groups. Membership of these associations has been widely used in the literature to measure social capital (Putnam et al., 1993; Narayan & Pritchett, 1999; Grootaert, 1999; Alesina & La Ferrara, 2000; Grootaert et al., 1999). Putnam et al. (1993) argue that participation in social groups may lead to transmission of knowledge and may increase aggregate human capital and the development of trust, which improves the functioning of markets.

Since different social organizations play different roles in the lives of rural communities, it is important to establish which particular institutions may be more related to adoption of agricultural technologies and which particular technology. To achieve this objective, a dummy variable (membership in production institutions) is used in the adoption model.

Controlling for the impacts of land tenure

It is hypothesized that insecure land tenure is a disincentive for farmers to invest in land improvements and conservation and therefore decreases agricultural productivity. In this study, land tenure measured by the right to bequeath land to next generations (an indicator of long-term tenure security) is used as the control for the effect of land tenure.

Other explanatory variables

Examination of the literature on adoption of soil conservation and fertility enhancing technologies in Africa suggests that choices among the different technologies depend on household attributes (level of poverty and asset endowments, access to information, household size, age and education of household head), institutional factors (land tenure, social capital) and plot level characteristics (state of soil nutrients, slope, farm size) (Shiferaw & Holden, 1998; Pender et al., 2004; Kabubo-Mariara, 2005; Nkonya et al., 2005). The set of regressors that were chosen, their definition, measurement and expected direction of influence on adoption are given in Table 1.

Table 1: Definition of variables used in the empirical analysis and key attributes of the surveyed sample (n=2110)

Variable	Definition	Values/measure	Expected sign
Sex	Sex of household head	1=Male and 0=Female	+/-
Bequeath	Right to bequeath land to next generations	1=yes and 0=no	+
Dist Res	Distance from plot to residence	Kilometers	-
Dist MKT	Distance from plot to nearest market	Kilometers	-
Nutrient prob.	Perceived nutrient deterioration of plot	1 if observed deterioration and 0 if not	+
Non-farm inc.	Non-farm income	Uganda shillings	+
Agric extension	Access to agricultural extension information	Dummy (1=if household had access to an extension agent in 2002, 0=if not)	+
Age of hh head	Age of household head	Number of years	+/-
Educ of hh head	Education of household head	Number of years in school	+
Hh size	Size of household	Number of household members	+
Livestock	Livestock ownership in tropical livestock units (TLUs)	Average TLU for Uganda is cow =0.9, ox =1.5, calf =0.25, sheep or goat =0.2	+
Number of parc	Number of parcels a household owns	Number	+
Agro-climate	Agro-ecological zones based on rainfall patterns	Agro-ecological zones, (Dummy: bimodal rainfall =1 and unimodal rainfall=0)	+/-
Memb to pdn org	Membership of production associations	1=yes and 0=no	+

Descriptive statistics of key attributes of the study sample (sample size n=2110)

District	Population (people/km^2)	Head count (% below poverty line)	Agro-climate	Land management practices (% farmers)					Livestock assets in TLU	Non-farm income ($/annum)
				Fallow	Organic fertilizer	Inorganic fertilizer	Terracing	None (no adoption)		
Masaka	151	35.9	Bimodal	10.40	18.04	01.22	00.92	64.41	1.66	323
Iganga	288	56.2	Bimodal	12.96	12.15	01.39	00.00	66.74	1.13	259
Kapchorwa	67	13.3	Unimodal	00.00	28.85	15.72	16.98	34.32	3.28	222
Soroti	50	47.6	Unimodal	80.00	05.00	05.00	00.00	06.87	7.19	81
Arua	82	67.3	Unimodal	46.90	04.40	07.56	04.26	34.37	2.93	161
Lira	70	66.7	Unimodal	86.21	00.00	00.00	00.00	10.42	4.11	245
Kabale	250	37.6	Bimodal	35.84	07.78	02.41	19.88	30.22	1.45	186
Mbarara	88	37.9	Bimodal	12.71	24.82	01.37	09.28	49.36	5.34	318
All	92	44.7		27.9	12.61	04.14	09.50	42.64	2.53	229

4.2 Specification of the land management decisions MNL model

An MNL model for land management practices was estimated using data collected from all the eight districts. The complete choice set (response variable) for the MNL model gives 16 factorial combinations of possible outcomes (Table 2). However, it is clear from Table 1 that farmers who combine different soil conservation and fertility management practices represent a very small percentage (an average of 3.43%). This meant that modeling all possible combination outcomes results in very small sample units in many of the combination outcomes. We therefore decided to group all choices other than only fallowing (outcome 1), only using organic fertilizers (outcome 2), only using inorganic fertilizers (outcome 3), only terracing (outcome 4), or none, i.e. no adoption (outcome 16) into one other alternative choice outcome (i.e. all possible combinations of choices – outcomes 5 to 15 in Table 2). Accordingly, the set of outcomes for the response variable was limited to six land management technology choices: (i) fallowing only (ii) using only organic fertilizer (iii) using only inorganic fertilizer, (iv) only terracing (v) using a combination of SFM practices and (vi) continuous cropping without any land management (i.e. no adoption of any of the land fertility management practices – outcome 16 of Table 2, which is used as the reference choice for comparing the marginal effects of other choice outcomes). 'Terracing' here means using stones (*fanya juu)*, or bench (*fanya chini*) types of terraces. 'Organic fertilizer' means mulch, animal manure, household refuse, biomass transfer and cover crops. 'Inorganic fertilizer' means N fertilizer (urea, ammonium nitrate), P fertilizer (SSP, DAP and TSP) and composite fertilizers (NPK). These technologies were chosen because they are commonly used in Uganda as land management practices (see Table 2) or are being promoted for use through the country's extension system.

Table 2: Alternative outcomes as possible combinations of land fertility management practices defining modeled decision choices (where 1 means that the practice is adopted and 0 that it is not)

Possible outcomes	Technology bundle			
	Fallowing	Organic fertilizer	Inorganic fertilizer	Terracing
1	1	0	0	0
2	0	1	0	0
3	0	0	1	0
4	0	0	0	1
5	1	1	1	1
6	1	1	1	0
7	1	1	0	0
8	1	1	0	1
9	1	0	1	1
10	1	0	0	1
11	1	0	1	0
12	0	1	1	0
13	0	1	0	1
14	0	1	1	1
15	0	0	1	1
16	0	0	0	0

Before empirical estimation of the MNL model, the independent variables were scrutinized for possible correlations since multicollinearity is a common problem with such datasets. Distance to the nearest all-weather road and distance to the nearest seasonal road were found to be strongly correlated with distance to markets. Also, main source of income was correlated with non-farm income; and ethnic dominance and origin of farmers' association (whether local or foreign) showed a strong correlation with membership. These variables were therefore excluded from the analysis.

A two-stage econometric process was used to correct for endogeneity caused by the endogenous regressors being correlated with the error term. In the first stage, a poverty model was estimated using the probit[2] maximum likelihood procedure. In the second stage, fitted values of the endogenous variable (poverty) were computed using the first stage parameter estimates and used as regressors (instruments) in the MNL adoption model to estimate the determinants of technology adoption.

The other problem common in cross-section data analysis is heteroscedasticity. This study used White's heteroscedasticity consistent covariance matrix (HCCM) to correct for heteroscedasticity of an unknown form (White, 1980). The study specifies the Huber-White sandwich estimator to correct for heteroscedasticity. Long (1997)

[2] Logit estimation is also appropriate for analysing binary response data. There is therefore no apriori reason to prefer probit over logit estimation (Gujarati, 1995; Greene, 2000)

argues that the HCCM provides a consistent estimator of the covariance matrix of the slope coefficients in the presence of heteroscedasticity and can be used to avoid its adverse effects on hypothesis testing even when nothing is known about the form of heteroscedasticity.

MNL models are very commonly used for estimating polychotomous choice models because of their relative ease of estimation and interpretation. However, the MNL imposes a rather restrictive assumption known as the irrelevance of independent alternatives (IIA) assumption. This assumption implies that the ratio of the utility levels between two choices, say organic fertilizer and inorganic fertilizer, remains the same irrespective of the number of choices available. The Hausman test (Hausman & McFadden, 1984) was used to check whether the IIA assumption is violated. The test results show that we cannot reject the null hypothesis of independence, suggesting the use of MNL is appropriate. Stata software (StataCorp, 2005) was used to implement the econometric analysis.

5. Results of the multinomial analyses of determinants of adoption of land improvement and conservation practices

This section discusses the results of the econometric analyses of the links between poverty (measured as members of the population falling below the poverty line), property rights,[3] social capital[4] and the land management practices of farmers in Uganda. The estimated MNL coefficients showing marginal effects and P-levels are presented in Table 3.

[3] Security (insecurity) of tenure or property rights means having (not having) the right to bequeath land to the next generation.
[4] Access (no access) to social capital means being (not being) a member of a production association.

Table 3: Marginal effect for the MNL for adoption of land management technologies (sample size=2110)

Variable	Fallow		Organic fertilizer		Inorganic fertilizer		Terracing		Terracing+SFM		Non-adopters	
	ME	P-level	ME	P-level	ME	P-level	ME	P-level	ME	P-level	ME	P-level
Sex	0.0916***	0.0000	0.0114	0.3560	-0.0166*	0.0530	0.0232***	0.0010	0.0051	0.5930	-0.1146***	0.0000
Bequeath	0.0447**	0.0470	0.0417***	0.0010	-0.0111*	0.0590	0.0038	0.5090	0.0010	0.9310	-0.0800***	0.0030
Dist res	0.0110***	0.0040	-0.0407***	0.0000	0.0015***	0.0000	0.0011**	0.0280	0.0027***	0.0040	0.0244***	0.0020
Dist MKT	0.0094***	0.0070	0.0002	0.9350	-0.0044***	0.0000	0.0002	0.7840	0.0038***	0.0000	-0.0092**	0.0200
Nutrient prob.	0.0304	0.1060	0.0095	0.3430	-0.0046	0.2260	-0.0034	0.5270	-0.0110	0.2380	-0.0210	0.3350
Non-farm inc.	0.0588***	0.0000	-0.0088	0.1400	-0.0058**	0.0240	-0.0423***	0.0000	-0.0347**	0.0220	0.0329*	0.0660
Agric extension	0.0061	0.7840	0.0105	0.3800	0.0157**	0.0150	0.0110	0.1240	-0.0160	0.1510	-0.0274	0.2920
Age of hh head	0.0020**	0.0140	-0.0008*	0.0760	-0.0006***	0.0080	-0.0003	0.2010	0.0004	0.4740	-0.0008	0.4170
Educ of hh head	0.0004	0.9080	0.0007	0.6700	-0.0006	0.2800	-0.0014	0.1250	0.0013	0.4750	-0.0004	0.9190
Hh size	-0.0116***	0.0090	0.0072***	0.0040	0.0052***	0.0000	0.0010	0.4260	-0.0013	0.6560	-0.0006	0.9190
Poverty	0.2375***	0.0060	-0.1525***	0.0010	-0.0815***	0.0000	-0.0025	0.9030	-0.0657	0.1470	0.0646	0.5280
Livestock	-0.0007	0.7560	-0.0008	0.4910	-0.0002	0.7160	0.0007**	0.0460	-0.0007	0.3780	0.0017	0.4600
Number of parc	0.0207***	0.0000	-0.0072***	0.0010	0.0018***	0.0010	0.0034***	0.0000	0.0064***	0.0000	-0.0251***	0.0000
Agro-climate	-0.2763***	0.0000	0.0446***	0.0010	-0.0969***	0.0000	0.0245***	0.0000	-0.0078	0.6620	0.3118***	0.0000
Memb to pdn org	0.0432*	0.0560	-0.0050	0.6550	0.0089	0.1030	0.0117*	0.0860	-0.0069	0.4820	-0.0519**	0.0450

SFM = soil fertility management; non-adopters are used as the base category. *, **, and *** represent the level of significance at 10%, 5% and 1% respectively.

Most of the explanatory variables are statistically significant at 10% or less and have the expected signs except for a few surprise outcomes discussed below. Generally the results show that poverty hinders the adoption of SFM and conservation technologies. Poverty is negatively related to adoption of organic fertilizer, inorganic fertilizer, terracing and a combination of terracing and other SFM practices. The magnitudes of the estimated marginal effects of poverty indicate that, compared to other factors, poverty has a very strong influence on the adoption of these practices. Poverty is also found to positively influence the probability of non-adoption of any technology. The negative association between poverty and technology adoption suggests that poverty is a key constraint to adoption of land management technologies, which supports the findings of earlier, related studies (Li et al., 1998; Shiferaw & Holden, 1998, 1999). However, it could also be a reflection of poor targeting of technologies, since the national extension services in Uganda have been blamed for targeting the rich and neglecting the poor (Hassan & Poonyth, 2001). These findings suggest that government efforts to reduce poverty would improve adoption of conservation and SFM practices. More important is to target the needs of poor farmers when developing and disseminating SFM technologies.

The results also suggest a positive relationship between adoption of fallowing and poverty. This is a rather surprising result, because it suggests that the poor may adopt fallowing more than the rich, who are expected to have more land. However, there may be two explanations for this finding. First, sample descriptive statistics showed that there is no significant difference in farm size between the different income quintiles. In fact, the results show further that poor districts such as Lira and Soroti have on average larger farms than better-off districts, because the poor districts of the north have a low population density and hence more land is available. It is also important to note that the poor usually have limited choices, given the cost implications of the alternative of intensification through external inputs such as inorganic fertilizers.

The right to bequeath land to future generations is seen as an indicator of long-term tenure security and as a result encourages farmers to have longer planning horizons. As expected, we find that long-term tenure security positively influences adoption of fallowing, organic fertilizer application, terracing and a combination of terracing and other SFM technologies, generally reducing the probability of non-adoption. This suggests that policies that facilitate and encourage tenure security, such as easing the land registration and titling processes in order to ensure long-term tenure security, can significantly increase the probability of adoption of SFM and provide incentives for investment in conservation activities.

However, a negative relationship was found between land tenure and adoption of inorganic fertilizer. This suggests that farmers prefer to use inorganic fertilizer on less secure land to maximize short-term benefits and reserve other inputs for owned plots with long-term security. Similar results were found by Gavian and Fafchamps (1996) in Ethiopia.

Membership of production associations was found to be positively related to the likelihood of adopting fallowing, terracing and use of inorganic fertilizer and generally reduces the probability of non-adoption of all technologies. These findings suggest that investment in and promotion of social capital institutions such as production associations is important for encouraging the adoption of SFM and conservation technologies.

Two policy implications of these outcomes are clear. First, development projects should not be designed to deal with all communities uniformly, but should be adapted to different levels of existing social institutions and norms. Second, extension workers need to understand the social and institutional fabric of their areas of work. They should promote and exploit the existing social infrastructure to disseminate information about new technologies and encourage cooperative action in areas of resource pooling such as labor sharing and savings.

The results of this study show a negative relationship between membership of production associations (savings and credit associations, rotating credit schemes, farmers' groups and women's groups) and the adoption of organic fertilizer. Of these categories, membership in the first two (savings and credit) constitutes 60% of the total membership. Availability of credit through these organizations to support SFM alternatives to the labor intensive organic fertilizer could therefore be the reason. In the districts of Arua and Kapchorwa, where inorganic fertilizer is mostly used, production associations such as farmers' groups are directly involved in procuring inorganic fertilizer and distributing it to the members, which promotes the use of purchased inputs and hence there is less need for organic sources.

The results show that, although farmers' access to information is positively related to most of the practices, agricultural extension does not significantly affect the adoption of most of the technologies other than the use of inorganic fertilizer. Prior adoption studies in Uganda (Nkonya et al., 2005) have come up with similar findings. There may be two reasons for this weak relationship between extension and adoption decisions. First, the extension system in Uganda has been packaged to promote the use of inorganic fertilizer, in an effort to intensify agricultural production, and, second, the extension services are inadequate and sometimes completely lacking. For instance, only 28% of the sampled households had had a single visit by an extension agent over a period of one year. The policy implication of this outcome is that there is a need to revitalize the extension services and ensure that they support the use of traditional SFM and conservation technologies that are more readily available to the farmers.

The positive and significant relationship between household size and adoption of organic fertilizer and terracing suggests that households that are endowed with family labor tend to use labor intensive management practices. The negative relationship between household size and fallowing could be attributed to the fact that larger households tend to have smaller farms and hence cannot afford to fallow but must use other SFM practices. Farmer's age was significantly and positively related to adoption of fallowing, but negatively related to adoption of inorganic fertilizer. One possible explanation for this outcome could be that older farmers are more risk averse and therefore resistant to changing to newer technologies since they are more used to traditional management systems.

Education was negatively related to adoption of terracing and inorganic fertilizer, contrary to expectations that better educated household are more likely to adopt land management practices. A possible explanation for this outcome is that education improves access to alternative livelihood strategies such as non-farm activities, which may increase the labor opportunity cost and compete with agricultural production (Nkonya et al., 2004).

In fact, non-farm income was found to be positively related to adoption of fallowing but negatively related to adoption of inorganic fertilizer, terracing, a combination of terracing and other SFM technologies, and organic fertilizer. This is another surprising result, since non-farm income is expected to provide the much-needed cash to buy external inputs, but consistent with the results of earlier analyses (Nkonya et al., 2005). There are two possible explanations for this outcome. First, agriculture is generally not profitable in Uganda (Nkonya, 2002) and this discourages investment in SFM and conservation. Second, since non-farm activities are generally more profitable and are full-time activities and sometimes located away from the farm, they take away the much needed farm labor. Non-farm activities eventually become the key source of family livelihood. As Haggblade et al. (1989) argue, initially farmers integrate non-farm activities with farming activities on a seasonal or part-time basis. Returns from non-farm activities are invested in farming activities but eventually, because of increases in demand for non-farm goods, those involved in non-farm activities break away from farming to become involved in non-farm activities on a full-time basis.

Agro-climatic zones stand out as an important factor that could explain differential use of SFM and conservation technologies in the study areas. For instance, the likelihood of using fallowing and inorganic fertilizer in the bimodal agro-climatic zones is 27.63 and 9.69%, respectively – lower than in unimodal agro-climatic zones. As noted earlier, most districts in the unimodal zones are sparsely populated, so fallowing is more likely here than in the densely populated districts in the bimodal zones. The likelihood of using inorganic fertilizer is also higher in the unimodal agro-climatic zones because of the organized input supply for maize and barley farmers in the Kapchorwa district and tobacco farmers in the Arua district, and the better extension services in the Soroti district.

In general, having more plots reduces the probability of non-adoption. Having more plots is an indicator of a larger farm size, which allows the farmer to practice terracing and fallowing quite easily. A major problem in the densely populated highland districts is that terraces are occupying a large amount of productive space and so they are being destroyed. However, the results also show a negative relationship between number of plots and organic fertilizer use. This is again as expected, since the use of bulky manure on many plots involves high transport and distribution costs.

Overall, longer distances from homesteads to plots increase the probability of non-adoption, since using organic fertilizer is a labor intensive activity – the greater the distance, the greater the labor needs and associated costs of transport and distribution. Farmers therefore choose to use less costly technologies such as fallowing and inorganic fertilizer in far-off plots and more labor intensive organic fertilizer in plots close to their homesteads.

As expected, distance to markets was found to reduce the probability of adopting inorganic fertilizer but to increase the probability of using fallow and a combination of terracing and other SFM technologies. Far-off markets imply high costs of transactions for both inputs and outputs. The high costs, coupled with the level of poverty, therefore reduce the probability of using marketed inputs such as inorganic fertilizer while increasing the use of traditional technologies such as fallowing. These findings suggest that road infrastructure development would increase adoption of marketed inputs.

Ownership of livestock has a limited impact on most land management technologies and is only positively and significantly related to adoption of terracing. Surprisingly, we do not find that livestock ownership has a positive and significant impact on adoption of organic fertilizer. The explanation for this may be that in areas where households keep cattle, which produce a significant amount of manure, the farmers are nomads for whom livestock is the main source of income or are not seriously involved in crop agriculture except for small subsistence gardens, and in areas where households keep sheep and goats and other small animals, the farmers may be involved in crop agriculture but their animals produce only small amounts of manure.

6. Conclusions and policy implications

This paper analyzes the impact of poverty, social capital and land tenure on the adoption of SFM and conservation activities. To capture the interdependence and joint nature of adoption decisions, we performed an MNL analysis that generated findings that suggest the following,

1) Poverty increases the probability of non-adoption of technologies in general and particularly reduces the probability of adopting organic and inorganic fertilizers and terracing, mainly because the poor have limited access to cash and markets and lower land and livestock assets. This finding suggests that government programs to reduce poverty would go a long way to promote the use of SFM and conservation practices.

2) Land tenure security is positively correlated with the adoption of fallowing and organic fertilizer use but generally reduces the probability of non-adoption of land management technologies. However, it was not found to significantly influence the adoption of inorganic fertilizer and terracing. These results also suggest that programs that enhance tenure security, such as land registration, would encourage the adoption of most land management practices.

3) We also find that participation in social institutions generally tends to increase the probability of adopting some land management practices. This finding is especially important in Uganda, where social capital issues are not well researched or incorporated into government policy. Investment in social capital is therefore of paramount importance for the adoption of land management technologies. The policy implication here is that extension workers should understand the social and institutional fabric of the places where they work, and they need to articulate the relevance of promoted technologies to the local social context so that the villagers become more receptive to new agricultural techniques and methods. For policy purposes,

therefore, development projects should not be designed so that they deal with all communities uniformly, but be adapted to take advantage of existing social institutions and norms.

Acknowledgements

The authors are grateful to Kirk Hamilton of the World Bank and Ephraim Nkonya of the International Food Policy Research Institute (IFPRI) for facilitating access to the dataset used for this study. Any errors remain the sole responsibility of the authors.

References

Alesina, A & La Ferrara, E, 2000. Participation in heterogeneous communities. Quarterly Journal of Economics 115(3), 847–904.

Appleton, S & Sewanyana, S, 2003. Poverty estimates from the Uganda National Household Survey II, 2002/03. Economic Policy Research Centre – EPRC memo, Kampala, Uganda.

Barrett, CB, Lee, DR & McPeak, JG, 2005. Institutional arrangements for rural poverty reduction and resource conservation. World Development 33(2), 193–7.

Bekele, W & Drake, L, 2003. Soil and water conservation decision behavior of subsistence farmers in the Eastern highlands of Ethiopia: A case study of the Hunde-Lafto area. Ecological Economics 46, 437–51.

Brasselle, AS, Gaspart, F & Platteau, J-P, 2002. Land tenure security and investment incentives: Puzzling evidence from Burkina Faso. Journal of Development Economics 67, 373–418.

Caswell, M & Zilberman, DL, 1985. The choices of irrigation technologies in California. American Journal of Agricultural Economics 67, 224–34.

Dasgupta, P, 1995. The population problem: Theory and evidence. Journal of Economic Literature 33, 1897–902.

Deininger, K & Okidi, J, 2001. Rural households: Incomes, productivity and non-farm enterprises. In Reinkka, R & Collier, P (eds) Uganda's Recovery: The Role of Farms, Firms, and Government. Washington, DC, The World Bank.

Dorfman, JH, 1996. Modeling multiple adoption decisions in a joint framework. American Journal of Agricultural Economics 17, 547–55.

Duriappah, A, 1996. Poverty and environmental degradation: A literature review and analysis of the nexus. World Development 26(12), 2169–79.

Gabremedhin, B & Swinton, SM, 2003. Investment in soil conservation in Northern Ethiopia: The role of land tenure security and public programs. Agricultural Economics 29, 69–84.

Gavian, S & Fafchamps, M, 1996. Land tenure and allocative efficiency in Niger. American Journal of Agricultural Economics 78, 460–71.

Geda, A, De Jong, N, Mwabu, G & Kimenyi, SM, 2001. Determinants of poverty in Kenya: A household level analysis. Unpublished Kenya Institute of Public Policy Research and Analysis-KIPPRA report, Nairobi.

GoU (Government of Uganda), 2002 (several issues). Background to the Budget. Ministry of Finance, Planning and Economic Development, Uganda.

GoU (Government of Uganda), 2004. Poverty Eradication Action Plan. Ministry of Finance, Planning and Economic Development, Uganda.

Greene, WH, 2000, Econometric Analysis. Prentice-Hall, New Jersey.

Grootaert, C, 1999. Social capital, household welfare and poverty in Indonesia. Discussion Paper. World Bank Social Capital Initiative, Washington DC..

Grootaert, C, Oh, GT & Swamy, A, 1999. Social capital and outcomes in Burkina Faso. Unpublished World Bank memo, Washington, DC.

Gujarati, DN, 1995. Basic Econometrics. McGraw-Hill, New York.

Haggblade, S, Hazell, P & Brown, J, 1989. Farm-non-farm linkages in rural sub-Saharan Africa. World Development 17(8), 1173–201.

Hassan, RM, 1996. Planting strategies of maize farmers in Kenya: A simultaneous equations analysis in the presence of discrete dependent variables, Agricultural Economics 15, 137–49.

Hassan, RM & Poonyth, D, 2001. Biases and effectiveness of extension services to maize farmers in Kenya before and after the training and visits system. Agrekon 40(3), 438–56.

Hausman, JA & McFadden, D, 1984. Specification tests for the multinomial logit model. Econometrica 52, 1219–40.

Holden, S, Shiferaw, B & Wik, M, 1998. Poverty, credit constraints and time preference of relevance for environmental policy. Environment and Developmental Economics 3, 105–30.

Isham, J, 2000. The effect of social capital on technology adoption: Evidence from rural Tanzania. Center for Institutional Reform and the Informal Sector (CIRIS) Working Paper No. 235, College Park, USA

Kabubo-Mariara, J, 2003. The linkages between property rights, migration and productivity: The case of Kajiado District, Kenya. Environment and Development Economics 8(4), 621–36.

Kabubo-Mariara, J, 2005. Herders' response to acute land pressure under changing property rights: Some insights from Kaijiado District, Kenya. Environment and Development Economics 10(1), 67–86.

Lee, L, Maddala, G & Trost, R, 1980. Asymptotic covariance matrices of two-stage probit and tobit methods for simultaneous equation models with selectivity. Econometrica 48, 491–501.

Li, G, Rozelle, S & Brandt, L, 1998. Tenure, land rights, and farmer investment incentives in China. Agricultural Economics 19, 63–71.

Long, JS, 1997. Regression models for categorical and limited dependent variables. Sage, Thousand Oaks, USA.

Migot-Adholla, SE, Hazell, P, Blarel, B & Place, F, 1991. Indigenous land rights systems in sub-Saharan Africa: A constraint on productivity? World Bank Economic Review 5(1), 155–75.

Mink, SD, 1993. Poverty, population and the environment, World Bank Discussion Paper No. 189, Sections III and IV, pp.13–37, Washington DC

Mukherjee, S & Benson, T, 2003. The determinants of poverty in Malawi, 1998. World Development 31(2), 339–58.

Narayan, D & Pritchett, L, 1999. Cents and sociability: Household income and social capital in rural Tanzania. Economic Development and Cultural Change 47(4), 871–97.

NEMA (National Environmental Management Authority), 2002 (several issues). State of Environment Report in Uganda. NEMA, Kampala, Uganda.
Nkonya, EM, 2002. Uganda crop trader characteristics and their marketing constraints. East African Journal of Rural Development, 18(1).
Nkonya, E, Pender, J, Jagger, P, Sserunkuma, D, Kaizzi, C & Ssali, H, 2004. Strategies for sustainable land management and poverty reduction in Uganda. Research Report No. 133, IFPRI (International Food Policy Research Institute), Washington DC.
Nkonya, E, Pender, J, Kaizzi, C, Kato, E, and Mugarura, S, 2005. Policy options for increasing crop productivity and reducing soil nutrient depletion and poverty in Uganda. IFPRI Environment and Production Technology Division (EPTD) Discussion Paper No. 134, Washington DC.
Nyangena, W, 2005. Social capital and institutions in rural Kenya: Is Machakos unique? Unpublished PhD Thesis, University of Gothenburg, Sweden.
Pender, J, Ssewanyana, S, Kato, E & Nkonya, E, 2004. Linkages between poverty and land management in rural Uganda: Evidence from Uganda National Household Survey, 1999/00. A paper presented at a workshop on Poverty and Natural Resource Management linkage, held at Hotel Africana, June 2004, Kampala, Uganda.
Place, F & Otsuka, K, 2000. Land tenure systems and their impacts on productivity in Uganda. Journal of Development Studies 38(6), 105–28.
Putnam, RD, Leonardi, R & Nanetti, RY, 1993. Making Democracy Work: Civic Traditions in Modern Italy. Princeton University Press, Princeton, NJ.
Reardon, T & Vosti, S, 1995. Links between rural poverty and the environment in developing countries: Asset categories and investment poverty. World Development 23, 1495–506.
Reid, C & Salmen, L, 2000. Understanding social capital and agricultural extension in Mali: Trust and social cohesion. Social Capital Initiative Working Paper No. o. 22, World Bank, Washington DC..
Shiferaw, B & Holden, S, 1998. Resource degradation and adoption of land conservation technologies in the Ethiopian highlands: A case study of the Andit Tid, North Shewa. Agricultural Economics 18, 233–47.
Shiferaw, B & Holden, S, 1999. Soil erosion and smallholders' conservation decisions in the highlands of Ethiopia. World Development 27(4), 739–52.
Scherr, JS, 1999. Poverty-environmental interactions in agriculture: Key factors and policy implications. Paper prepared for the United Nations development Program and European Commission expert workshop on Poverty and the Environment, Brussels, Belgium.
Scherr, JS, 2000, A downward spiral? Research evidence on the relationship between poverty and natural resource degradation. Food Policy 25, 479–98.
StataCorp, 2005. Stata Statistical Software: Release 9.0 Collage Station, TX: Stata Corporation, USA.
Swinton, SM & Quiroz, R, 2003. Is poverty to blame for soil, pasture and forest degradation in Peru's Altiplano? World Development 31(11), 1903–19.
UNDP (United Nations Development Program), 2005. Human Development Report. UNDP, Rome.
White, H, 1980, A heteroscedastic-consistent covariance matrix estimator and a direct test of heteroscedasticity. Econometrica 48, 817–38.

World Bank, 2001. World Development Report 2000/2001: Attacking poverty. Oxford University Press, Oxford.

World Bank, 2005. World Development Indicators. World Bank, Washington, DC.

Wu, J & Babcock, BA, 1998. The choice of tillage, rotation and soil testing practices: Economic and environmental implications. American Journal of Agricultural Economics 80, 494–511.

The demand for meat in Egypt: An almost ideal estimation

MOHAMED ALTABEI ALBOGHDADY*

Agricultural Economics Department, Faculty of Agriculture, Suez Canal University

MOHAMED KHAIRY ALASHRY

Agricultural Economics Department, Faculty of Agriculture, Suez Canal University

Abstract

This paper analyzes the demand for meat in Egypt for the period 1990–2005 using the linearized Almost Ideal Demand System to estimate own-price, cross-price and expenditure elasticities. It found that the Marshallian own-price elasticity was the highest for fish, followed by chicken, beef and duck. On the other hand, the cross-price elasticity of beef showed a complementary relationship with the other meat types, except for fish, which is substitutive. Chicken and fish showed a substitutive relationship with all other meat types. Duck showed a substitutive relationship with all meats except rabbit. Mutton and rabbit showed a versatile relationship with the other meat types. The highest substitutive relationship was between mutton and beef. Compensated own-price elasticity estimates showed similar trends but smaller values than uncompensated ones, which is theoretically consistent.

Keywords: meat; Almost Ideal Demand System; seemingly unrelated regressions; Egypt

Cet article analyse la demande en viande, en Egypte pour la période 1990–2005 à l'aide du système A.I.D.S. linéarisé, afin d'évaluer les élasticités en matière de dépense, de prix croisé et de prix de l'offre. L'étude a montré que l'élasticité marshallienne du prix de l'offre était la plus élevée pour le poisson, suivie du poulet, du bœuf et du canard. D'autre part, l'élasticité du prix croisé pour le bœuf a révélé une relation complémentaire avec les autres types de viande, excepté pour le poisson, qui est substitutive. Le poulet et le poisson ont montré une relation substitutive avec tous les autres types de viande. Le canard a montré une relation substitutive avec toutes les viandes excepté le lapin. Le mouton et le lapin ont montré une relation versatile avec les autres types de viande. La relation substitutive la plus importante est celle entre le mouton et le bœuf. Les estimations de l'élasticité du prix de l'offre compensé ont révélé des tendances similaires avec cependant des valeurs moindres que celles non compensées, ce qui en théorie demeure cohérent.

Mots-clés : *viande ; Système A.I.D.S. (Almost Ideal Demand System) ; régressions apparemment sans lien ; Egypte*

* Corresponding author: boghd@yahoo.com

1. Introduction

A wide range of factors, notably globalization and economic growth, have changed the lifestyle of developing countries in general, and Egypt in particular, in the direction of western or developed countries' lifestyles and diets. Such factors have not only increased meat consumption but also changed meat consumption patterns.

The way consumers allocate consumption expenditure among goods and services is of particular interest to economists. In developed countries, meat demand has been studied extensively. In developing countries, however, studies of this topic are often restricted by the data insufficiency of the past decades.

In reviewing studies of meat demand in Egypt we noted two points. Firstly, these studies divided meat into three major categories, red meat, white meat and fish, ignoring the estimation of demand parameters of each category's components (e.g. Mohamed, 2000; Ragab, 2005). As such classification gives only general estimates, it does not produce an accurate or detailed specification of meat demand in Egypt. Secondly, the adopted methodology concentrated only on the estimation of a single demand equation even though there are doubts about the reliability of the results obtained by this method.

The main aim of this paper is to produce more reliable demand parameter estimates of meat in Egypt. The reliability may be achieved by addressing the two points of weakness mentioned above. We therefore adopted the Linear Approximated Almost Ideal Demand System (LA/AIDS) methodology to estimate the demand for all meat types in Egypt. This methodology is concerned mainly with estimating own-price, cross-price and expenditure elasticities. The AIDS specification proposed by Deaton and Muellbauer (1980) is commonly used to estimate the price and income elasticities of the demand for goods when expenditure share data are available.

2. Data

Seven main types of meat are consumed in Egypt: beef, mutton, rabbit, chicken, duck, turkey and fish. The study excludes turkey as consumption of this meat is very low and there is insufficient data, and pork is not included because most Egyptian people are Muslims.

The data used for the econometric estimation are annual and were constructed by the authors on the basis of FAO statistics (FAO, undated) and publications of the Egyptian Ministry of Agriculture (MoA, various dates). The study covers the period 1990 to 2005.

3. Characteristics of meat consumption in Egypt

The FAO statistics show that in 2005 the daily per capita protein consumption in Egypt in 2005 was 107 gm/capita/day. Only 15.1 gm were of animal origin, distributed as 4.73 gm from red meat, 5.77 gm from poultry, 0.7 gm from milk and 3.91 gm from fish.

Figure 1 shows that for the past two decades, with few exceptions, the annual per capita consumption of meat has been increasing gradually. Consumption of red meat increased with some fluctuations from 10.13 kg/capita/year in 1990 to 14.6 kg/capita/year in 2000. There was a noticeable decrease between 2001 and 2005, down to 12.14 kg/capita/year in 2001, with a further decrease to 11.38 kg/capita/year by 2005.One of the main reasons for this was Bovine Spongiform Encephalopathy (BSE, widely known as 'mad cow disease'). Although the first BSE case was detected in 1986 in the UK, the disease caused fear among consumers in Egypt in 2001 and significantly decreased the demand for beef, and there were governmental polices restricting the import of beef from the infected markets.

White meat showed a gradual increase in per capita consumption through the period 1990–2005, from 4.64 kg/capita/year in 1990 to 12.12 kg/capita/year in 2005 – an increase of 0.5 kg/capita/year on average. The highest values reached in 2001 and 2002, 13.2 kg/capita/year and 13.3 kg/capita/year respectively, were probably due to the dramatic reduction in beef demand caused by BSE. The annual per capita consumption of fish showed significant increase, almost doubling from 7.98 kg/capita/year in 1990 and to 15.55 kg/capita/year in 2005 – an increase of 0.51 kg/capita/year on average. The steep increase in 2001 was probably also due to the drop in demand for beef because of BSE.

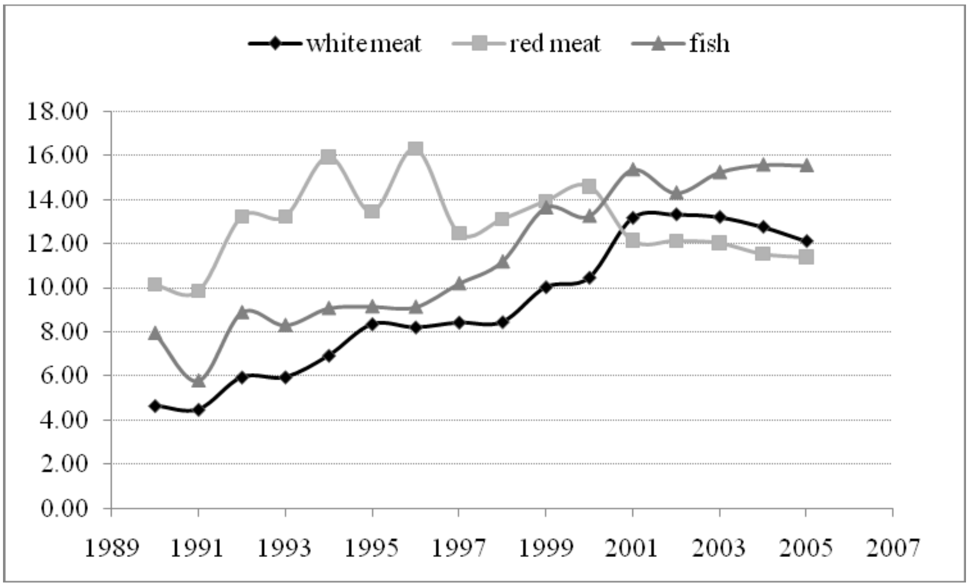

Figure 1: Per capita meat consumption in Egypt (1990–2005)

Table 1 shows the expenditure shares for each type of meat. The highest expenditure share is for beef (0.388), followed by fish (0.34), which implies that beef and fish represent about 73% of the total expenditure on all types of meat in Egypt.

Table 1: Summary statistics of expenditure shares for meat consumption (1990-2005)

Meat	Mean	Minimum	Maximum	SD
Beef	0.388	0.286	0.468	0.042
Chicken	0.135	0.065	0.168	0.034
Mutton	0.062	0.031	0.085	0.019
Duck	0.041	0.031	0.050	0.006
Fish	0.341	0.291	0.430	0.036
Rabbit	0.033	0.026	0.041	0.004

4. Methodology

Alston and Chalfant (1993) state that two demand systems have gained prominence in demand analysis, especially in the field of agricultural economics: the Almost Ideal Demand System (AIDS) and the Rotterdam model. Deaton and Muellbauer (1980) convert the nonlinear AIDS into a simplified linear AIDS (LA/AIDS) model by using the Stone's price index to replace the nonlinear price index. Because of its simplicity and lighter computational burden, this model is very popular for empirical demand analysis (Green & Alston, 1990).

This study therefore adopted the LA/AIDS model. We estimate the system of equations using the Restricted Seemingly Unrelated Regression (RSUR) method with the homogeneity and symmetry conditions imposed. The procedures for the model estimation are as follows.

Assume the AI expenditure share equation

$$\omega_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln\left(\frac{X}{P^\circ}\right) + \mu_{ij} \tag{1}$$

where ω_i represents the share allotted to i^{th} good out of group expenditure $(i = 1,2,...,n)$, P_j is the nominal price of the j^{th} good, X is the total expenditure, α_i, γ_{ij} and β_i are RSUR parameter estimates for the LA/AIDS model, μ_i is the random or error term., and P° is the translog price index defined by

$$\ln(P^\circ) = \alpha + \sum \alpha_j \ln P_j + \frac{1}{2}\sum_i^n \sum_j^n \gamma_{ij} \ln P_i \ln P_j \tag{2}$$

It is clear that the translog price index complicates the model. Deaton and Muellbauer (1980) suggested the Stone's price index, which can be used instead of the translog price index that is defined as follows:

$$\ln P^{\circ} = \sum_{i=1}^{n} \omega_i \ln P_i \qquad (3)$$

If we substitute the Stone's price index (equation 3) for the translog price index in equation 1, we then have

$$\omega_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i (\ln X - \sum_{i=1}^{n} \omega_i \ln P_i) + \mu_i \qquad (4)$$

As can be seen in equation 4, this substitution causes a simultaneity problem, because the dependent variable (ω_i) also appears on the right-hand side of the LA/AIDS. Eales & Unnevehr (1988, 1994) suggested using the lagged share ($\omega_{i,t-1}$) for equation 4. Replacing equation 3 with the lagged shares in equation 1 yields the LA/AIDS, given by

$$\omega_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i (\ln X - \sum_{i=1}^{n} \omega_{i,t-1} \ln P_i) + \mu_i \qquad (5)$$

Since budget shares sum to one, we impose the following set of restrictions on the parameter of the AIDS model:

1) Adding up implies: $\sum_{i=1}^{n} \alpha_i = 1 \qquad \sum_{i=1}^{n} \beta_i = 0 \qquad \sum_{i=1}^{n} \gamma_{ij} = 0$

   Then it follows that $\sum_{i=1}^{n} \omega_i = 1$, which is obvious from equation 1.

2) Homogeneity requires that $\sum_{j=1}^{n} \gamma_{ij} = 0$.

3) Symmetry is satisfied if $\gamma_{ij} = \gamma_{ji}$ for any two goods *i* and *j*.

As the present study focuses on the response of the demand for different meat types to changes in price and expenditure, the elasticities have been calculated at the sample mean of expenditure shares. The uncompensated (Marshallian) own-price elasticities

(ε_{ii}) and cross-price elasticities (ε_{ij}) can be derived respectively as (see Alston et al., 1994):

$$\varepsilon_{ii} = -1 + \frac{\gamma_{ii}}{\omega_i} - \beta_i \quad (6)$$

$$\varepsilon_{ij} = \frac{\gamma_{ij}}{\omega_i} - \beta_i \frac{\omega_j}{\omega_i}, i \neq j \quad (7)$$

The formula used to calculate the expenditure elasticities can be written as:

$$\eta_i = 1 + \frac{\beta_i}{\omega_i} \quad (8)$$

A positive value suggests that good i is normal. The income compensated or net (Hicksian) own-price elasticities (ℓ_{ii}) and cross-price elasticities (ℓ_{ij}) respectively are obtained by applying the Slutsky decomposition to (8) and using the price index in (3). These can be written as

$$(\ell_{ii} = -1 + \frac{\gamma_{ii}}{\omega_i} + \omega_i \quad (9)$$

$$\ell_{ij} = \frac{\gamma_{ij}}{\omega_i} + \omega_j, \; i \neq j \quad (10)$$

Consumer theory suggests that compensated own-price elasticities are negative for normal goods. Moreover, if (7) and (10) are positive the two goods are cross substitutes, otherwise they are complements.

Using the Slutsky equation again, it is possible to derive a relationship between the compensated cross-price elasticities and the expenditure elasticities as follows:

$$\varepsilon_{ij} = \omega_j \sigma_{ij} - \omega_j \eta_i \quad (11)$$

where σ_{ij} are the partial elasticities of substitution, also known as the Allen elasticities of substitution.

$$\sigma_{ij} = 1 + \frac{\gamma_{ij}}{\omega_i \omega_j} \quad i \neq j \tag{12}$$

The sign of σ_{ij} determines whether the goods i and j are complements or substitutes. If σ_{ij} is positive the two goods are substitutes, whereas if it is negative the two goods are complements.

5. Empirical results

This section describes the results of two tests: the time series properties, derived from the well-known Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979) that establishes whether the time series of all variables are stationary or not, and the empirical results from the structural breaks test.

5.1 Time series properties

Each time series variable included in a model should be tested for its time series properties. We used two tests to investigate the time series properties of the dataset: the unit root test, to examine the stationarity of the dependent variables, and the structural breaks test to examine the expenditure share variables (dependent variables) over the time series.

Unit root test

This tests whether a time series variable is non-stationary, using an autoregressive model. The Augmented Dickey-Fuller test constructs a parametric correction for higher-order correlation by assuming that the series follows an AR(k) process and adding the lagged difference terms of the dependent variable to the right-hand side of the test regression:

$$\Delta y_t = c + \alpha y_{t-1} + \sum_{j=1}^{k} d_j \Delta y_{t-1} + \varepsilon_t \tag{13}$$

Equation 13 tests for the null of a unit root against a mean-stationary alternative in y_t where y refers to the time series examined. The test results are presented in Table 2. The results confirmed that the null hypotheses are rejected for all variables. Consequently, all the variables used in the LA/AIDS model are integrated to the order one I(1), which means the time series of all variables are stationary at the difference one.

Table 2: Unit root test results for meat expenditure shares in Egypt (1990–2005)

Variable	Budget shares		Prices	
	Lags	Test statistics	Lags	Test statistics
Beef	5	-1.38	5	-1.95
Chicken	5	-2.17	5	-2.21
Mutton	5	-1.07	4	-2.01
Ducks	4	-1.64	4	-1.88
Fish	5	-1.25	5	-2.30
Rabbits	5	-2.51	3	-3.95
Expenditure	5	-0.83		

Note: 95% critical value for the augmented Dickey-Fuller statistic = -3.9949. The order is selected by the Akaike Information Criterion (AIC).

Structural breaks test

Jha and Sharma (2001) state that structural breaks are a result of some event significantly affecting the variables being studied. Such breaks can lead to a permanent shift in the level or slope (or both) of the series but the basic nature of the series remains unchanged.

To detect periods in which structural breaks occur, we examined a set of residuals from the fitted LA/AIDS share equations (equation 5), and the structural breaks are then the period(s) where the residuals exceeded two standard deviations.

Table 3: Structural breaks of the expenditure share for meat in Egypt (1990–2005)

Year	Beef	Chicken	Mutton	Duck	Fish
1990	-	-	-	-	-
1991	-0.155	-0.305	-0.036	-0.140	0.457
1992	0.602	0.309	-0.361	0.133	-0.946
1993	0.371	0.025	0.407	0.137	-0.514
1994	-0.660	0.441	0.109	0.389	0.192
1995	-0.527	-0.010	-0.290	0.065	0.573
1996	-0.085	-0.079	-0.397	-0.556	0.378
1997	-0.277	-0.552	-0.360	-0.225	0.896
1998	-0.452	-0.070	-0.379	-0.250	0.717
1999	-0.095	0.324	-0.500	0.212	-0.297
2000	-0.813	0.050	-0.115	0.311	0.725
2001	1.718	-0.194	0.269	0.129	-1.882
2002	0.597	-0.019	-0.169	-0.095	-0.518
2003	0.333	0.014	-0.562	0.155	-0.396
2004	0.264	0.147	-0.583	-0.117	-0.383
2005	-0.856	-0.088	0.296	-0.144	1.023

The results presented in Table 3 show that there are no structural breaks within any period of the expenditure share variables (dependent variables). The maximum break in beef occurred in 2001, as expected, by 1.718. Consequently, the maximum breaks occurred in the same year for fish, by -1.882. Moreover, all other expenditure share variables did not even reach 1 or -1.

Table 4: Parameter estimates for the restricted linear approximate AIDS model for meat demand in Egypt during the period 1990-2005

Explanatory variables	Dependent variables					
	Beef	Chicken	Mutton	Duck	Fish	Rabbit
Beef	0.187 *(3.639**)*					
Chicken	-0.054 *(-3.981**)*	0.052 *(3.427**)*				
Mutton	-0.069 *(-7.384**)*	0.014 *(1.754)*	0.112 *(7.109**)*			
Duck	-0.014 *(-3.763**)*	-0.001 *(-0.287)*	-0.009 *(-2.016)*	0.036 *(14.526**)*		
Fish	-0.033 *(-0.6251)*	-0.007 *(-0.273)*	-0.048 *(-4.898**)*	-0.013 *(-2.134*)*	0.112 *(1.604)*	
Rabbit	-0.016 *(-5.474**)*	-0.003 *(-1.104)*	0.001 *(0.366)*	0.001 *(0.691)*	-0.010 *(-1.931)*	0.029
Expenditures	-0.099 *(-2.581*)*	0.087 *(5.3201**)*	-0.078 *(-12.751**)*	-0.018 *(-5.111**)*	0.119 *(2.562*)*	-0.011
CONSTANT	1.769 *(3.242*)*	-1.090 *(-4.560**)*	1.163 *(12.858**)*	0.310 *(5.929**)*	-1.350 *(-2.027)*	0.198
R^2	0.54	0.94	0.98	0.94	0.36	
DW	1.81	1.93	1.54	1.38	1.77	
EL	32.39	52.71	68.76	76.33	32.01	
SL	337.28					
AIC	312.28					

Note: t-ratio are in parentheses where *, and ** denote significant at 0.05 and 0.01 respectively.
The t-ratio do not appear for coefficients which have been obtained using relevant restrictions.
EL refers to equation log-likelihood, SL is the system log-likelihood, and AIC is the Akaike Information Criterion.

5.2. Empirical results of the model

The model was estimated using the iterative Restricted Seemingly Unrelated Regression (RSUR) procedures (Zellner, 1962) with Microfit version 4. The set of restrictions led to a singular variance/covariance matrix. Therefore, to avoid the singularity problem, one of the share equations was dropped from the system, the rabbit share equation, which represents the lowest expenditure share on average.

The results of the RSUR system are shown in Table 4. The majority of the estimated equations contain a number of statistically significant coefficients, and overall the model fits the data well. The determination coefficients R^2s are 0.54, 0.94, 0.98, 0.94 and 0.36 for beef, chicken, mutton, duck and fish respectively. The impacts of consumer expenditure on the demand share of chicken and fish meat are positive, but negative for all other meats. In addition, the expenditure impact is significant at level 0.01, except for beef and fish which are significant at 0.05. We can therefore reasonably conclude that the parameter of expenditure reflects the impact of expenditure on budget share rather than quantity demanded. The detailed expenditure elasticities are presented in Table 5.

The estimates of Marshallian own-price elasticities and expenditure elasticities are given in Table 5. The own-price elasticities are found to be negative, as expected, except for mutton. The reason for this unexpected sign may be religious practices, as most Muslims butcher sheep or goats for the Adha feast, i.e. the reason is a cultural rather than an economic one that would suppose the consumer is responding rationally to price changes. Regarding the other elasticities, fish showed the highest own-price elasticity, followed by chicken, beef and duck.

Regarding the cross-price elasticities, beef showed a complementary relationship with the other meat types except with fish as the relation is substitutive. Chicken and fish showed a substitutive relationship with all other meat types. Duck showed a substitutive relationship with all meats except with rabbits. Mutton and rabbit showed a versatile relationship with the other meat types. The highest substitutive relationship was between mutton and beef.

The calculated expenditure elasticities using equation 8 are positive except for mutton. This positive sign implies that meat of different types can be considered normal goods. The expenditure elasticities for chicken (1.65) and fish (1.35) are greater than one, which implies that they can be considered luxury goods. On the other hand, beef, duck and rabbit are less than one, which implies that they are necessary goods. It is important to mention that a high percentage of ducks and rabbits are home produced and consumed, especially in rural areas. Consequently, their response to the income changes is somewhat weak.

Table 5: Uncompensated (Marshallian) price and expenditure elasticities of Egyptian Meat, LA/AIDS Model (1990 -2005)

	Beef	Chicken	Mutton	Ducks	Fish	Rabbits
Beef	**-0.420**	-0.432	-1.108	-0.335	-0.202	-0.189
Chicken	0.142	**-0.704**	0.258	-0.020	-0.320	0.118
Mutton	0.037	-0.089	**0.886**	-0.213	-0.797	0.045
Duck	0.116	-0.299	-0.028	**-0.104**	-1.038	0.052
Fish	-0.074	-0.086	-0.768	-0.319	**-0.792**	-0.089
Rabbit	0.975	-0.380	0.165	0.052	-1.253	**-0.127**
Expenditure	0.745	1.645	-0.254	0.547	1.348	0.660

Note: The bold values are the own-price elasticities, the others are the cross-price elasticities.

The compensated own-price elasticity estimates in Table 6 show similar trends but smaller values than uncompensated ones, which is theoretically consistent. This result indicates that the income effect on the own quantities demanded of beef, chicken, mutton, duck, rabbit and fish is very significant for the purchaser.

Table 6: Compensated (Hicksian) elasticities of Egyptian meat, LA/AIDS model (1990–2005)

	Beef	Chicken	Mutton	Ducks	Fish	Rabbits
Beef	**-0.131**	-0.014	-0.733	0.051	0.290	-1.568
Chicken	-0.005	**-0.482**	0.358	0.110	0.115	1.320
Mutton	-0.117	0.164	**0.870**	-0.163	-0.080	0.459
Duck	0.005	0.033	-0.107	**-0.082**	0.002	0.484
Fish	0.256	0.290	-0.441	0.021	**-0.332**	-0.590
Rabbit	-0.008	0.009	0.053	0.063	0.004	**-0.105**

6. Conclusions

The results show that the Marshallian own-price elasticity was the highest for fish, followed by chicken, beef, and duck. On the other hand, the cross-price elasticities of beef showed a complementary relationship with the other meat types, except with fish as the relationship is substitutive. Chicken and fish showed a substitutive relationship with all other meat types. Duck showed a substitutive relationship with all meat types except rabbit. Mutton and rabbit showed a versatile relationship with the other meat types. The highest substitutive relationship is between mutton and beef. Compensated own-price elasticity estimates show similar trends but smaller values than uncompensated ones, which is theoretically consistent.

The calculated expenditure elasticities are positive except for mutton, which implies that meat of different types can be considered normal goods. The expenditure elasticities for chicken and fish show they are luxury goods. On the other hand, beef, duck and rabbit are necessary goods.

References

Alston, JM & Chalfant, JA, 1993. The silence of the lambdas: A test of the almost ideal and Rotterdam models. American Journal of Agricultural Economics 75, 304–13.

Alston, JM, Foster, KA & Green, RD, 1994. Estimating elasticities with the Linear Approximate Almost Ideal Demand System: Some Monte Carlo results. The review of Economics and Statistics 76(2), 351–6.

Deaton, A & Muellbauer, J, 1980. An Almost Ideal Demand System. American Economic Review (70)3, 312–26.

Dickey, DA & Fuller, WA, 1979, Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association 74, 427–31.

Eales, JS & Unnevehr, LJ, 1988. Demand for beef and chicken products: Separability and structural change. American Journal of Agricultural Economics 70, 521–32.

Eales, JS & Unnevehr, LJ, 1994. The inverse Almost Ideal Demand System. European Economic Review 38, 101–15.

FAO (Food and Agriculture Organization of the United Nations), (n.d.). TradeSTAT. http://faostat.fao.org/site/604/default.aspx#ancor Accessed 7 March 2008.

Green, R & Alston, JM, 1990. Elasticities in AIDS models. American Journal of Agricultural Economics 72, 442–5.

Jha, R & Sharma, A, 2001. Structural breaks and unit roots: A further test of the sustainability of the Indian fiscal deficit. ASARC Working Papers 2001-08, Australia South Asia Research Centre, Australian National University, Canberra.

MoA (Egyptian Ministry of Agriculture), (various dates). www.agr-egypt.gov.eg/StudiesAll.aspx Accessed 3 January 2008.

Mohamed, HA, 2000. An Economic Study on Meat Consumption in Arab Republic of Egypt. Journal of Agricultural Sciences, Mansoura University, 25(12), 769–708.

Ragab, H, 2005. An analytical study for domestic consumer demand on meat in Egypt. Mansoura University Journal of Agricultural Sciences 30(3), 1423–32.

Zellner, A, 1962. An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. Journal of the American Statistical Association 57(298), 348–68.

The rural non-farm economy, livelihood strategies and household welfare

DAVID STIFEL*

Department of Economics, Lafayette College, Easton, Pennsylvania

Abstract

This paper examines the relationship between rural non-farm employment and household welfare using nationally representative data from Madagascar. It focuses on labor outcomes in the context of household livelihood strategies that include farm and non-farm income earning opportunities. It identifies distinct household livelihood strategies that can be ordered in welfare terms, and estimates multinomial logit models to assess the extent of the barriers to choosing dominant strategies. It finds that high-return non-farm activities provide an important pathway out of poverty, but that barriers such as lack of (a) education, (b) formal credit and (c) access to telecommunications restrict participation in such activities. Individual employment choice models and estimates of earnings functions provide supporting evidence of these barriers. Although the poverty reduction effects may be limited, low-return non-farm activities also play an important role as safety nets by providing opportunities for ex ante risk reduction and ex post coping with shocks.

Keywords: non-farm; livelihood strategy; diversification; labor; welfare; Madagascar

Cet article examine la relation entre l'emploi du secteur non agricole et le bien-être des ménages dans les zones rurales grâce aux données représentatives, à l'échelle nationale, de Madagascar. Il cible les revenus générés par le travail dans le cadre des stratégies de subsistance des ménages qui incluent les possibilités de gagner de l'argent des secteurs agricole et non agricole. Il identifie différentes stratégies de subsistance des ménages que l'on peut classer en termes de bien-être et examine des modèles logit multinomiaux pour évaluer l'étendue des barrières dans le choix des stratégies dominantes. L'étude montre que les activités du secteur non agricole générant des revenus élevés permettent de manière significative de se sortir de la pauvreté, mais que les barrières comme le manque d'éducation (a), de crédit officiel (b), et d'accès aux télécommunications (c) réduisent la participation à de telles activités. Les modèles de choix en matière d'emploi pour les personnes individuelles et les évaluations des fonctions génération de revenu mettent en lumière ces barrières. Bien que les effets réduction de pauvreté soient limités, les activités du secteur non agricole générant peu de revenus jouent également un rôle important, en tant que filets de sécurité, en permettant la réduction de risque ex-ante et l'absorption des chocs ex-post.

Mots-clés : *non agricole ; stratégie de subsistance ; diversification ; main-d'oeuvre ; bien-être ; Madagascar*

* Correspondence: stifeld@lafayette.edu

1. Introduction

The rural non-farm sector is often seen an important pathway out of poverty (Lanjouw, 2001). Indeed, an empirical regularity emerging from studies of the non-farm economy in developing countries is that there exists a positive relationship between non-farm activity and welfare on average (Barrett et al., 2001). In addition, non-farm employment has the potential to reduce inequality, absorb a growing rural labor force, slow rural-urban migration and contribute to the growth of national income (Lanjouw & Feder, 2001).

The supply of labor to the non-farm sector in rural areas, however, is perhaps best understood in the context of households' decision making based on livelihood strategies (Reardon, 1997). After all, 'diversification is the norm' (Barrett et al., 2001), especially among agricultural households, whose livelihoods are vulnerable to climatic uncertainties. For households facing substantial crop and price risks, and consequently agricultural income risks, there is a strong incentive to diversify their income sources. In principle, such diversification could be accomplished through land and financial asset diversification. But the absence of well-functioning land and capital markets in developing countries often means that these diversification strategies are not feasible. Consequently, many rural households find themselves pursuing second-best diversification strategies through the allocation of household labor (Bhaumik et al., 2006). In this setting, household labor supply and allocation decisions are not made simply on the basis of productivity calculations; rather, they involve weighing both productivity and risk factors (Barrett et al., 2008).

Given the multitude of constraints faced by households and the heterogeneity of non-farm employment opportunities available to them, livelihood diversification strategies vary widely (Barrett et al., 2005). This heterogeneity can make generalizations problematic and is a reason for our general lack of knowledge about the rural non-farm economy (Haggblade et al., 2007). Nonetheless, some broad characterizations are helpful.

One such characterization is based on the existence of both *push* and *pull* factors that influence the choices households make when it comes to non-farm employment. First, there is an incentive, or *push*, for households with weak non-labor asset endowments and who live in risky agricultural zones to allocate household labor to non-farm activities. Although households frequently do turn to the non-farm sector as an ex ante risk reduction strategy, distress diversification into low-return non-farm activities is also observed as an ex post reaction to low farm income (Von Braun, 1989; Haggblade, 2007). In this way, there are benefits to low-return non-farm activities that serve as a type of safety net that 'helps to prevent poor [households] from falling into even greater destitution' (Lanjouw, 2001). Second, such factors as earnings premia from high productivity or high income activities may attract, or *pull*, some household labor into non-farm employment (Dercon & Krishnan, 1996; Barrett et al., 2001; Lanjouw & Feder, 2001; Reardon et al., 2001; Haggblade, 2007). These high-return non-farm jobs may serve as a genuine source of upward mobility (Lanjouw, 2001).

Another characterization is based on the type of livelihood strategies adopted. Identifying distinct livelihood strategies built on labor allocations can be informative, especially if certain strategies are found to offer higher returns than others. For example, the co-existence of high- and low-return strategies is an indication that there are barriers to adopting the former. As Brown et al. (2006:23) explain,

> a simple revealed preference argument suggests that, where different asset allocation strategies yield different income distributions that can be ordered in welfare terms…, any household observed to have adopted a lower return strategy must have faced a constraint that limited its choice set relative to those of its neighbors.

Indeed, the positive correlation commonly found between household income and non-farm participation is consistent with access to these high-return strategies being limited to a subpopulation of well-endowed households.[1] After all, it is those who begin poor who typically face difficulties raising the funds required for investment and overcoming other entry barriers to participating in the type of non-farm activities that might raise their standards of living (Dercon & Krishnan, 1996; Barrett et al., 2005; Bhaumik et al., 2006).

In this paper, we examine the relationship between rural non-farm employment and household welfare using nationally representative data from Madagascar. In doing so, we focus attention on labor outcomes in the context of household livelihood strategies that include farm and non-farm income earning opportunities. We identify distinct household livelihood strategies that can be ordered in welfare terms and estimate multinomial logit models to assess the extent to which there exist barriers to choosing dominant strategies. Individual employment choice models, as well as estimates of earnings functions, provide supporting evidence of these barriers.

A weakness in the extensive and growing literature on household income diversification strategies is that the empirical analyses have generally been confined to limited geographical areas (Dercon & Krishnan, 1996; Ellis, 1998; Barrett et al., 2001; Little et al., 2001; Brück, 2004; Bhaumik et al., 2006; Barrett et al., 2005; Brown et al., 2006). This paper aims to fill this gap and to complement the existing literature by using nationally representative household survey data to generalize the results more broadly.

In the next section we describe the main data source and define basic terms used in the paper. Section 3 provides an overview of individual labor market outcomes in Madagascar and identifies household livelihood strategies. In Section 4 we estimate the determinants of the livelihood strategies identified in the previous section to test for the existence of barriers that may prevent households from adopting high-return strategies associated with non-farm employment. In Section 5, given that household strategy choices are limited by the characteristics of their members, we estimate the determinants of individual employment choice and individual earnings. Section 6 concludes with remarks and observations.

2. Data and definitions

This section describes the main data source and defines the terms ‘employment’, ‘rural’ and ‘non-farm’ as used in this paper.

[1] The effect of non-farm participation is thus ambiguous. On the one hand, entry barriers that limit the accessibility of those with limited asset endowments to high-return non-farm activities tend to result in more inequality. On the other hand, the ‘safety-net’ role of the non-farm sector tends to buoy these same households and consequently have an equalizing effect (Lanjouw, 2001; Haggblade et al., 2007).

Data

Our main source of information in this analysis is the 2005 Madagascar *Enquête Prioritaire auprès des Ménages* (EPM), a nationally representative integrated household survey of 11,781 households, 5,922 of which are in rural areas. The data were collected by the *Institut National de la Statistique* (INSTAT) between September and December, 2005. The sample was selected through a multi-stage sampling technique in which the strata were defined by the region and milieu (rural, secondary urban centers and primary urban centers), and the primary sampling units were *fokontany*.[2] Each of the *fokontany* was selected systematically, with probability proportional to size and sampling weights defined by the inverse probability of selection to obtain accurate population estimates.

The multi-purpose questionnaires included sections on education, health, housing, agriculture, household expenditure, assets, non-farm enterprises and employment. Employment and earnings information are available in the employment, non-farm enterprise and agriculture sections. For a measure of household well-being, in this analysis we use the estimated household-level consumption aggregate constructed by INSTAT.

Definitions: Employment, rural and farm vs non-farm

Although workforce participation is high in Madagascar, formal labor markets are thin in rural areas. Fewer than 6% of those involved in income generating activities are compensated in the form of wages or salaries (Stifel et al., 2007). Given the agricultural orientation of the economy and the importance of family-level production units, most rural workers in this country are self-employed. We therefore adopt for this analysis a broad definition of labor markets that includes self-employment. If a labor market is a place where labor services are bought and sold, then self-employed individuals are seen as simultaneously buying and selling their own labor services.

Two concepts related to the term ‘rural non-farm’ need clarification. First, when we refer to ‘rural’ income (or employment), we mean income earned by rural households. This definition allows for income to be earned anywhere, including urban areas (Barrett et al., 2001).[3] Second, we follow Reardon et al. (2001) and Haggblade et al. (2007) in defining ‘non-farm’ activities as any activities outside agriculture (own-farming and wage employment in agriculture). This definition requires further clarification of what is meant by ‘agriculture’. As described by Reardon et al. (2001:396),

> …agriculture produces raw agrifood products with one of the production factors being natural resources (land, rivers/lakes/ocean, air); the process can involve ‘growing’ (cropping, aquaculture, livestock husbandry, woodlot production) or ‘gathering’ (hunting, fishing, forestry).

Thus, in addition to cropping, agriculture includes livestock husbandry, fishing and forestry. Non-farm production therefore includes industry (e.g. mining, wood products, energy, food and beverages, textiles and leather and construction materials) and services (e.g. commerce, handicrafts, hotels and restaurants, transport, public works and private health). Note that

[2] There are 17,433 *fokontany* (village-level administrative divisions) in Madagascar.

[3] The data do not provide enough information to distinguish whether employment is in urban areas, but questions are asked about distance to the place of work. In 2005, for example, only 18% of wage workers employed in industrial and service jobs traveled more than 5 km to their place of work.

although agro-processing is closely linked to agriculture (e.g. by transforming raw agricultural products) it is classified as non-farm (Haggblade et al., 2007).

Finally, wage earnings were measured in the survey by asking wage-employed individuals how much they earned in terms of cash and in-kind payments. Non-wage (family) farm earnings were measured by estimating household agricultural earnings as a residual (total household consumption less all non-agricultural earnings and transfers). Household agricultural earnings were then divided by the number of household members working on the family farm and deflated regionally to approximate individual non-wage agricultural earnings. We caution that an implicit assumption underlying the use of this approximation of agricultural earnings is that household net savings are zero.[4]

3. Characteristics of rural labor markets and household livelihood strategies

In this section we examine the characteristics of rural labor markets in Madagascar from the perspective of individuals and then analyze these individual outcomes in the context of household livelihood strategies.

Individual outcomes

Rural labor markets in Madagascar are characterized predominantly by agricultural activities. Some 93% of economically active adults (aged 15 to 64) are employed in agriculture in one form or another, whether it is their primary or secondary job. Among primary jobs, 89% are agricultural (see Table 1), nearly all involving non-wage work on the family farm. Only 4% are wage positions.[5] Further, 71% of second jobs (held by 32% of all employed adults) are in agriculture. Unlike primary jobs, however, secondary jobs in agriculture are more likely to be wage positions (64%).

Table 1: Employment among economically active adults (15–64) in rural Madagascar (2005)

		Percent employed in…					
	Percent with	Farm			Non-farm		
	1st or 2nd job	Non-wage	Wage	**Total**	Non-wage	Wage	**Total**
1st job	*100*	85	4	**89**	5	6	**11**
Expenditure quintile							
Poorest	*100*	90	4	**95**	3	3	**5**
Q2	*100*	87	5	**91**	5	4	**9**
Q3	*100*	89	4	**93**	4	4	**7**
Q4	*100*	85	3	**88**	6	7	**12**
Richest	*100*	75	3	**77**	10	12	**23**

4 Another approach, to value agricultural production, was also taken but the unit prices used to value unsold production proved to be problematic.

5 Employment in the questionnaire was defined as activities for which the individual received remuneration. This may explain the low percentage of agricultural wage labor, as reciprocal agricultural labor was not included. In the comprehensive agricultural module of the 2001 EPM survey, we find that reciprocal labor was used on 44% of the plots.

Education level							
None	*100*	90	4	**94**	4	2	**6**
Primary	*100*	86	3	**89**	6	5	**11**
LowSecondary	*100*	71	4	**75**	11	14	**25**
UpperSecondary	*100*	53	3	**56**	11	34	**44**
PostSecondary	*100*	25	3	**28**	10	62	**73**
2nd job	*32*	26	46	**71**	24	4	**29**
Expenditure quintile							
Poorest	*29*	18	61	**78**	17	4	**22**
Q2	*35*	21	53	**74**	22	4	**26**
Q3	*33*	25	47	**73**	23	4	**27**
Q4	*33*	25	42	**67**	28	5	**33**
Richest	*28*	43	21	**65**	30	5	**35**
Education Level							
None	*32*	21	51	**73**	24	3	**27**
Primary	*32*	28	43	**71**	25	5	**29**
LowSecondary	*29*	37	30	**67**	24	9	**33**
UpperSecondary	*36*	50	17	**67**	23	9	**33**
PostSecondary	*27*	63	4	**67**	26	7	**33**

Source: Author's calculations from EPM 2005

Nearly 20% of active adults are employed in some form of non-farm activity. Only 11% of first jobs are in the non-farm sector, whereas 29% of second jobs are non-agricultural (Table 1). This finding is consistent with the notion that individuals are drawn to non-farm employment for their second jobs during periods of slack demand for agricultural labor. Unfortunately, this cannot be verified with the data at hand.

As is commonly found in other African countries (Barrett et al., 2001), there is a positive relationship between rural non-farm employment and welfare as measured by per capita household expenditure.[6] The percentage of workers with non-farm employment rises by expenditure quintile, with 11% employed in the poorest quintile in this sector and 31% in the richest. Among primary employment activities, only 5% were non-farm for those in the poorest quintile, while nearly a quarter were non-farm for those in the richest (Table 1).

As noted earlier, there may be substantial barriers to entry to high-return non-farm activities (Barrett et al., 2001). One such barrier may be lack of skills and education among the poor. As shown in Table 1, there is a strikingly strong positive relationship between educational attainment and non-farm activities among first jobs. For example, only 6% of those with no education are employed in the non-farm sector, compared to 44% of those with upper secondary education and 73% of those with post-secondary. The biggest differences are for wage activities, where 2% of those with no education had non-farm wage employment, compared to 34% of those with upper secondary education and 62% of those with post-

[6] Household expenditures are more accurately defined as consumption as they include not only expenditure items but also own-consumption of household agricultural and non-agricultural production as well as the imputed stream of benefits from durable goods and housing. The consumption aggregate for the EPM 2005 was constructed by INSTAT (2006).

secondary. The education–non-farm employment gradient is not as steep for secondary employment, probably because most non-farm employment among second jobs is in the form of non-wage (85%) rather than wage activities.

The general attraction of non-farm wage employment suggested in Table 1 is further illustrated by the relatively high earnings in this sector (Table 2). With a median of Ar 78,000 per month (approximately US$37),[7] earnings for non-farm wage workers are more than double not only those in the farm sector (Ar 31,000 for non-wage and Ar 38,000 for wage), but also those in the non-farm non-wage sector (Ar 37,000). Interestingly, on the basis of earnings alone, non-farm non-wage employment is not unambiguously preferred to farm activities since there is no clear pattern showing which sector has the higher earnings. As is characteristic of non-farm sectors throughout the developing world, and as will become clearer in this paper, non-farm employment activities in Madagascar are highly heterogeneous (Haggblade et al., 2007).

Table 2: Median monthly earnings of adults (15–64) in rural Madagascar (2005)

Thousands of ariary	Farm			Non-farm		
	Non-wage	Wage	**Total**	Non-wage	Wage	**Total**
1st job	31	38	**31**	37	78	**67**
Expenditure quintile						
Poorest	17	36	**18**	25	48	**28**
Q2	26	38	**27**	21	66	**41**
Q3	31	38	**32**	32	69	**47**
Q4	39	42	**39**	37	78	**63**
Richest	58	44	**58**	67	100	**89**
Education level						
None	29	37	**30**	28	49	**36**
Primary	33	42	**33**	26	72	**48**
LowSecondary	41	37	**40**	70	89	**84**
UpperSecondary	45	29	**45**	75	100	**91**
PostSecondary	38	*173	**45**	195	150	**151**
2nd job	24	20	**21**	22	39	**24**
Expenditure quintile						
Poorest	12	17	**17**	16	29	**18**
Q2	17	22	**20**	20	39	**21**
Q3	23	22	**22**	23	39	**24**
Q4	29	18	**20**	21	37	**22**
Richest	37	30	**35**	32	57	**35**
Education level						
None	23	19	**20**	21	30	**21**
Primary	22	22	**22**	22	35	**24**
LowSecondary	27	25	**26**	31	58	**37**
UpperSecondary	29	*30	**30**	24	*57	**37**
PostSecondary	*28	*40	***28**	*73	*57	**60**

Source: Author's calculations from EPM 2005
Note: 1 USD = approx. 2,100 MGA in 2005.
* Fewer than 20 observations

[7] At the time of the 2005 survey, the exchange rate was approximately Ar 2,100 per US dollar.

The evidence in Table 2 suggests that, in general, individuals may be pressed into non-farm non-wage employment as part of household income diversification strategies designed to reduce risk. Since it is not clear that earnings alone are enough to attract individuals to this sector, *push* factors such as land constraints, risky farming and weak or incomplete financial systems may instead be the forces compelling households to diversify their income sources by allocating household labor to non-farm non-wage employment. Conversely, *pull* factors such as higher earnings appear to be attracting labor to the non-farm wage.

Push factors may also motivate individuals to take on second jobs, particularly those in farming and in non-farm non-wage activities where median earnings are roughly two thirds those of first jobs. Although earnings for second jobs in the non-farm wage sector are approximately half those for first jobs (Ar 39,000 compared to Ar 78,000), they remain attractive relative to all other earnings, whether for first or second jobs.

Monthly farm wage earnings for first jobs are surprisingly high compared to family farm earnings (a median of Ar 38,000 compared to Ar 31,000). There are two possible reasons for this. One may be measurement issues because of the small size of the sample (only 4% of economically active adults) or differences in the definitions of wage and non-wage earnings, and the other may be the seasonal nature of agricultural wage employment. Indeed, median monthly earnings for seasonally wage employed individuals in agriculture are higher than for those with permanent employment (Ar 42,000 compared to Ar 31,000), and among wage employed individuals with permanent jobs, median earnings are similar to those of family farm workers.

Household outcomes

As noted above, in the presence of weak land and financial markets, household non-farm labor supply decisions are made by weighing both productivity and risk factors in the context of household livelihood strategies. Nonetheless, not all activities are available to all households. Diversification strategies may be affected by the constraints that exist for many activities. As Dercon and Krishnan (1996) note, 'the ability to take up particular activities will distinguish the better off household from the household that is merely getting by'. In this section we therefore explore household patterns of labor diversification and identify strategies that can be ordered in welfare terms.

Given that households typically have more than one economically active member, we find that household income sources are more diversified than individual income sources (Table 3). While the percentage of households with at least one member employed in agriculture is the same as the percentage of individuals employed in agriculture (93%), households are more likely than individuals to also derive labor income from non-farm sources. For example, whereas 20% of economically active individuals in rural areas have some sort of non-farm employment, 31% of households in rural areas have at least one member in non-farm employment.

Table 3: Household employment activities* in rural Madagascar (2005)

Percent	Farm			Non-farm		
	Non-wage	Wage	**Total**	Non-wage	Wage	**Total**
Total	92	24	**93**	22	13	**31**
Expenditure quintile						
Poorest	94	28	**96**	15	8	**22**
Q2	94	29	**95**	22	10	**29**
Q3	96	26	**97**	23	10	**31**
Q4	92	21	**93**	25	16	**37**
Richest	81	12	**82**	26	21	**41**

Source: Author's calculations from EPM 2005

* Percent of households with at least one member employed in the various categories

This pattern is seen consistently across the household expenditure distribution. While only 11% of individuals in the poorest quintile have non-farm employment, 22% of households have non-farm employment. Similarly, 31% of economically active individuals in the richest quintile have non-farm jobs compared to 41% of households.

The rural non-farm economy is also a relatively important source of household income (Table 4). On average, households derive 22% of their income from non-farm jobs, whereas for individuals it is 20%. Conversely, although 93% of economically active adults derive at least some of their income from agriculture, only 78% of household income comes from this source.

Table 4: Sources of income by sector of activity in rural Madagascar (2005)

Share of total labor income		Non-farm			
	Farm	*Total*	*Industry*	*Services*	*Total*
2005	78	22	*3*	*19*	100
Poorest	85	15	*3*	*12*	100
Q2	82	18	*2*	*16*	100
Q3	82	18	*4*	*15*	100
Q4	79	21	*2*	*19*	100
Richest	68	32	*4*	*28*	100

Source: Author's calculations from EPM 2005

As with employment, there is a strong positive relationship between non-farm income shares and welfare. Those in the poorest quintile derive 15% of their income from non-farm employment, whereas households in the richest quintile derive more than twice this much (32%). A consequence of this may be that, with non-farm incomes accruing largely to the richer sector, the non-farm economy may lead to greater income inequality (Lanjouw & Feder, 2001).

Livelihood strategies

Is there a way that we can broadly define households in rural Madagascar so as to distinguish them by their livelihood strategies and provide insights into the choices available to them? If so, what distinct livelihood strategies do households adopt and can they be ordered in welfare terms? Identifying livelihood strategies in an informative manner is not straightforward, since a precise operational definition of 'livelihood' remains elusive. Consequently, methods of identifying livelihoods have been varied (Brown et al., 2006).[8] The approach adopted here is a simple one, but it effectively delineates households into categories that facilitate welfare orderings.

To determine these strategies, we begin by categorizing households according to permutations of choices among farm and non-farm and wage and non-wage activities. As Table 5 shows, there are three broad categories – farm activities only, non-farm activities only and combinations of farm and non-farm activities. The distribution of these strategies among the rural population is as follows: 67% live in households that allocate all their labor to agricultural activities, 27% have some members who work in agriculture and some who work off-farm,[9] and only 5% rely solely on non-farm activities for income.[10]

[8] A common method is to group households by income shares (e.g. Dercon & Krishnan, 1996; Barrett et al., 2005). Brown et al. (2006) used cluster analysis to identify livelihood strategies in the rural Kenyan highlands, but while this approach is intuitively appealing, a similar exercise carried out with the EPM data resulted in strategies for which no stochastic dominance orderings could be established.

[9] This is consistent with Haggblade's (2007) observation that 'most rural non-farm activities are undertaken by diversified households that operate farm and non-farm enterprises simultaneously'.

[10] We ignore those households whose sole source of income is non-labor income since these are made up mostly of the elderly, who do not actively participate in the labor market.

Table 5: Household livelihood strategies in rural Madagascar (2005)

	Percent pursuing each strategy							
	Expenditure quintile						Poverty	
	Poorest	Q2	Q3	Q4	Richest	Total	Headcount	Depth
Livelihood strategies								
Only farm	**77**	**71**	**66**	**64**	**55**	**67**	**78**	**31**
Family & wage farm	22	25	19	19	9	19	85	34
Wage farm only	1	1	1	0	0	1	83	42
Family farm only	53	45	47	46	46	47	75	30
Farm & non-farm	**20**	**25**	**30**	**30**	**29**	**27**	**70**	**25**
Family & wage farm and non-farm	3	4	5	3	3	4	79	30
Wage farm and non-farm	1	1	0	1	1	1	71	30
Family farm and non-farm	16	19	25	26	25	22	69	25
- Non-wage non-farm	*11*	*14*	*16*	*16*	*15*	*14*	*71*	*26*
- Non-wage & wage non-farm	*1*	*2*	*1*	*2*	*1*	*1*	*69*	*23*
- Wage non-farm	*4*	*4*	*8*	*8*	*8*	*6*	*63*	*22*
Only non-farm	**2**	**3**	**2**	**4**	**13**	**5**	**39**	**15**
Non-wage & wage non-farm	0	1	1	1	3	1	38	12
Non-wage non-farm	1	1	1	1	3	1	46	18
Wage non-farm	1	1	1	2	6	2	37	14
Non-labor income	**2**	**2**	**1**	**1**	**3**	**2**	**57**	**24**
Total	***100***	***100***	***100***	***100***	***100***	***100***	***73***	***29***

Source: Author's calculations from EPM 2005

Although there is some overlap within these three categories, there is also a clear overall welfare ordering. Poverty rates are highest among households that rely exclusively on farming (78%) and lowest among those that rely solely on non-farm activities (39%). Although the poverty rate for households that adopt both farm and non-farm activities is lower than the rural poverty rate, it is still high at 70%.

What is most striking is that despite seemingly high agricultural wage earnings (Table 2), households with members involved in agricultural wage activities tend to be the among the poorest. For example, households that combine family farming with wage farming have the highest poverty rates (85%) and are concentrated at the lower end of the income distribution (e.g. 22% of the poorest expenditure quintile compared to 9% of the richest quintile). Further, of the 1% living in households that rely solely on agricultural wage labor, 83% are poor. Indeed these households are poorer than any other group as measured by the depth of poverty.[11] This suggests that households may be resorting to agricultural wage activities as an ex post reaction to low farm income or because of various ex ante push factors. For this analysis we therefore define a distinct livelihood strategy in which households resort to

[11] This is the P_1 measure in the Foster et al. (1984) class of poverty measures.

agricultural wage activities ('any agricultural wage' or AW). This category of households includes those with family farm or non-farm activities, or both, as long as at least one member of the household worked for a wage in agriculture. Nearly a quarter of the rural population lives in a household in this category, and 83% of them are poor.

The other three distinct strategies follow naturally from Table 6 and are illustrated along with AW in this table. The first identifies households that rely solely on family farming (FF). These account for 47% of the rural population, 75% of whom are poor. The second identifies the 22% of the rural population who live in households with members involved in both family farm and non-farm activities (FFNF). As Table 5 shows, these households' non-farm activities are primarily non-wage family enterprises (72%). The poverty rate for this group is even lower at 69%. Finally, the third identifies 5% of the rural population, 39% of whom are poor and live in households whose income is solely from non-farm activities (NF). Unlike the FFNF households, those living in NF households are predominantly in wage employment (73%).

Table 6: Aggregated household livelihood strategies in rural Madagascar (2005)

	Percent pursuing each strategy							
	Expenditure quintile						Poverty	
	Poorest	Q2	Q3	Q4	Richest	Total	Headcount	Depth
Livelihood strategies								
Any farm wage	27	31	24	23	13	24	83	33
Family farm only	53	45	47	46	46	47	75	30
Family farm & non-farm	16	19	25	26	25	22	69	25
Non-farm only	2	3	2	4	13	5	39	15
Non-labor income	2	2	1	1	3	2	57	24
Total	*100*	*100*	*100*	*100*	*100*	*100*	*73*	*29*

Source: Author's calculations from EPM 2005

Besides being chosen by differing poverty levels, these strategies also differ in the returns they offer across nearly the entire distribution of income. This suggests a clear welfare ordering in that some strategies are superior to others because they bring in more income. Appealing to dominance analysis as a way of testing for the existence of such superior strategies (Brown et al., 2006), in Figure 1 we plot the cumulative frequencies of per capita household consumption for each of the four household types. The idea is that dominance tests permit us to make ordinal judgments about livelihood strategies on the basis of the entire distribution of household well-being, not just particular points (such as the poverty line). Specifically, pairs of livelihood-specific distributions are compared over a range of consumption values. One distribution is said to first-order dominate the other if and only if the cumulative frequency is lower than the other for every possible consumption level in the range (Ravallion, 1994). The implication of this lower distribution is that there is a greater likelihood that households adopting this strategy will have higher consumption levels.

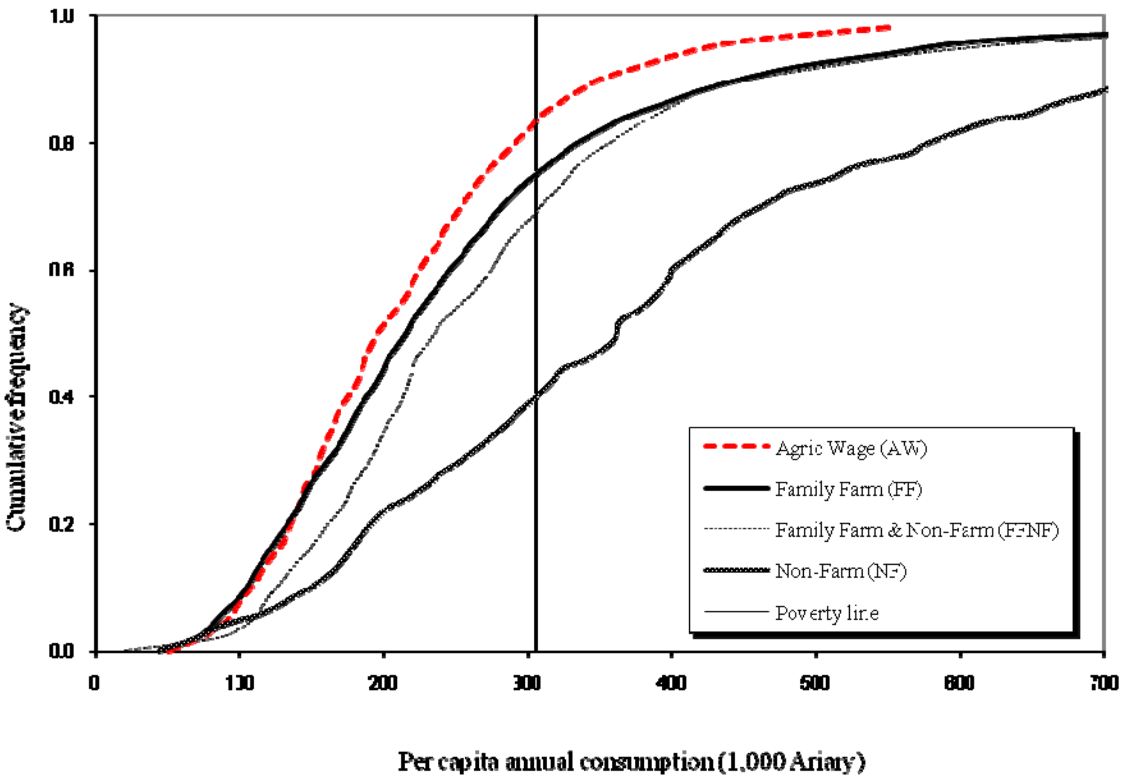

Figure 1: Cumulative frequency of household consumption by livelihood strategy

Figure 1 shows that at very low levels of consumption there is no clear ordering of strategies.[12] However, for the 91% of households with per capita consumption levels of Ar 120,000 and above, NF first-order dominates the other three strategies.[13] In other words, on the basis of this criterion, NF is a superior strategy. Similarly, the FFNF strategy dominates FF up to a value of Ar 375,000. Further, since FF dominates AW for all consumption values above Ar 150,000 (these two distributions are indistinguishable for values below this), AW is inferior to the other three strategies. Thus, strategies that include some non-farm employment are superior to those that rely solely on farming or some form of farm wage employment.

4. Analysis of rural household livelihood strategies

Barrett et al. (2001:316) observe that 'The positive wealth-non-farm correlation may also suggest that those who begin poor in land and capital face an uphill battle to overcome entry

[12] This follows partly because there are so few households at the lower tails. Note further that because the distributions cross multiple times at the lower tails, tests of second and third order dominance also prove inconclusive in terms of ordering the distributions. These tests place more weight on differences at the lower end of the distribution than the test of first order dominance does.

[13] We also statistically test the vertical difference between the NF distribution and each of the other distributions (Davidson & Duclos, 2000; Sahn & Stifel, 2002). For 100 test points between Ar 120,000 and Ar 400,000, the null hypothesis that the difference in the cumulative frequencies is zero was rejected. We thus conclude that the frequency distributions are different over this range.

barriers and steep investment requirements to participation in non-farm activities capable of lifting them from poverty'.

The evidence from Section 3 above indicates that there are superior household livelihood strategies associated with non-farm employment. This naturally makes us ask why so few rural households choose the dominant strategies (5% for NF and 22% for FFNF). The next question is whether there are barriers that prevent households from adopting these strategies.

To address this, we analyze rural household livelihood strategy choice using multinomial logit models. The choices, ordered from inferior to superior, are those described above: (a) any agricultural wage (AW), (b) family farming only (FF), (c) family farm and non-farm activities (FFNF) and (d) non-farm activities only (NF). The estimated effects in these models should not be interpreted literally as *determinants* of choices for two reasons. First, unobserved household characteristics such as motivation and entrepreneurship may be correlated with both the observed characteristics (access to credit, ownership of durable goods, etc.) and the chosen livelihood strategy. In such cases, the endogeneity bias of the parameter estimates cannot be ruled out. Second, since not all the choices will necessarily be available to each household, the parameters should be interpreted as reduced form estimates of how household and community characteristics affect the probabilities that households are *able* to choose one of the four livelihood strategies. The household and community covariates used in the estimates are summarized in Table 7.

Table 7: Summary statistics for models of household livelihood strategy choice in rural areas

Sample: ***All households with labor income in rural areas***	Any agric. wage		Family farm only		Family farm and non-farm		Non-farm only	
	mean	std dev	mean	std dev	mean	std dev	mean	std dev
Age of household head	41.6	12.0	43.5	13.0	43.3	11.2	40.9	11.7
Female household head (dummy)	0.136	0.343	0.125	0.331	0.129	0.335	0.230	0.421
Migrant (dummy)	0.084	0.278	0.067	0.250	0.092	0.289	0.195	0.397
Household structure								
Household size (number of members)	6.289	2.476	6.014	2.499	6.423	2.536	4.806	1.813
Share of children < 5	0.166	0.152	0.135	0.150	0.157	0.152	0.118	0.145
Share of children 5–14	0.327	0.194	0.332	0.201	0.323	0.192	0.306	0.216
Share of men 15–64†	0.239	0.151	0.255	0.157	0.243	0.152	0.260	0.194
Share of women 15–64	0.252	0.129	0.257	0.137	0.268	0.139	0.306	0.172
Share of members 65+	0.015	0.061	0.020	0.075	0.010	0.045	0.010	0.058
Education dummies – most educated member								
Primary	0.558	0.497	0.498	0.500	0.459	0.499	0.272	0.445
Lower secondary	0.075	0.263	0.106	0.308	0.180	0.384	0.249	0.433
Upper secondary	0.032	0.176	0.040	0.196	0.089	0.284	0.189	0.392
Post secondary	0.007	0.081	0.008	0.086	0.037	0.189	0.170	0.376
Radio (dummy – HH owns one)	0.479	0.500	0.509	0.500	0.663	0.473	0.664	0.473
Non-labor income (log)	2.64	4.47	2.02	4.23	2.53	4.50	3.37	5.19
Value of agricultural assets (log)	2.14	1.40	2.53	1.80	2.52	1.57	0.57	1.16
Land holding dummies								
None	0.046	0.210	0.016	0.124	0.031	0.173	0.828	0.377
< 1 hectare†	0.530	0.499	0.238	0.426	0.350	0.477	0.069	0.254
1–3 hectares	0.318	0.466	0.502	0.500	0.441	0.497	0.081	0.273
3–5 hectares	0.072	0.259	0.140	0.347	0.095	0.294	0.007	0.083

5–10 hectares	0.021	0.142	0.057	0.231	0.045	0.208	0.008	0.091
10+ hectares	0.012	0.110	0.048	0.214	0.037	0.190	0.006	0.080
Difficult access to formal credit (dummy)	0.54	0.50	0.52	0.50	0.46	0.50	0.50	0.50
Community characteristics								
MFI available in community	0.518	0.500	0.424	0.494	0.431	0.495	0.468	0.500
Phone (dummy at least one HH owns)	0.018	0.132	0.031	0.172	0.082	0.275	0.440	0.497
Electricity access (dummy)	0.072	0.258	0.083	0.275	0.076	0.266	0.541	0.499
Piped water access (dummy)	0.508	0.500	0.406	0.491	0.473	0.499	0.615	0.487
Distance to nearest city (dummies)								
<2 hours	0.051	0.220	0.053	0.224	0.091	0.287	0.351	0.478
2–5 hours	0.226	0.419	0.214	0.410	0.225	0.418	0.228	0.420
5–10 hours†	0.355	0.479	0.174	0.379	0.174	0.379	0.097	0.296
10–15 hours	0.095	0.293	0.104	0.306	0.099	0.299	0.082	0.274
15–24 hours	0.101	0.301	0.074	0.262	0.088	0.283	0.051	0.220
24+ hours	0.173	0.378	0.380	0.486	0.323	0.468	0.192	0.394
Percent with labor income in each category	24		48		23		5	
Sample size	1,085		3,065		1,143		366	

Source: Data from EPM 2005

† Left out category in the estimates

The estimated marginal effects that appear in Table 8 are interpreted as the average change in the probability of a household selecting a particular livelihood strategy corresponding to a one unit change in the independent variables. Because the average marginal effects are shown instead of the estimated coefficients, all four livelihood strategies (including the left-out category) can be shown. The marginal effects sum to zero across the categories.[14]

Table 8: Regression analysis of household livelihood strategy choice in rural areas

Multinomial logit *Sample:* ***All households with labor income in rural areas***	Any agric. wage			Family farm only			Family farm and non-farm			Non-farm only		
	Marg effect	t-val		Marg effect	t-val		Marg effect	t-val		Marg effect	t-val	
Age of household head	-0.001	-3.06	***	0.000	0.79		0.001	1.52		0.000	0.93	
Female household head (dummy)	0.01	0.40		-0.04	-2.32	**	0.02	1.28		0.01	2.10	**
Migrant (dummy)	0.02	1.16		-0.06	-3.17	***	0.04	2.03	**	0.01	1.18	
Household structure†												
Household size (number of members)	0.012	4.67	***	-0.013	-4.08	***	0.006	2.02	**	-0.005	-3.30	***
Share of children < 5	0.00	-0.03		0.00	-0.06		0.00	0.10		0.00	0.00	
Share of children 5–14	0.00	-0.02		0.00	0.00		0.00	0.01		0.00	0.04	
Share of women 15–64	0.00	-0.05		0.00	-0.05		0.00	0.10		0.00	-0.01	
Share of members 65+	0.01	0.08		0.01	0.10		-0.02	-0.16		0.00	0.05	
Education dummies - most educated member												
Primary	0.01	0.57		-0.04	-3.33	***	0.03	2.63	***	0.00	0.77	
Lower secondary	-0.07	-4.77	***	-0.12	-5.71	***	0.14	6.03	***	0.05	4.58	***
Upper secondary	-0.06	-2.96	***	-0.21	-7.33	***	0.20	6.17	***	0.07	4.19	***
Post secondary	-0.10	-3.89	***	-0.33	-7.71	***	0.34	6.58	***	0.09	3.64	***

[14] The left-out category in the estimation is FF. Note that the sample does not include those households without any labor income.

Radio (dummy - HH owns one)	-0.03	-3.14	***	-0.04	-3.41	***	0.06	5.25	***	0.01	1.70	*
Non-labor income (log)	0.00	0.03		0.00	-0.02		0.00	-0.01		0.00	0.03	
Value of agricultural assets (log)	0.00	0.09		0.00	0.43		0.00	0.32		0.00	-1.96	**
Land holding dummies††												
None	0.07	2.75	***	-0.29	-9.63	***	-0.12	-6.49	***	0.33	7.32	***
1–3 hectares	-0.06	-6.60	***	0.08	5.79	***	-0.02	-1.53		0.00	0.08	
3–5 hectares	-0.07	-5.28	***	0.14	6.79	***	-0.05	-3.22	***	-0.01	-0.91	
5–10 hectares	-0.09	-4.50	***	0.13	4.64	***	-0.06	-2.64	***	0.01	0.91	
10+ hectares	-0.07	-3.32	***	0.07	2.45	**	0.00	-0.16		0.01	0.33	
Difficult access to formal credit (dummy)	0.04	3.72	***	-0.01	-1.11		-0.02	-1.99	**	0.00	-0.82	
Community characteristics												
MFI available in community	-0.03	-2.42	**	0.06	3.73	***	-0.02	-1.19		-0.01	-2.75	***
Phone (dummy at least one HH owns)	0.00	-0.11		-0.11	-3.91	***	0.09	3.17	***	0.03	2.62	***
Electricity access (dummy)	-0.02	-1.23		0.06	2.84	***	-0.06	-3.21	***	0.01	1.70	*
Piped water access (dummy)	0.01	1.39		-0.03	-2.60	***	0.01	0.87		0.01	1.82	*
Distance to nearest city (dummies)†††												
< 2 hours	0.02	0.69		-0.05	-1.74	*	0.04	1.41		0.00	-0.42	
2–5 hours	-0.01	-1.00		0.05	2.63	***	-0.04	-2.36	**	0.00	0.26	
10–15 hours	0.01	0.70		-0.06	-2.64	***	0.05	2.16	**	0.00	0.00	
15–24 hours	0.07	2.80	***	-0.10	-3.82	***	0.05	1.82	*	-0.01	-1.62	
24+ hours	-0.03	-1.88	*	0.00	-0.24		0.05	2.49	**	-0.01	-2.10	**
Percent with labor income in each category	24			48			23			5		
Percent correctly predicted										63		
Number of observations										5,659		
Pseudo R-squared										0.31		

Source: Data from EPM 2005

Note: Region dummies included but not shown. Left out strategy in estimation is 'Family farm only'.

Note: Marginal effects show the average change in the probability of chosen strategy resulting from a unit change in the independent variable. Consequently the marginal effects sum to zero across the categories.

† Left out category is share of men 15-64; †† Left out category is < 1 hectare; ††† Left out category is 5–10 hours.

Three potential barriers to participation in high-return non-farm activities by households are highlighted in the model estimates. First, households with higher levels of educational attainment tend to be those who choose the dominant NF and FFNF strategies. The measure of household education used here is the education level of the most educated member of the household.[15] Households in which the most educated member attained a lower (upper) secondary level of education are 14% (20%) more likely to adopt a FFNF strategy than those with no education at all. Households with less education are most likely to adopt the least remunerative AW and FF strategies. Given the positive relationship between household welfare and education in Madagascar (Amendola & Vecchi, 2007), poor households with

[15] In doing so, we assume that there are household public good characteristics to education. Basu and Foster (1998) suggest that literacy may have public good characteristics in the household and formalize an 'effective' literacy rate based on this aspect of education (See also Valenti, 2001; Basu et al., 2002). Sarr (2004) finds evidence from Senegal that illiterate members of households benefit from the earnings of literate members. Almeyda-Duran (2005) also finds that in some situations there are child health benefits to village level proximity to literate females.

low levels of education generally face greater barriers than the non-poor in their choices of high-return livelihood strategies.

Second, households without access to formal credit[16] tend to adopt inferior AW strategies and are less likely to combine family farming with non-farm activities. For those households adopting AW strategies, credit market failures may be a barrier to adopting any of the higher-return livelihood strategies. For the FFNF, some households may indeed engage in non-farm activities because they have access to credit, as the model estimates suggest. But given the measure of credit access used in this model, the result is also consistent with the notion that farm households may engage in non-farm activities as a means of generating cash to substitute for the absence or high cost of credit. The idea is that they do this in order to purchase agricultural inputs or to make farm investments (Ellis, 1998). In the measure of access used here, households that are not classified as 'having difficulty accessing formal credit' in the EPM data include those that report not seeking credit because they either (a) did not need it (9%) or (b) did not want to have any debt (33%). Indeed, the source of start-up financing for household non-farm enterprises is predominantly household saving (78%). It may be households such as these that rely on non-farm activities to accumulate cash savings as a substitute for the absence of credit markets.[17]

In an effort to address the potential endogeneity of the household-specific credit access measure and to measure an independent effect of credit availability, a community-level variable is included in the model to indicate the presence of a microfinance institution (MFI).[18] As expected, the presence of an MFI is associated with lower probabilities of households adopting AW strategies. However, it is also associated with a 1% decrease in the probability of adopting the preferred NF strategy. Indeed, households living in communities with MFIs present are 6% more likely to adopt FF strategies. This result is consistent with non-farm activities substituting for the absence of credit markets. However, it may also be because MFIs target poorer communities (Zeller et al., 2003). Such targeting can lead to biased estimates of the effect of MFI availability on livelihood choice (Pitt et al., 1993).

Third, households with access to forms of outside communication have a greater likelihood of choosing the dominant livelihood strategies. For example, households owning a radio are 6% more likely to have members undertaking a preferred strategy of participating in both family farming and non-farm activities. Similarly, those that live in villages in which at least one household has a phone are 11% more likely to have members involved in non-farm activities. Admittedly, owning a radio could be a consequence of higher earnings associated with the dominant strategy.[19] We therefore proceed with caution with regard to radio access, and emphasize the effect of village access to telecommunications as measured by at least one household owning a phone.[20] This form of communication represents access to information

[16] Households are categorized as such when they have sought loans from formal institutions (banks or microfinance institutions) and were turned down, or if they report not applying for loans because (a) procedures are too complicated, (b) interest rates are too high, (c) they do not know the procedures, (d) they do not have collateral, or (e) they do not know of a lending institution.

[17] Although their livelihood strategies differ slightly from those identified here, Brown et al. (2006) similarly found that liquidity constraints appear to hamper the ability of households in the rural Kenyan highlands to diversify into high-return activities.

[18] The presence of a formal sector bank has no effect.

[19] Radio ownership has been used as a proxy for household welfare either as an asset (Sahn & Stifel, 2000) or as a predictor of household consumption (Stifel & Christiaensen, 2007).

[20] The model was also estimated using various measures of community radio access in an effort to address the endogeneity issue. One variant included a dummy variable for villages with at least one radio. Since over 98%

about price and market conditions outside the community. Households living in communities without such access are more likely to allocate labor to farming activities geared toward home consumption and the local market – i.e. those activities that are likely to have lower remunerative rewards.[21]

Turning to other correlates of household livelihood strategy choice, it is interesting to note that although households living in rural communities with electrification are slightly more likely to adopt the dominant NF strategies (1%) they are even more likely to concentrate solely on family farming (6%). Households living in such communities are *less* likely to adopt the second best strategy of mixed family farming and non-farm activities (6%). Despite the mixed results, one lesson to be learned from the data is that although households adopting NF strategies tend to be situated in communities with electricity access (e.g. 54% of NF households have electricity compared to 9% for all other households; see Table 7), such access is not a sufficient condition for participation in non-farm employment activities. This may be due to endogenous placement of electrification or the bundling of electrification with other infrastructure variables, or both.

Remoteness may affect the choice set of livelihood strategies available to households by affecting transaction costs and by determining the degree of access to markets and to market information. This is consistent with the multinomial logit model estimates where travel time to the nearest city serves as a proxy for remoteness and transaction costs. With increased travel times, households are less likely to rely on family farming alone and more likely to combine family farming activities with non-farm activities. For example, households that live 15 to 24 hours away from a major city are 10% less likely to adopt FF strategies and 5% more likely to adopt FFNF strategies. This is consistent with the notion that agricultural surplus can more easily be marketed to urban areas in less remote areas, while competition in the non-farm sector is greater in the vicinity of urban areas (Lanjouw & Feder, 2001). Finally, households living more than 15 hours away from the nearest city are 1 to 2% less likely to undertake wage-dominated NF strategies.

Access to land has differential effects on household strategy choice. This being the case, these estimates neither confirm nor refute the claim that those poor in land holdings face entry barriers. For example, while households with more land are less likely to adopt AW strategies, they are more likely to concentrate their household labor solely in family farming. This is not surprising since land is an important agricultural input for farming households.[22]

Not only are landless households 7% more likely to adopt AW strategies that are inferior to those of smallholder households (less than one hectare), they are also 33% more likely than any landed households to adopt superior NF strategies. Whether inferior AW strategies or superior NF strategies are chosen by landless households probably depends on other characteristics that enable them to overcome the barriers to participation in non-farm activities.[23]

---

of villages fall into this category, little effect was found. Similarly, no effect was found when using a variable indicating the share of households in the community with radios.

[21] This is consistent with Randrianarisoa et al.'s (2009) finding using 2001 data, that demand for hired non-farm labor in rural Madagascar is stimulated by similar access to information.

[22] Similarly, households with more non-land agricultural assets are also less likely to concentrate all of their labor efforts in non-farm activities.

[23] These estimates may also suffer from endogeneity bias as lack of land ownership may be correlated with unobserved household characteristics that are themselves correlated with advantages available to those working in non-farm wage employment.

The relationship between land holdings and the choice of the FFNF strategy is nonlinear. Households that are more likely to adopt this strategy are either those with small land holdings (less than three hectares) or large land holdings (ten or more hectares). Those with medium-sized land holdings (three to five hectares) are 5 to 6% less likely to combine family farming with non-farm employment. This may follow from household labor constraints on the farm, since more land requires more household labor input. Although large holders are also affected by these constraints, they are also more likely to be wealthier and more capable of hiring labor. Such households are in a better position to invest in the human capital of their family members and to diversify into non-farm activities.

5. Analysis of rural employment and labor earnings

Since the ability of households to diversify their income sources depends to a large extent on the characteristics of their economically active members, we now use regression analysis to address rural employment patterns and earnings. This permits us to tackle the question of how barriers to participation in non-farm activities are associated with individual as well as household characteristics. We also assess the characteristics associated with earnings, once employment choices are made, by estimating earnings functions. In this context, we are able to further disaggregate the non-farm sector further into non-wage and wage activities (Malchow-Møller & Svarer, 2005).

Rural employment

We start with multinomial logit choice models similar to those in the previous section. In this case, however, instead of households the sample is made up of all 13,339 economically active individuals living in rural areas. Their employment is characterized as (a) agricultural wage, (b) family farming, (c) non-farm non-wage or (d) non-farm wage. Although there is considerable overlap in the distribution of earnings among these four employment types, they are roughly ordered in welfare terms (lowest annual earnings to highest on average). Separate models are estimated for primary and secondary employment, though only the former are presented here (Table 9).[24]

Table 9: Regression analysis of primary employment in rural areas

Multinomial logit

Sample: ***First jobs held by adults (15+) in rural areas***	Agric. wage			Family farm			Nonfarm non-wage			Nonfarm wage		
	Marg effect	t-val		Marg effect	t-val		Marg effect	t-val		Marg effect	t-val	
Individual characteristics												
Female (dummy)	-0.01	-1.23		-0.01	-1.54		0.03	4.15	***	-0.01	-2.50	**
Age	0.000	1.68	*	-0.001	-2.86	***	0.001	2.64	***	0.000	0.13	
Household head (dummy)	-0.02	-4.94	***	0.02	1.43		-0.01	-1.74	*	0.02	1.95	*
Spouse of household head (dummy)	-0.02	-5.59	***	0.02	2.17	**	0.00	-0.21		0.00	0.10	
Migrant (dummy)	0.00	-0.28		-0.04	-3.68	***	0.01	1.94	*	0.02	3.77	***
Education dummies†												
Primary	-0.01	-3.85	***	-0.02	-3.16	***	0.02	3.06	***	0.02	3.12	***
Lower secondary	-0.01	-3.67	***	-0.09	-7.20	***	0.04	4.06	***	0.07	6.75	***

[24] The secondary employment estimates are available on request from the author.

Upper secondary	-0.02	-2.29	**	-0.22	-8.24	***	0.05	2.88	***	0.19	8.06	***
Post secondary	0.00	-0.22		-0.39	-8.18	***	0.04	1.53		0.36	8.33	***
Household characteristics												
Female household head (dummy)	0.01	1.70	*	-0.06	-4.77	***	0.04	4.03	***	0.01	0.69	
Age of household head	0.00	-2.76	***	0.00	2.89	***	0.00	-2.13	**	0.00	0.20	
Household Structure												
Household size (no. of members)	0.001	0.84		-0.002	-1.68	*	0.000	-0.31		0.002	2.10	**
Share of children < 5††	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Share of children 5–14	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Share of women 15–64	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Share of members 65+	0.00	0.00		0.00	0.01		0.00	0.01		0.00	-0.02	
Radio (dummy - HH owns one)	0.00	-1.10		-0.03	-5.42	***	0.03	5.43	***	0.01	2.45	**
Non-labor income (log)	0.00	0.00		0.00	-0.01		0.00	0.00		0.00	0.02	
Value of agricultural assets (log)	0.00	-0.03		0.00	0.24		0.00	-0.13		0.00	-0.19	
Land holding dummies†††												
None	0.12	6.81	***	-0.45	-19.15	***	0.18	9.13	***	0.15	8.30	***
1–3 hectares	-0.01	-4.05	***	0.04	7.13	***	-0.01	-3.03	***	-0.01	-3.37	***
3–5 hectares	-0.01	-3.18	***	0.05	7.45	***	-0.02	-2.72	***	-0.02	-4.64	***
5–10 hectares	-0.01	-2.49	**	0.04	3.95	***	-0.01	-0.93		-0.02	-2.51	**
10+ hectares	-0.01	-1.28		0.01	0.43		0.00	-0.13		0.01	0.62	
Difficult access to formal credit (dummy)	0.01	3.67	***	-0.02	-3.23	***	0.00	0.27		0.00	0.90	
Community characteristics												
MFI available in community	0.01	1.34		0.01	2.06	**	-0.01	-1.51		-0.01	-3.20	***
Phone (dummy at least one HH owns)	0.01	0.82		-0.10	-5.60	***	0.06	4.81	***	0.02	2.96	***
Electricity access (dummy)	-0.01	-2.41	**	-0.01	-0.72		-0.02	-2.70	***	0.03	4.14	***
Piped water access (dummy)	0.00	1.00		-0.03	-4.52	***	0.02	3.26	***	0.01	2.17	**
Distance to nearest city (dummies)††††												
< 2 hours	0.01	1.17		-0.05	-3.24	***	0.04	2.83	***	0.01	0.63	
2–5 hours	0.00	0.54		0.00	-0.31		-0.01	-0.91		0.01	0.98	
10–15 hours	-0.01	-1.62		-0.02	-1.55		0.02	1.77	*	0.01	1.22	
15–24 hours	0.01	1.78	*	-0.02	-1.78	*	0.00	-0.42		0.01	1.32	
24+ hours	0.00	-0.81		0.00	0.36		0.00	-0.35		0.00	0.55	
Percent in each category	4			85			5			6		
Number of observations										13,339		
Pseudo R-squared										0.30		

Source: Data from EPM 2005

Note: Region dummies included but not shown. Left out category is ‘agricultural non-wage’.

Note: Marginal effects show the average change in the probability of ‘sector’ of employment resulting from a unit change in the independent variable. Consequently the marginal effects sum to zero across the categories.

† Left out category is no education; †† Left out category is men 15–64; ††† Left out category is < 1 hectare; †††† Left out category is 5–10 hours

As with the household livelihood choice models, education is associated with higher probabilities of non-farm employment. Individuals with a lower (upper) secondary education are 7% (19%) more likely to work in non-farm wage activities than those with no education. Such individuals are particularly less likely to work on the family farm for their primary employment. In the context of household livelihood strategies, this suggests that in households adopting FFNF strategies members with less education are more likely to remain on the farm, while those with more education perform higher-paying non-farm wage activities. Interestingly, members with higher levels of education are also more likely to help out on the family farm for their second jobs – perhaps contributing their labor during peak agricultural demand periods (e.g. field preparation, planting, transplanting and harvest).

Although statistically significant, the relationship between credit and individual employment is small. Those living in households without access to credit are 1% more likely to be involved in agricultural wage employment and 2% less likely to work on the family farm (non-farm non-wage). These small individual effects nonetheless do add up for the household unit as a whole, given that this is a household-level constraint. The finding that individuals in credit constrained households are those who are more likely to resort to agricultural wage labor (associated with low-return household livelihood strategies) is consistent with the household choice models in Section 4 and with previous research on the importance of credit to household livelihood choice and welfare (Dercon & Krishnan, 1996; Ellis, 1998; Brown et al., 2006).

Access to communication devices (radio and phone) has relationships with individual employment similar to those it has with household livelihood strategies. Those with such access are more likely to engage in higher-return non-farm activities and are less likely to work on the family farm as their primary form of employment.

The individual choice models shed additional light on the relationship between rural electrification and employment opportunities. Electricity access in the community is associated with more non-farm wage employment, but not with non-farm non-wage activities. This is consistent with the household livelihood models in which a positive relationship was found between electricity access and NF strategies where the bulk of non-farm jobs undertaken by these households are wage activities (73%). It is also consistent with the negative relationship found between electricity access and FFNF strategies, given that the non-farm activities for these households are predominantly non-wage (72%).

For the 90% of the rural population living in villages without electricity, high-return non-farm employment opportunities are more limited. Of those with higher paying non-farm wage jobs, 36% live in communities with electricity access, compared to less than 10% of those with lower-return non-farm wage employment. Nonetheless, because electrification in communities is most certainly not randomly placed, it is difficult to establish the causal relationship. For example, while access to electricity may create more non-farm employment opportunities, dynamic communities with more non-farm employment may be better positioned to establish electricity connections in the first place.

Interestingly, although we find no clear pattern with regard to remoteness (travel time to city) and first jobs, there appears to be a more systematic relationship with second jobs. In the most remote areas, secondary employment tends to be concentrated in non-farm non-wage activities that involve providing services in the local market. These non-farm activities may fill a gap created by the high transaction costs associated with remoteness and the consequent restricted access to major markets. Further, this pattern of diversification may also be driven by the seasonal nature of agricultural calendar as individuals seek out employment opportunities during the periods of slack demand for agricultural labor (Ellis, 1998).

Because households in the less remote areas (two to five hours) are more likely to specialize in family farming, individuals in these areas are 10% more likely to only have one job (i.e.

on the family farm) than those who live five to ten hours away from major cities. This may follow from higher returns to agriculture in less remote areas (Stifel & Minten, 2008), inducing households to concentrate their household labor in family farming.

Except for those individuals who live in households with large land holdings (ten hectares or more), there is a positive association between land holdings and family farming. For example, those with between one and ten hectares of land are 4 to 5% more likely to work on the family farm than are small holders (with under one hectare), while those who are landless are 45% less likely to do so. With landless individuals 18% and 15% more likely to work off-farm in non-wage and wage activities, respectively, non-farm employment for these individuals appears to be a result of 'push' factors. However, landless individuals are 25% *more* likely than small holders to only have one job. This suggests that the relative returns to employment for the landless (e.g. non-farm activities) are higher than for small holders who are most likely to be family farmers. These individuals may in fact be landless because they are unable to find high-return employment.

Turning to other individual correlates, we find that women are significantly more likely to be employed as non-wage workers in the non-farm sector (3% more than for men), but are less likely to undertake non-farm wage work.[25] As individuals get older, they are less likely to work on the family farm and more likely to undertake non-wage employment off the farm. While household heads and their spouses are less likely to work as agricultural wage laborers, household heads are more likely to find non-farm wage work, while their spouses are more likely to remain on the family farm. Those who migrated to their current location within the past five years are more likely to be involved in non-farm activities and less likely to work on a family farm.

Rural labor earnings

We now turn to econometric estimates of earnings and, by extension, the correlates of employment quality once an individual has 'chosen' a sector. In particular, earnings functions are estimated separately for those who are employed in (a) agricultural wage, (b) family farming, (c) non-farm non-wage or (d) non-farm wage activities (Table 10). The dependent variable in each of these models is the log of real daily earnings.[26] The explanatory variables are typical of those found in standard Mincerian earnings functions and include experience,[27] levels of education, hours worked, a dummy variable that takes on a value of one if the individual is female, and controls for location (not shown). We also control for selection bias by using a correction method proposed by Bourguignon et al. (2002). This is an extension of Lee's (1983) method in which the selectivity is modeled as a multinomial logit, rather than as a probit (Heckman, 1979). The multinomial logit selection models are based on those that appear in the previous section.

[25] Lanjouw (2001) had a similar finding based on probit models for El Salvador where women were more likely than men to be employed in low-productivity non-farm activities. He did not find a significant difference, however, for high productivity jobs.

[26] Since we use the log of earnings, the estimated coefficients represent a percentage change in earnings for a one unit change in the independent variable.

[27] Experience is difficult to measure because we do not know when individuals began working. Here we use the difference between individual's age and the number of years of schooling plus five years. It is important to account for experience because experience and educational attainment are negatively correlated. Since experience is likely to contribute positively to earnings (up to a point), the error terms in the estimated models are likely to be negatively correlated with educational attainment if experience is not included as an explanatory variable. The result is likely to be a downward bias in the estimates of returns to schooling.

Table 10: Regression analysis of daily labor earnings in rural Madagascar (2005)

Dependent variable = log(daily earnings)												
Sample: ***Primary jobs of all rural adults (15-64)***	Agric. wage			Family farm			Non-farm non-wage			Non-farm wage		
	Coef.	t-value		Coef.	t-value		Coef.	t-value		Coef.	t-value	
Farm												
Hours worked per day	0.03	1.92	*	0.00	0.13		0.07	3.63	***	0.04	3.12	***
Experience	0.02	0.93		-0.01	-2.22	**	-0.03	-1.37		0.01	0.69	
Experience-squared	-0.0002	-0.66		0.0002	1.95	*	0.0005	1.13		0.0000	0.10	
Education†												
Primary education dummy	0.14	1.83	*	-0.02	-0.91		-0.09	-0.79		0.36	2.87	***
Lower secondary education dummy	0.22	1.32		0.10	2.92	***	0.48	2.51	**	0.71	2.93	***
Upper secondary education dummy	0.47	1.33		0.14	2.28	**	0.55	2.18	**	1.09	2.92	***
Post secondary education dummy	0.65	1.12		-0.06	-0.51		0.75	1.87	*	1.63	3.38	***
Female dummy	-0.12	-2.25	**	0.00	0.07		-0.20	-2.05	**	-0.42	-6.22	***
Constant	7.44	8.70	***	7.40	79.22	***	8.47	6.54	***	6.29	8.28	***
Number of observations	455			10,409			666			692		
R-squared	0.20			0.04			0.10			0.31		

Data: EPM 2005
Note: Region dummies included but not shown
Note: Estimates corrected for selection (Bourguignon et al., 2002)
† Level of education for non-wage models is the highest level of education attained by a household member working in the farm (or in the rural non-farm economy).

We find positive and significant estimates of schooling that are substantial, but that are varied across employment types. We caution that these returns are likely to be overestimated because the correlation between education and earnings does not necessarily represent causation. For example, because adolescents living in households with more education are more likely to attend school (Stifel et al., 2007), schooling is not randomly distributed among the individuals in the sample, and the parameter estimates are probably biased.[28] Thus we proceed with caution.

Returns to schooling are largest among those in the non-farm sector in general and among the wage employed in particular. They are significant for secondary education in family farming, though not for primary education. For agricultural wage workers, the positive returns to education are only significant for those with primary education. This is probably because the sample of agricultural wage workers is small and very few have secondary education or higher. As expected, returns to schooling for non-farm employment are considerably larger than in farming. For example, while the returns to lower secondary education are 71% (higher earnings than those without schooling), the returns are 48% and 10% for non-farm non-wage and family farming, respectively.[29]

In short, education is an important factor associated not only with non-farm employment opportunities for the rural population in Madagascar but also with higher earnings for those employed in the non-farm sector. It appears that those individuals and households with little or no education face barriers not only to acquiring non-farm jobs, but also to reaping the full benefits of the potentially high-return non-farm sector.

Controlling for education, experience and other factors associated with employment selection, we find that women's non-agricultural wage and non-wage earnings are 42% and 20% lower than those of men, respectively. Although we do not find a significant difference between the earnings of men and women in agriculture, this does not imply that the earnings are necessarily equal, since our measure of agricultural earnings is based on equal sharing of total household agricultural earnings.[30]

6. Concluding remarks

In this paper we examine the relationship between rural non-farm employment and household welfare using nationally representative data from Madagascar. In doing so, we focus our attention on labor outcomes in the context of household livelihood strategies that

---

[28] As Behrman (1999) notes, 'individuals with higher investments in schooling are likely to be individuals with more ability and more motivation who come from family and community backgrounds that provide more reinforcement for such investments and who have lower marginal private costs for such investments and lower discount rates for the returns to those investments and who are likely to have access to higher quality schools'.

[29] The level of education used in the non-wage models is the highest level of education attained by a household member working in the family farm/non-farm enterprise. The rationale for this measure is that non-wage earnings are measured by total farm/enterprise earnings and then are distributed equally among those working on the farm/enterprise. Given intra-household (in this case intra-farm or intra-enterprise) education externalities, the most appropriate measure of education is that of the member with the highest level of education.

[30] There are two sources of error implicit in this measure of agricultural labor earnings. The first assumption is that all household agricultural labor is equally productive, and the second is that resources are shared equally within the household, which is not necessarily the case (Quisumbing & Maluccio, 2000; Sahn & Stifel, 2002).

include farm and non-farm income earning opportunities. We identify distinct household livelihood strategies that can be ordered in welfare terms, and estimate multinomial logit models to assess the extent to which there are barriers to choosing dominant strategies. Individual employment choice models, as well as estimates of earnings functions, provide supporting evidence of these barriers.

We find that the non-farm sector may indeed provide an important pathway out of poverty. As is commonly found in other African countries (Barrett et al., 2001), there is a positive relationship between rural non-farm employment and welfare as measured by per capita household expenditure. The percentage of workers with non-farm employment rises by expenditure quintile, with 11% in this sector employed in the poorest quintile and 31% in the richest.

It is perhaps best, however, to understand rural non-farm employment in the context of household livelihood strategies. After all, 'diversification is the norm' (Barrett et al., 2001), especially among agricultural households whose livelihoods are vulnerable to climatic uncertainties. In principle, diversification could be accomplished through land and financial asset diversification. But the absence of well-functioning land and capital markets often means that these diversification strategies are not feasible. Consequently, many rural households find themselves pursuing second-best diversification strategies through the allocation of household labor (Bhaumik et al., 2006). Household labor supply and allocation decisions among farm and non-farm activities are thus made by weighing both productivity and risk factors.

The four distinct household livelihood strategies identified for rural Madagascar, ordered from inferior to superior, are (a) any agricultural wage (AW), (b) family farming only (FF), (c) family farm and non-farm activities (FFNF) and (d) non-farm activities only (NF). Multinomial logit model estimates of household strategy choice indicate that there may be barriers to participation in high-return non-farm activities (FFNF and NF). First, households with higher levels of educational attainment tend to be those that choose the dominant strategies. It appears that poor households with low levels of education generally face greater barriers than the non-poor in their choices of high-return livelihood strategies. Second, households without access to formal credit tend to adopt inferior strategies and are less likely to combine family farming with non-farm activities. Third, households with access to telecommunication – and by extension information on price and market conditions outside of the community – are more likely to choose the dominant livelihood strategies. Households living in communities without such access are more likely to allocate labor to farming activities that are geared to home consumption and the local market – i.e. those activities that are likely to have lower remunerative rewards.

Nonetheless, although these potential barriers may mean that high-return strategies are limited to a subpopulation of well-endowed households, the non-farm sector can still benefit the poor. On the one hand, for those with limited asset endowments entry barriers limit access to high-return non-farm activities (e.g. the wage sector). On the other hand, low-return non-farm activities tend to provide opportunities for ex ante risk reduction, as well as for ex post coping with shocks. The non-farm non-wage sector tends to play this safety net role in Madagascar. In addition, non-farm activities may also have an indirect effect on poverty by affecting agricultural wages. Increased non-farm employment may tighten the agricultural wage market, leading to higher wages that are an important source of income for the poorest households.[31]

References

Almeyda-Duran, R, 2005. Proximate literacy, inter and intrahousehold externalities and child health outcomes: Evidence from India. Mimeo. Columbia University, New York, NY.

Amendola, N & Vecchi, G, 2007. Growth, inequality and poverty in Madagascar, 2001-05. World Bank Madagascar Country Office, Antananarivo, Madagascar. Mimeo.

Barrett, C, Bezuneh, M, Clay, D & Reardon, T, 2005. Heterogeneous constraints, incentives and income diversification strategies in rural Africa. Quarterly Journal of International Agriculture 44(1), 37–60.

Barrett, C, Reardon, T & Webb, P, 2001. Nonfarm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics, and policy implications. Food Policy 26(4), 315–31.

Barrett, C, Sherlund, S & Adesina, A, 2008. Shadow wages, allocative efficiency, and labor supply in smallholder agriculture. Agricultural Economics 38(1), 21–34.

Basu, K & Foster, J, 1998. On measuring literacy. Economic Journal 108, 1733–49.

Basu, K, Narayan, A & Ravallion, M, 2002. Is literacy shared between households? Labour Economics 8, 649–65.

Behrman, J, 1999. Labor markets in developing countries. In Ashenfelter, O & Card, D (Eds), Handbook of Labor Economics, Vol. 3. Elsevier Science, London.

Bhaumik, SK, Dimova, R & Nugent, J, 2006. Pulls, pushes and entitlement failures in labor markets: Does the state of development matter? IZA Discussion Paper No. 2258. Institute for the Study of Labor (IZA), Bonn, Germany.

Bourguignon, F, Fournier, M & Gurgand, M, 2002. Selection bias correction based on the multinomial logit model. Working Paper No. 2002-04, *Centre de Recherche en Économie et Statistique* (CREST), Paris.

Brown, D, Stephens, E, Ouma, JO, Murithi, F & Barrett, C, 2006. Livelihood strategies in the rural Kenyan highlands. African Journal of Agricultural and Resource Economics 1(1), 21–36.

Brück, T, 2004. The welfare effects of farm household activity choice in post-war Mozambique. Discussion Paper of DIW Berlin 413. German Institute for Economic Research (DIW Berlin), Berlin, Germany.

Davidson, R & Duclos, J-Y, 2000. Statistical inference for stochastic dominance and for the measurement of poverty and inequality. Econometrica 68,1435–64.

Dercon, S & Krishnan, P, 1996. Income portfolios in rural Ethiopia and Tanzania: Choices and constraints. Journal of Development Studies 32(6), 850–75.

Ellis, F, 1998. Household strategies and rural livelihood diversification. Journal of Development Studies 35(1), 1–38.

Foster, J, Greer, J & Thorbecke, E, 1984. A class of decomposable poverty measures. Econometrica 52, 761–6.

Haggblade, S, 2007. Alternative perceptions of the rural nonfarm economy. In Haggblade, S, Hazell, P & Reardon, T (Eds), Transforming the Rural Nonfarm Economy. Johns Hopkins University Press, Baltimore.

[31] The author would like to thank Peter Lanjouw for making this point.

Haggblade, S, Hazell, P & Reardon, T, 2007. Introduction. In Haggblade, S, Hazell, P & Reardon, T (Eds), Transforming the Rural Nonfarm Economy. Johns Hopkins University Press, Baltimore.

Heckman, J, 1979. Sample selection bias as a specification error. Econometrica 47, 153–61.

INSTAT (Institut National de la Statistique), 2006. Enquête périodique auprès des ménages 2005: Rapport principal. INSTAT, Antananarivo, Madagascar.

Lanjouw, P, 2001. Nonfarm employment and poverty in rural El Salvador. World Development 29(3), 529–47.

Lanjouw, P & Feder, G, 2001. Rural nonfarm activities and rural development: From Experience towards strategy. World Bank Rural Development Strategy Background Paper No. 4. World Bank, Washington, DC.

Lee, L, 1983. Generalized econometric models with selectivity. Econometrica 51, 507–12.

Little, P, Smith, K, Cellarius, B, Coppock, DL & Barrett, C, 2001. Avoiding disaster: Diversification and risk management among East African herders. Development and Change 32, 401–33.

Malchow-Møller, N & Svarer, M, 2005. Wage-labour activities by agricultural households in Nicaragua. Journal of Development Studies 41(7), 1221–46.

Pitt, M, Rosenzweig, M & Gibbons, D, 1993. The determinants and consequences of placement of government programs in Indonesia. World Bank Economic Review 7(3), 319–48.

Quisumbing, A & Maluccio, J, 2000. Intrahousehold allocation and gender relations: New empirical evidence from four developing countries. Food Consumption and Nutrition Division Discussion Paper No. 84. International Food Policy Research Institute (IFPRI), Washington, DC.

Randrianarisoa, JC, Barrett, C & Stifel, D, 2009. The demand for hired labor in rural Madagascar. Mimeo.

Ravallion, M, 1994. Poverty Comparisons. Harwood Academic, Chur, Switzerland.

Reardon, T, 1997. Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. World Development 25(5), 735–47.

Reardon, T, Berdegué, J & Escobar, G, 2001. Rural nonfarm employment and incomes in Latin America: Overview and policy implications. World Development 29(3), 295–409.

Sahn, D & Stifel, D, 2000. Poverty comparisons over time and across countries. World Development 28(12), 2123–55.

Sahn, D & Stifel, D, 2002. Robust comparisons of malnutrition in developing countries. American Journal of Agricultural Economics 84(3), 716–35.

Sarr, L, 2004. The impact of family literacy on the earnings of illiterates: Evidence from Senegal. Cornell Food and Nutrition Policy Program (CFNPP) Working Paper No. 159. Cornell University, Ithaca, NY.

Stifel, D & Christiaensen, L, 2007. Tracking poverty over time in the absence of comparable consumption data. World Bank Economic Review 21(2), 317–41.

Stifel, D & Minten, B, 2008. Isolation, welfare and agricultural productivity. Agricultural Economics 39(1), 1–15.

Stifel, D, Rakotomanana, FH & Celada, E, 2007. Assessing labor market conditions in Madagascar: 2001–2005. World Bank Africa Region Working Paper Series No. 105. World Bank, Washington, DC.

Valenti, P, 2001. Should we be concerned about the distribution of literacy across households? An axiomatic investigation. Mimeo. Cornell University, Ithaca, NY.

Von Braun, J, 1989. The importance of non-agricultural income sources for the rural poor in Africa and implications for food and nutrition policy. PEW/Cornell Lecture Series on Food and Nutrition Policy. Cornell Food and Nutrition Policy Program, Ithaca, NY.

Zeller, M, Sharma, M, Henry, C & Lapenu, C, 2003. An operational method for assessing the poverty outreach performance of development projects: Results from four case studies in Africa, Asia and Latin America. Proceedings of the 25th International Conference of Agricultural Economists (IAAE), 16–22 August, Durban, South Africa.