Forest dependence and participation in forest co-management in Malawi[1]

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ABSTRACT. We develop an endogenous sample selection model to investigate how forest dependence influences household's decision to participate in forest co-management program. Using data from Chimaliro and Liwonde forest reserves in Malawi, we find that where forests primarily have a gap filling or safety net role in Chimaliro, high forest dependency induces higher rates of participation. However, with more commercial forest uses and a more heterogeneous social context as in Liwonde, high forest dependency reduces the incentives for participation. The findings point to the need to design parallel interventions alongside the forest co-management program in order to provide supplementary income sources to participants and increase the incentives for participation. *(JEL classification: C31, Q23).*

Key words: *forest dependence, participation, forest co-management, endogenous sample selection model, Malawi.*

1. INTRODUCTION

The key question of this paper is: What makes people to participate in the forest co-management (FCM) program in Malawi? In particular, how does *forest dependence* (share of forest income) affect households' participation decisions? Providing answers to this questions is vital for assessing local people's responses to devolution policies that would give an indication of the appropriateness of devolution programs as both a pro-poor and forest conserving strategy, and yields important insights into the design of future programs.

For many years, policies for managing common pool resources (CPRs) including forests had marginalized the local people by denying them access to these resources. Today, many developing countries have pursued policy reforms and implemented devolution programs that allow for the greater involvement of local communities or user groups in managing these resources (Meinzen-Dick et al*.,* 1999). Although most reforms have been promulgated by the failure of governments to implement effective strategies to curb overexploitation of the resources and the fiscal constraints faced by many governments, it is widely argued that devolution of natural resource management is the most viable option for ecological and economic sustainability of the natural resources (Conroy et al*.,* 2002). In the forest sector, with the realization that subsistence forest use constitutes an integral part of rural livelihood system, devolution of forest management is now the core of national forestry policies in many countries (Campbell and Luckert, 2002).

This paper assesses the conduciveness of the forest devolution policies in Malawi by examining the link between *forest dependence* and *participation*. In theory, the finding of a positive correlation between *forest dependence* and *participation* may indicate that the devolution policies foster cooperation among rural households in forest conservation to sustain the future flow of benefits. Conversely, the finding of a negative correlation depicts an institutional failure (Dasgupta, 1996), which indicates that the program imposes costly constraints on forest use such that forest-dependent households stay out of the program. The finding of no association between *forest dependence* and *participation* may suggest that factors (e.g., ideological, moral or ethical) motivate them to participate in the program (Heyer et al*.,* 2002).

Many studies have been conducted in the past to determine factors or sets of conditions that induce participation or cooperation in CPR management (e.g., Molinas, 1998; Dayton-Johnson, 2000; Varughese and Ostrom, 2001). Although these studies have enriched the literature, and helped to shape policies for managing common pool resources worldwide, none of the studies has – to our knowledge - explicitly examined empirically how people's dependence on the resources influences their participation decisions.

In this paper, we first present a theoretical farm household model to assess how households allocate their labor endowment to different productive activities including participation in FCM program to maximize utility. We then develop an empirical endogenous sample selection model of participation as a system of simultaneous equations in which participation decision is modeled as function of *forest dependence* and *forest use,* a dummy variable indicating whether an individual collects forest products from co-managed forest reserves. The specification of our model considers the fact that quite a few households use co-managed forest reserves (illegally) but do not participate in the scheme.

Using two different household-level data sets from Chimaliro and Liwonde forest reserves in Malawi, we estimate the model in three steps to account for the contemporaneous correlation of unobserved factors that determine *forest use, forest dependence* and *FCM participation*. The first two steps follow the standard Heckman (1979) sample-selection correction procedure to correct for selection bias in the estimates of the share of forest income or *forest dependence* (second step) by including the inverse Mills' ratios obtained from the first stage (*forest use* equation). The third step addresses endogeneity of *forest dependence* in assessing the impact of *forest dependence* on *participation* by including predicted estimates of the share of forest income from the second stage as one of the predictors of participation. To compare the robustness of our results, we estimate the first and second stage equations (*forest use* and *forest dependence)* also using maximum likelihood.

This article contributes to the debate on whether devolution of forest management is a universal solution to environmental degradation in different socioeconomic and ecological conditions by using unique data from two distinct sites. A key element in both theoretical and empirical models is how participation affects access to forest reserves in different socioeconomic, cultural and institutional settings. This is the first study to apply advanced econometric techniques to investigate the determinants of participation in CPR management from a developing country.

The rest of the paper is organized as follows: we present the background to Malawi's forest policies and co-management program in section 2. We develop and formalize our theoretical framework in section 3. This is followed by the specification and estimation of our empirical model, and a description of data used in the analysis in section 4. The empirical results are discussed in section 5, while some conclusions are given in section 6.

2. BACKGROUND

Malawi has a long history of involving local people to manage local forests dating back to the 1920s. For many years, the colonial administration was preoccupied with controlling the use and conservation of natural resources, including trees and forests. By mid 1920s, most forests had been gazetted as protected areas (Kayambazinthu, 2000). However, due to conflicts between the state and the local communities over land, the colonial government established the Communal Forest Scheme managed by the central government (District Administration). Under the scheme, approximately 2.7 million ha of forested area was allocated to communities for their use and management referred to as Village Forest Areas (VFAs) (Kayambazinthu, 2000). These VFAs were managed by Village Forest Committees (VFCs) led by village heads. However, the scheme only lasted one decade when the policy focus of the colonial administration shifted from community forestry to forest establishments for commercial exploitation.

After independence in 1964, all forest-related matters on customary land[1] were handled by the local government (District Councils). In 1985, the management responsibility reverted to the central government (Forestry Department). By that time, the authority of village heads to control the VFAs was overpowered by the political influence, which dictated the composition and operations of the VFCs. The number of active VFAs dropped from 5,108 in 1963 to 1,182 in 1994 (Kayambazinthu and Lockie, 2002).

The participatory-approach to natural resource management was revived in the 1990s, especially following the 1992 United Nations Earth Summit in Rio de Janeiro during which participatory development was accepted as an integral part of the rural development strategy. In 1996, the Malawi Government formulated the National Forestry Policy and the New Forestry Act was endorsed by parliament in 1997. The new legislation removed a number of barriers to people's involvement in the conservation of trees, forests and protected forest areas, and empowered village heads to confiscate forest products illegally obtained from natural woodlands (Sakanda 1996; Malawi Government, 1997).

In 1996, with support from the World Bank and United Kingdom (DFID), the government launched the forest co-management (FCM) program in Chimaliro and Liwonde forest reserves. These forest reserves comprise natural 'miombo' woodlands dominated by *Brachystergia*, *Julbernadia* and *Isoberlinia* and are located in the central/Northern and Southern regions of Malawi, respectively (Ngulube, 1999). The program was designed to improve rural livelihoods by generating household income, contributing to food security and providing environmental services while enhancing the productivity of forests through sustainable forest management and utilization (Meyers et al., 2001).

Approximately 210 ha and 1,172 ha out of 160, 000 ha and 274 000 ha of Chimaliro and Liwonde forest reserves were respectively demarcated into three blocks. The demarcation process was participatory involving the local people, civil society, government and chiefs during which ancestral boundaries separating different clans were traced to determine the customary boundaries (Jere et al*.,* 1999). In Chimaliro, the block sizes were 18, 118 and 74 ha, while in Liwonde they were 416, 288 and 468 ha. There are no significant differences in the species composition, stocking densities and size classes across co-managed blocks in

[1] With the exception of land explicitly registered as private land, or gazetted as "government land," all the remaining land falling within the jurisdiction of a recognized Traditional Authority granted to a person or group and used exclusively for the benefit of a specific community is customary land (Malawi Government, 2002).

Liwonde (Makungwa and Kayambazinthu, 1999). In Chimaliro, species composition across blocks is generally the same, while stocking densities vary considerably due to differences in soil characteristics (Chanyenga and Kayambazinthu, 1999).

The overall legal framework for the FCM program is guided by a constitution (Marsland et al., 1999). The constitution stipulates, *inter alia,* the rights and obligations of the committees and government, conditions on the sharing of revenue between government and the community, and the types of forest products that can be legally collected from the forest reserves. The program activities are implemented at the block level. Within each block, a forest management committee (VFC) with representatives from the designated villages provides leadership in drawing up its own local bylaws and block management plans. The FCM activities include boundary marking, firebreak maintenance, controlled early burning, fire fighting and supervised harvesting. In general, the operations of the program differ from block to block and between the two reserves due to differences in the leadership and cooperation among the local people. Most of the co-management activities are undertaken during the dry season (July-October) when demand for agricultural labor is low and when forest reserves become more susceptible to wild fires.

There are no strong restrictions regarding who should participate in the program. Participation is voluntary as long as the household lives within the designated villages, abide by the local bylaws and participate in implementing forest management plans besides attending FCM meetings and patrolling to monitor illegal activities. In return, the scheme legitimizes participants' access and use of forest reserves to collect various forest products. These include fuelwood, thatch grass, poles, fodder, mushrooms, wild fruits and other non-timber forest products (NTFPs) (Kayambazinthu, 2000). These products, and especially fuelwood, are important in people's daily livelihood. Edible forest products also help to fill gaps in food supplies during the lean period of between November and March (rainy season) when most NTFPs especially mushroom and wild fruits become more abundant. Some households, mainly in Liwonde, obtain their main source of income through selling of fuelwood, cane baskets, mushrooms, honey, wild loquat (*Uapaca kirkiana*) and other fruits by the roadside.

Institutional studies conducted in Malawi have singled out the FCM program in Chimaliro as a model of a successful devolution program in Africa (e.g., Kayambazinthu, 2000). This is in contrast to Liwonde where the FCM program has not been effective in halting excessive exploitation of forest products for commercial purposes leading to a higher utilization pressure (Makungwa and Kayambazinthu, 1999; Ngulube, 1999). Compared to Chimaliro, few institutional studies have been conducted in Liwonde. This study uses data from both Chimaliro and Liwonde to understand factors that influence participation decisions in order to trace sources of the unequal performance of the program between the two sites.

3. THEORETICAL FRAMEWORK

The model developed in this section draws upon the economic theory of agricultural household behavior (e.g., Singh et al., 1986) to analyze the question of how people decide to participate in the FCM program in Malawi. The starting point is "the basic cost-benefit calculations of a set of users utilizing a resource" (Ostrom, 1999: 4). Each user compares the net benefits from participation with the net benefits of non-participation. We put this cost-benefit calculation into an agricultural household modeling framework, which allows us to understand better how different household characteristics and context specific factors influence the participation decision, e.g., the degree of forest dependence (share of forest income) and social capital (peer pressure, past experience, tribal homogeneity).[2]

Based on the insights from the fieldwork and analysis of data, we focus on three types of costs and benefits. First, participation affects access to the forest reserves as elaborated below. Second, participation requires spending valuable time in the project (meetings, patrolling, etc.). Third, participation yields social benefits in terms of building the household's social capital within the village. The model developed is static, i.e., it does not include the possible higher future benefits participants can derive from better management of the forests.

We make a few analytical simplifications to make the model more tractable and enable us to focus on key aspects of the participation decision. The model assumes imperfections in the labor market in that the household may rent out labor, but cannot hire labor[3]. The markets for the relevant outputs (forest and agricultural products in particular) are assumed to be

[2] Fakuyama (2000) defines social capital as an instantiated informal norm that promotes cooperation between two or more individuals. The norms (e.g., reciprocity, trust, networks and respect) constitute social capital, which can range from a norm of reciprocity between two friends to wider social norms such as collective action.
[3] This is broadly in line with rural households in Malawi where very few farmers rent in labor while some work off-farm particularly during peak season on tobacco estates.

functioning perfectly[4], which allows us to focus on total income and consumption rather than individual goods.

The household maximizes a twice-differentiable quasi-concave utility function, which depends on total consumption *(C)* and leisure (L_H).[5] The household also derives utility from a 'social good' (*S*) as a reward for participating in the FCM program. Therefore, the household maximizes a utility function of the following form:

$$\text{Max } U = U(C, L_H, S; H) \qquad (1)$$

where H is a vector of household characteristics that affect household preferences. The household faces the following technological, time and budget constraints:

$$Q^F \leq Q^F(L_F, D; R, \square) \qquad (2)$$

$$Q^G \leq Q^G(L_G; M, \Re) \qquad (3)$$

$$D = D(P; H, V, R) \qquad (4)$$

$$S = S(P; H, V); \quad S(1) > S(0) = 0 \qquad (5)$$

$$L \geq L_F + L_G + L_W + L_P + L_H \qquad (6)$$

$$p_F Q^F + p_G Q^G + wL_w + E \geq C \qquad (7)$$

$$L_F, L_G, L_W, L_H, Q^F, Q^G, C \geq 0 \qquad (8)$$

Equation (2) is the production function for a (composite) forest commodity, stating that output depends on family labor devoted to forest product collection L_F, and forest access (*D*). A technology parameter $\square$ and a vector of forest resource characteristics R also affect production, and are assumed to be beyond household's control. Equation (3) is a simple production function for agricultural output, which is a function of family labor (L_G) and household's land area (*M*) (historically given). This production is also conditioned on an exogenously production technology $\Re$.

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[4] There are reasonably well functioning markets for the major agricultural markets in both sites and forest products particularly in Liwonde.

[5] One may also think of *C* as a composite commodity, including forest, agricultural and market purchased goods, with the price set to unity.

Equation (4) is central in the model, and describes how access to the forest reserve (D) is affected by the household's participation in the program (P). Participation is a binary variable taking the value 1 (participation) or 0 (non-participation). Access also depends on household and village characteristics (H and V), as well as resource characteristics R, e.g., distance to forest reserves and forest restrictions. In this paper, our broad definition of access goes beyond its legal definition. It includes how accessible the forest reserves are both in terms of legal rights, but also the degree of enforcement of regulations including punishment for violating the rules. For example, non-participants may collect forest products during odd hours (at dawn or night), while participants may collect openly during the daytime.

According to the program, a household not participating in the program should not have access to collect forest products from the forest reserves ($D(0) = 0$). However, a large number of non-participants using the forest reserves shows that this is not the case. We therefore distinguish between two different situations. In the first case, the program functions reasonably well (but not necessarily perfect) in excluding non-participants, thus, $D(1) > D(0)$. In the second case, the program is ineffective in excluding or restricting non-participants from using the forest reserves, while at the same time, restraining participants in the terms of permissible uses (e.g., frequency of collection). Where it is difficult for non-participants to violate the rules, participation in the program can limit access, i.e., $D(1) \leq D(0)$.

Equation (5) gives the "social good" as a function of participation in the program, or the "production of social capital from participation." We have normalized the non-participation to zero. A number of household and village variables affect participation, which in return yields social capital (e.g., trust, solidarity and respect).

Equation (6) gives the household's total labor endowment or time (L), which is allocated to forest production (collection) (L_F), agriculture (L_G), off-farm wage labor (L_w), time spent on co-management activities (meetings, patrolling, etc.) (L_P), and leisure (L_H). L_P is zero (0) if the household does not participate in the program, while it is fixed to $\bar{L}_P$ when the household participates, i.e.: $L_P(P=1) = \bar{L}_P > L_P(P=0) = 0$.

The LHS of equation (7) is total household income, which includes the value of produced forest and agricultural commodities (Q^F and Q^G), valued at market prices (p_F and p_G). The household earns wage income (wL_w) if it participates in the labor market. We also include exogenous income such as remittances (E). Equation (7) states that household consumption (C) cannot exceed total income. Equation (8) represents the non-negativity constraints.

The choice variables are L_F, L_G, L_w, L_H, Q^F, Q^G, C and P. Since P is a discrete variable, the optimization strategy is first to optimize labor allocation, for a given value of P (i.e., $P=1$ and $P=0$). We then compare the utility outcomes of the two values of P, and choose the P, which maximizes utility. We open up for corner solutions for both forest production ($L_F = 0$) and off-farm labor ($L_w = 0$), in line with what we find in our data. Leaving out equations (4) and (5), the Lagrangian for this Kuhn-Tucker problem is given by:

$$\begin{aligned} \ell &= U(C, L_H, S; H) + \lambda_1 \left[Q^F - Q^F \left(L_F, D; R, \square \right) \right] \\ &+ \lambda_2 \left[Q^G - Q^G \left(L_G; M, \Re \right) \right] + \lambda_3 \left[L - L_F - L_G - L_w - L_P - L_H \right] \\ &+ \lambda_4 \left[p_F Q^F + p_G Q^G + w L_w + E - C \right] \end{aligned} \tag{9}$$

The first order conditions can be summarized as follows (together with equations (2), (3), (6), (7)):

$$p_F Q^F_{L_F} \leq p_G Q^G_{L_G} = \frac{U_{L_H}}{U_C} = \frac{\lambda_3}{\lambda_4} \geq w \tag{10}$$

If the household is engaged in forest production, the first inequality sign is replaced with an equality sign. Similarly, participation (selling labor) in the labor market means that the second inequality sign is replaced with an equality sign. When the household participates in both activities, (10) is a familiar optimality condition stating that the value of marginal labor productivity in agriculture and forestry should be equal to the market wage rate, which again is equal to the marginal rate of substitution between leisure and consumption. In the case of no labor market participation, the household's shadow wage rate is given by $\omega = \lambda_3 / \lambda_4$. The market wage is below ω, and the household prefers working in agriculture, leisure and possibly forestry.[6]

This paper focuses on the participation decision, and for this problem, we write the model in a semi-structural form ('almost reduced form', as P is an endogenous variable):

[6] An alternative assumption would be that the households participate in the labor market, but are quantity constrained, i.e., they work $\overline{L}_w$ and earn $w\overline{L}_w$. In this case the logic of the model would be as when the household does not participate in the labor market, i.e., the relevant wage rate is the shadow wage rate of the household (ω) rather than the market wage rate (w), cf. Angelsen (1999).

$$U = U^{*}(P; p_F, p_G, w, E, \square, \Re, \bar{L}_P, H, V, R), \quad P = 0,1 \tag{11}$$

We further define the net gain from participation, *B*, as:

$$B = U^{*}(1) - U^{*}(0) = B(p_F, p_A, w, E, \square, \Re, \bar{L}_P, H, V, R) \tag{12}$$

A household will participate in the program if the difference in utility between participation and non-participation (*B*) is non-negative, i.e.:

$$\begin{aligned} P &= 1 \quad \text{iff} \quad B \geq 0 \\ P &= 0 \quad \text{iff} \quad B < 0 \end{aligned} \tag{13}$$

In this model, participation affects utility in three ways. First, participation influences access as explained above. In the first case, when participation improves access to the forest reserve (i.e., *D(1) > D(0)*), several factors will influence the value of better access. High prices of forest products will increase the benefits from better access. Limited access to off-farm employment opportunities expressed in terms of a low wage rate (*w*), has the same effect. In the case where the household is not participating in the labor market ($\omega > w$), factors such as small landholdings (*M*), low agricultural prices (p_G) and poor technologies $(\Re)$ will increase the value of *B.* In general, we can expect households with high dependence on forest products to be more inclined to participate in forest co-management program (Baland and Platteau, 1996, p 273). In the case where *D(1) < D(0),* all these conclusions are reversed.

Second, there is a fixed labor cost of participating in the program, $\bar{L}_P$. Obviously, the higher this labor requirement, the lower is *B, ceteris paribus.*[7] For households participating in the labor market, the opportunity costs of time is given by the market wage rate (*w*), and the participation cost increases as the wage rate increases. For poor households not participating in the labor market, we can expect them to have a lower shadow wage rate, and therefore be more likely to participate, *ceteris paribus.*

Third, participation produces a social good or social capital in forms of prestige, status and respect depending on a set of cultural norms or values by which society or village community uses to reward, judge, approve or disapprove its citizens. In rural Malawi,

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[7] In a more elaborate model both L_P may be endogenous, and be an element of the *S(.)* function. Aggregate co-management labor inputs may also affect *A(.),* e.g., more labor for policing can reduce access of non-participants.

participation in village affairs is crucial for the social acceptability of individuals and material or moral support during, for example, sickness, funerals, weddings and rituals. Here, cultural norms act as standard for shaping the behavior and actions of village members (Heyer et al., 2002).

In a homogeneous society with strong social norms and values, participants enjoy social benefits in the form of trust, respect, social acceptability and reputation, which are elements of social capital. Among the rich and elite, these benefits can provide a strong incentive for participation in the program other than the material benefits. Among the poor, poverty may also compel them to participate in the program to gain access to forest outputs from the forest reserves, but also for fear of being denied access to other benefits outside the FCM program such as benefiting from safety net programs[8], general vital information and social benefits. Where communities are more heterogeneous or highly market integrated, the social benefits from participating in the program are likely to be smaller. As such, social pressure may have little or no influence on inducing greater participation in the program.

4. EMPIRICAL MODEL

From our theoretical framework, the decision to participate in the FCM program depends, *inter alia,* on whether participating in the scheme will facilitate access to the forest reserves, and the importance given to this hinges on household's degree of forest dependence. We take into account that some households have access to forest outputs from co-managed forests without participating in the program. The key model is the probit participation equation, which is a function of, *inter alia*, forest dependence. However, forest dependence is endogenous and is therefore estimated first. Since not all households use forest reserves, there is a (potential) selection bias. We correct this by using two procedures, the Heckman two-step (Heckit) and maximum likelihood estimation procedures.

Our model is thus specified as system of simultaneous equations to account for the interrelationships among *forest use, forest dependence* and *FCM participation* as follows:

$$A_i = Z_i\gamma + \varepsilon_i \qquad \text{(forest use)} \qquad (14)$$

$$y_i = x_i\beta + u_i \qquad \text{(forest dependence)} \qquad (15)$$

$$P_i = W_i\varsigma + \psi\hat{y}_i + e_i \qquad \text{(participation)} \qquad (16)$$

[8] In Malawi, traditional chiefs play a very important role in determining who should be a beneficiary of such programs.

where A_i is *forest use* (forest access) which is a dummy variable indicating whether an individual derives some income from co-managed forest reserves; y_i denotes *forest dependence* defined as the ratio of forest income (from the forest reserve) to the total household income; P_i is an indicator variable for participation; $i = 1, ..., N$ denotes households; Z_i, x_i and W_i are vectors of exogenous variables that determine *forest use, forest dependence* and *participation*, respectively; γ, β, ς and ψ are unknown parameters and $u_i, \varepsilon_\text{i}$, and e_i are error terms. Since our aim in this study is to examine the link between *forest dependence* and *participation*, we focus on the coefficient ψ in equation (16) although many variables in the vector of the coefficients ς are also important to gain insights into other determinants of participation.

For our model, we consider forest income exclusively from the co-managed forest reserves. Consequently, y_i is observed for a household i together with covariates x_i and Z_i if $A_i = 1$. We make following distributional assumptions about the errors terms $u_i, \varepsilon_\text{i}$, and e_i: $u_i \sim N(0, \sigma_u^2)$, $\varepsilon_i \sim N(0,1)$, $e_i \sim N(0, \sigma_e^2)$ and $E(u_i \mid Z_i, \varepsilon_i) = E(u_i \mid \varepsilon_i) = \rho$, where ρ is the correlation between u_i and ε_i. σ_u^2 and σ_e^2 are the respective variances of u_i and e_i, while the variance of the error term ε_1 in equation (14) is normalized to unity.

4.1 Model estimation

4.1.1 The three-step estimation

We estimate our model in three systematic steps as follows: The first two steps are the standard Heckman (1979) two-step sample selection correction procedure. The **first step** aims at obtaining the inverse Mills' ratios to correct for selection bias in the estimates of the share of forest income (*forest dependence)*. From equations (14), we specify the following reduced form *forest use* model:

$$A_i = \begin{cases} 1 & \text{if} \quad Z_i \xi + x_i \beta + v_i \geq 0 \\ 0 & \text{otherwise} \end{cases} \tag{17}$$

where, $\xi = \beta\gamma$, $v_i = \beta u_i + \varepsilon_i$, and v_i □ $(0, \sigma_v^2)$. The associated log likelihood function is

$$\log L(\alpha, \beta) = \sum_{A_i=1} \log\left(\Phi\left(\frac{Z_i\xi + x_i\beta}{\sigma_v}\right)\right) + \sum_{A_i=0} \log\left(1 - \Phi\left(\frac{Z_i\xi + x_i\beta}{\sigma_v}\right)\right) \quad (18)$$

where, $\Phi(.)$ is the cumulative function of the standard normal distribution. By the normality assumption, we optimize this log likelihood function by maximum likelihood to estimate parameters of the model. The dependent variable for *forest use* equation (A_i) was computed from the information given by a respondent if a household collects forest products from co-managed forest reserves coded as one (1) and zero (0) for the "yes" and "no" responses.

The **second step** aims at obtaining the predicted estimates of the share of forest income (*forest dependence*) corrected for sample selection bias $(\hat{y})$. According to Maddala (1983), applying the ordinary least squares (OLS) to equation (15) produces inconsistent estimates of the share of forest income since the expected value of the error term conditional on *forest use* is non-zero. Thus, the conditional mean of the share of forest income in equation (15) is:

$$E(y_i \mid A_i = 1) = x_i\beta + E(u_i \mid Z_i, \varepsilon_i) = x_i\beta + E(u_i \mid \varepsilon_i) \quad (19)$$

such that $E(u_i \mid \varepsilon_i) \neq 0$. The conditional expectation of the error terms u_i and ε_i is:

$$E(u_i \mid \varepsilon_i) = E(u_i \mid \varepsilon_i \leq Z_i\gamma) = E(\sigma_u, \rho \mid \varepsilon_i) = \rho\sigma_u \frac{\phi(Z_i\gamma)}{\Phi(Z_i\gamma)}, \quad (20)$$

where, $\phi(.)$ and $\Phi(.)$ are the standard normal density and cumulative distribution functions, respectively. We define $\lambda_i = \phi(.)/\Phi(.)$ as the inverse Mills' ratios, which is the covariance between residuals of the selection (*forest use*) and the outcome (*forest dependence*) equations estimated from equation (18). Replacing $E(u_i \mid \varepsilon_i)$ by the inverse Mills' ratios λ_i as a sample selection-bias correction term in equation (17), we re-specify the *forest dependence* equation as:

$$y_i = x_i\beta + \theta\lambda_i + \eta_i . \quad (21)$$

Where η_i is error term that is assumed to have the conditional mean zero (0) and variance σ_η^2, while θ is an unknown parameter. The statistical significance of the coefficient for the inverse Mills' ratio θ gives evidence of sample selection bias.

The dependent variable for equation (21) (*forest dependence)* was computed as the ratio of forest income to the total household income. Forest income includes cash income from sales of different products from the forest reserves, value of domestic forest use, and income associated with participating in FCM program. Total household income is calculated from information given by a respondent on cash and subsistence income from agriculture, fisheries, forests and livestock; labor income from off-farm activities such as cottage businesses and employment; value of non-cash gifts, cash gifts and remittances received 12 months prior to the survey.

The **third step** addresses the problem of endogeneity in estimating the impact of *forest dependence* on *participation* (equation 16). From equation (21), we derive the predicted estimates of share of forest income, we denote $\hat{y}_i$. We then specify our *participation* model with predicted estimates of share of forest income as one of the explanatory variables:

$$P_i = \begin{cases} 1 & \text{if} \quad W_i\varsigma + \delta\hat{y}_i + \kappa_i \geq 0 \\ 0 & \text{otherwise} \end{cases} \tag{22}$$

where $\kappa_i \sim N(0, \sigma_\kappa^2)$, δ is our parameter of interest. We estimate the model using maximum likelihood by optimizing the following log likelihood function:

$$\log L(\tau, \delta) = \sum_{T_i=1} \log\left(\Phi\left(\frac{W_i\tau + \delta\hat{y}_i}{\sigma_\kappa} \right) \right) + \sum_{T_i=0} \log\left(1 - \Phi\left(\frac{W_i\tau + \delta\hat{y}_i}{\sigma_\kappa} \right) \right) \tag{23}$$

The dependent variable for participation in equation (23) is constructed from the responses given by a respondent if any member of the household participates in the program or not[9]. We treat this as a discrete variable with a value of one (1) for "yes" responses and zero (0) for "no" responses.

4.1.2 Maximum likelihood estimation

Although the Heckman (1979) two-step method used to correct sample selection bias (the first two stages) has been widely applied in various studies (e.g., Wales and Woodland, 1980; Fernandez et al., 2001; Nawata, 2004), this estimation technique is not efficient (Greene, 2000; Wooldridge, 2002). We therefore simultaneously estimate equations (14) and (15) by maximum likelihood to compare the results with those from the Heckman method. Combining equations (14) and (15), we derive the following expression:

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[9] The membership status was crosschecked with the list of participants within each village that was obtained through Participatory Rural Appraisals (PRA), and in some cases, supplied by the committee.

$$A_i = Z_i\gamma + \rho((y_i - x_i\beta)/\sigma_u) + \omega_i, \quad \omega_i \sim N\left(0,1\text{-}\rho^2\right) \tag{24}$$

where $\omega_i = \varepsilon_i + \beta u_i$. Since y_i, x_i and Z_i, are observed when $A_i = 1$, it follows that

$$\Pr(A_i = 1 \mid y_i, x_i) = \Phi\left(\frac{Z_i\gamma + \rho(y_i - x_i\beta)/\sigma_u)}{(1-\rho^2)^{1/2}}\right), \tag{25}$$

and its corresponding log likelihood function is:

$$\log L(\gamma,\beta) = \sum_{A_i=1}\log\left(\Phi\left(\frac{Z_i\gamma + \rho((y_i - x_i\beta)/\sigma_u)}{(1-\rho^2)^{1/2}}\right)\right) + \sum_{A_i=1}\log\left(\phi\left(\frac{y_i + x_i\beta}{\sigma_u}\right)\right) + \sum_{A_i=0}\log\left(\Phi\left(-Z\gamma\right)\right) \tag{26}$$

By the normality assumption, we estimate the model by optimizing the log likelihood function directly by iteration algorithm of a general non-linear optimization program (Greene, 2000). The impact of forest dependence on participation is estimated by using the specification of equation (23) except that the predicted estimates of the share of forest income (*forest dependence* variable) $\hat{y}_i$ are derived from equation (26). We use White-heteroscedasticity consistent estimator to obtain robust standard errors to account for heteroscedasticity.

4.2. Data and variables

The main source of data in this study is the household survey conducted in 31 villages adjacent to Chimaliro and Liwonde forest reserves between June and December in 2002. Prior to the survey, meetings, focus group discussions and key informant interviews were held with leaders of the FCM committees, chiefs, government officials, local non-governmental organizations and interest groups (e.g., associations, forest traders and craftsmen). The aims of these meetings were to get a general overview of the conduct, governance and performance of the program, and to compile a list of participating villages from which we randomly selected representative villages. We then held community meetings in each of the selected villages to learn about the operations of the program at the village level, and compiled household lists to select randomly representative households for the survey.

A total of 404 households comprising participants and non-participants were selected randomly for the survey: 205 households from 20 villages in Chimaliro and 199 households from 11 villages in Liwonde. The survey questionnaire contained general questions on demographic and socio-economic characteristics of the households, income, assets and specific aspects of the program. Summary statistics for variables used in the analysis are in appendix A.

5. RESULTS AND DISCUSSION

5.1. Descriptive Statistics

Before we discuss the empirical results, Table 1 describes features that distinguish program participants and non-participants in each of the two forest reserves.

Table 1: Comparison of characteristics between participants and non-participants

	Chimaliro		Liwonde	
	P	NP	P	NP
Age of household head (years)	46.854	45.388	39.585	42.871*
Education (primary and above=1)	0.921	0.888	0.667	0.783**
Household type (female=1)	0.348***	0.164	0.312***	0.160
Household size	5.528	5.638	4.957	5.170
Sex ratio (adult female/male ratio)	1.284*	1.116	1.256**	1.047
Duration of food insecurity (months)	5.191	5.052	7.086	7.151
Share of forest income	0.018	0.021	0.136	0.312***
Woodlot ownership (Yes own=1)	0.708***	0.483	0.269	0.226
Land holding size (ha)	5.676	5.613	2.490	2.212
Livestock ownership (Yes own=1)	0.382	0.448	0.311	0.283
Migration status (non-migrant=1)	0.526**	0.393	0.366	0.340
Duration of residence (years)	36.466**	30.652	27.151**	21.858
Tribal cohesion (belong to main tribe=1)	0.809	0.793	0.408**	0.255
Past group experience (yes=1)	0.618***	0.026	0.107	0.094
Distance to forest product market (km)	6.903	10.178***	4.242	5.246*
Distance to forest reserve (km)	1.168	1.210	0.361	0.545**
Total annual income (MK)	24443.89	31440.66**	33610.32	27193.80
Total annual forest income (MK)	449.45	962.11**	5313.63	9784.89***
Share of forest income	0.018	0.021	0.136	0.312***
Forest business (participate=1)	0.562	0.491	0.797	0.887**
Sub sample	89	116	93	106
Total observations	205		199	

**P<0.10, **P<0.05, ***P<0.001; Stars indicate that the means are statistically different between participants (P) and non-participants (NP).*

The table shows that participants in both Liwonde and Chimaliro are relatively more likely to be female-headed households, have higher sex (female/male) ratio and have lived longer in the same village. In addition, households in Chimaliro are older; more educated (90%), and have more assets (land, livestock and woodlots). Hence, they seem to be relatively less exposed to the risk of food insecurity. Households in Chimaliro run out of own produced food (maize) for approximately four (4) months before the next harvest compared to seven (7) months in Liwonde. Nearly 28% of the households in Chimaliro have previous group experience, compared to 10% in Liwonde.

The table further shows that households in Chimaliro are less ethnically differentiated than in Liwonde. More than 80% of the households in Chimaliro belong to the main tribe (Tumbuka) compared to only 33% in Liwonde belonging to the main tribe (Yao). We also note that the share of forest income is higher in Liwonde (23%) than in Chimaliro (2%). In Chimaliro, a larger percentage of participants possess woodlots and are permanent residents with past group experience. In Liwonde, a larger percentage of the participants belong to the main tribe. The non-participants in Liwonde are relatively older, more educated, have higher share of forest income, participate in forest businesses and stay farther from the forest reserves and forest markets.

5.2 Determinants of participation

As discussed earlier, the first two stages of our estimation procedure are only necessary to obtain selection bias-corrected estimates of the predicted share of forest income to explore the impact of *forest dependence* on *participation*. We therefore skip the discussion of the results from the first two stages and present results for the determinants on participation, except to note that we find evidence of sample selection in both sites. Table 2 displays estimation results from both the three-step procedure and the maximum likelihood for comparison purposes. From the table, the first column presents results without the forest income share (*forest dependence*) variable. The other two columns present results that include *forest dependence* variable estimated from the Heckman method (Heckit model) and maximum likelihood (ML model). In both the Heckit and ML models, we also include a multiplicative interaction term between *forest dependence* and *group pressure* to investigate how participation among forest dependent households changes with *group pressure* or alternatively, how *group pressure* influences participation, as people become more forest dependent.

Table 2: Determinants of participation in the FCM program in Chimaliro and Liwonde

Variables	Chimaliro						Liwonde					
	No income share		Heckit model		ML model		No income share		Heckit model		ML model	
Individual variables	Coef.	S. E.	Coef.	S. E.	Coef.	S. E.	Coef.	S. E.	Coef.	S. E.	Coef.	S. E.
Age of household head	0.017	0.016	0.001	0.019	0.010	0.018	-0.019**	0.010	-0.019**	0.010	-0.018*	0.010
Education (1=primary and above)	0.480	0.466	0.203*	0.196	0.244*	0.135	-0.089	0.257	-0.053	0.269	-0.121*	0.071
Household type	0.518	0.387	1.157**	0.455	1.665***	0.619	0.289	0.254	0.209	0.264	0.244	0.249
Household size	0.127*	0.070	0.129*	0.076	0.219**	0.091	-0.094*	0.049	-0.094*	0.049	-0.180***	0.049
Sex ratio	0.472**	0.228	0.300	0.273	0.018*	0.010	0.233*	0.133	0.222*	0.133	0.186	0.135
Duration of food insecurity	0.168***	0.046	0.144***	0.068	0.212***	0.085	-0.005	0.037	0.012	0.041	0.029	0.040
Woodlot ownership	0.655*	0.388	0.149***	0.049	0.170***	0.580	-0.184	0.271	-0.207	0.268	-0.035	0.277
Land holding size	0.071**	0.029	0.237***	0.057	0.197***	0.056	0.087	0.074	-0.059	0.079	-0.035	0.091
Livestock ownership	0.010	0.365	1.210**	0.604	1.529**	0.754	-0.191	0.254	-0.124	0.274	-0.021	0.275
Migration status	0.485	0.507	0.921	0.579	0.573	0.555	0.641	0.428	0.549**	0.240	0.660*	0.340
Group pressure	0.421***	0.716	0.930***	0.214	0.749***	0.181	0.269	0.290	0.253	0.214	0.285	0.192
Tribal cohesion	0.321	0.437	0.911**	0.452	0.636**	0.324	0.065	0.244	0.013	0.247	0.187	0.253
Years of residence	0.031*	0.017	0.046**	0.019	0.050**	0.020	0.029***	0.010	0.029***	0.011	0.028***	0.011
Past group experience	0.326***	0.051	0.464***	0.082	0.386***	0.062	-0.142	0.364	-0.063	0.388	-0.039	0.375
Distance to forest reserve	-0.058	0.106	0.061	0.110	0.042	0.114	-0.403**	0.184	-0.355*	0.190	-0.355*	0.183
Distance to forest markets	-0.021	0.050	-0.072	0.063	-0.111	0.070	-0.148***	0.036	-0.091*	0.046	-0.103*	0.077
Firewood price	-0.009**	0.004	-0.017**	0.007	-0.027***	0.009	-0.004**	0.002	-0.004**	0.002	-0.006***	0.002
Forest business	-0.114	0.370	-0.001	0.386	-0.316	0.413	-0.145	0.290	-0.131	0.289	-0.110	0.291
Block 1 dummy	0.154***	0.048	0.158***	0.055	0.196***	0.056	0.131***	0.041	0.580*	0.302	0.130*	0.079
Block 2 dummy	0.834*	0.456	0.893	0.544	1.242**	0.508	0.103***	0.034	0.501	0.627	0.121*	0.061
Forest dependence	-	-	0.193***	0.047	0.141***	0.045	-	-	-0.196***	0.051	-0.374**	0.183
Interaction variable	-	-	-0.187***	0.057	-0.094**	0.038	-	-	0.405	0.666	0.214	0.566
Constant	-0.524***	0.153	-0.830***	0.243	-0.722***	0.209	-0.109	0.075	-0.181	1.133	0.547	1.247
No. of observations	205		205		205		199		199		199	
Wald chi^2(22)	72.23		63.40		69.95		67.78		71.11		75.64	
Prob > chi^2	0.000		0.000		0.000		0.000		0.000		0.000	
Pseudo R^2	0.711		0.756		0.742		0.245		0.250		0.267	
Log pseudo likelihood	-40.521		-34.239		-36.184		-106.849		-103.194		-100.840	

**P=0.10, **P=0.05, ***P=0.001; Coef.= Coefficient; S.E.= robust standard errors [1]Interaction variable (group pressure * predicted forest income share)*

The validity of all models in Table 2 is confirmed by the significance of the Wald Chi-square statistics indicating that the control variables in each model are jointly significant. We also see from the table that more variables are statistically significant from the maximum likelihood (ML models) than the three-step procedure. Hence, the discussion of the implications of our empirical results will focus on ML results.

5.2.1 Forest dependence and participation

Our primary focus in this study is to explore how *forest dependence* influences households' participation decisions. Table 2 shows that *forest dependence* has a contrasting effect on participation between the two locations. The coefficient for *forest dependence* is positive and statistically significant in Chimaliro, but negative and significant in Liwonde. This implies that high forest dependency is likely to induce participation in FCM program among households in Chimaliro, while in Liwonde it reduces the incentives for participation. Thus, the two sites seem to represent two contrasting cases discussed in the theory section on how participation affects access to the forest reserve. In the following sections, we elaborate possible explanations for these contradicting results.

Firstly, unlike Chimaliro which is located in a remote area and where markets for primary forest products especially fuelwood are almost non-existent, markets for forest products are well established in Liwonde. This is largely due to scarcity of forest products in the Southern Region arising from high population. Liwonde is located close to urban cities of Blantyre and Zomba, where demand for forest products especially firewood is high. Most forest products in Liwonde fetch higher prices than in Chimaliro (Ngulube, 1999). Our estimates show that firewood fetches MK199.00 per cubic meter in Liwonde (US$4.43/$m^3$) compared to only MK66.00 per cubic meter (US$1.47/$m^3$) in Chimaliro. The profitability of forest products has induced greater commercialization of forest products in Liwonde. Large amounts of various forest products harvested from the forest reserves are sold by the roadside to the traveling public and intermediate traders.

The finding of a strong negative effect of firewood price and distance to forest markets on participation in Liwonde suggests that market integration and increased value of forest products reduce the incentives among households to participate in the program as it may constrain their access to the forest reserve. The program restricts the frequency, type and quantity of forest products the participants can harvest from the forest reserve, while it seems very ineffective in excluding and regulate forest use by non-participants.

In addition, 70% of the revenue from commercial sales of forest products from co-managed forests by the FCM committees is remitted to government while the community retains only 30% (Kayambazinthu, 2000). Although joint or bulk selling of forest products from the forest reserves is not common and often not enforced, it may have an impact of scaring away potential participants.

Overall, participants make considerable sacrifices to participate in the program. This is especially true for Liwonde where the households are more forest-dependent as forest income accounts for nearly a quarter of their total earnings (23%). As a result, most households who cannot afford the cost of restrained forest use in the interest of conservation stay out of the program, and collect forest products from the forest reserve illegally.

Secondly, in Malawi village chiefs are the traditional 'custodian' of rural development programs and have the final verdict on most decisions made by the FCM committees (Kayambazinthu and Lockie, 2002; Shackleton et al., 2002). Generally, the Tumbukas (main ethnic tribe in Chimaliro) have deep respect toward those in authority such as chiefs and politicians. Since most households in Chimaliro belong to the same tribe, local chiefs and leaders use their influence to foster cooperation among individuals. The finding of positive impacts of 'social capital' variables, namely group pressure, tribal cohesion and past group experience in Chimaliro suggests that 'social capital' is vital for inducing greater participation. Shackleton and Campbell (2001) also attributed the success of the FCM program in Chimaliro to the respect people have toward local chiefs. This indicates that the FCM program is likely to be successful in isolated areas where 'social capital' exists within the community, consistent with the discussion in section 3.

Finally, the coefficient for the interaction term between *forest dependence* and *group pressure* has also a contrasting effect on participation between the two sites. In Chimaliro, the coefficient for the interaction term is negative and statistically significant, while in Liwonde, it is positive but not significant. The negative correlation between participation and the interaction term in Chimaliro has implications for the sustainability of the FCM program. It implies that as people become increasingly dependent on forests as their main source of income beyond the current ‘safety net’ or ‘gap filling’ consumption levels, *group pressure* or ‘social capital’ is likely to be ineffective in sustaining and fostering the existing norms of cooperation in implementing the program.

In Liwonde, our data show that 65% of the households (N=199) are migrants belonging to different ethnic backgrounds. In addition, more than 80% of these migrants are engaged in selling forest and non-timber forest products as their primary occupation. The combined effect of tribal differentiation and the proliferation of forest-based enterprises due to the impact of market integration weaken the vitality group pressure to influence greater participation in forest conservation or to control overexploitation of forest resources for commercial purposes.

5.2.2. Other determinants of participation

Coming to other determinants of participation, we see that all parameter estimates for household variables in Chimaliro have the expected positive signs and are statistically significant except for participation in forest business. None of the household variables is significant in Liwonde except for household size. Results indicate that both coefficients for age and education of household head are negative and statistically significant in Liwonde while in Chimaliro, both coefficients are positive but only education is statistically significant. These results are consistent with our descriptive data where 54% of participants in Liwonde (N=93) compared to 34% in Chimaliro (N=89) are below 40 years old.

The finding of a strong positive effect of education on participation in Chimaliro supports our field observations that people with formal education - especially retired public servants and politicians - held key positions in block committees in Chimaliro, but less so in Liwonde. Due to their understanding of the importance of conserving forests, they are more likely to participate in the program themselves and motivate other villagers to participate as well. A *possible* explanation of the negative effect of education on participation in Liwonde is that wage employment opportunities are better than in Chimaliro. As such, educated people are more involved in off-farm and off-forestry activities and are, therefore, less interested in forestry issues.

An intriguing finding is that of a strong positive effect of food insecurity on participation in Chimaliro but not in Liwonde, considering that the risk of exposure to food insecurity is more severe among households in Liwonde than in Chimaliro. Due to strong enforcement of rules in Chimaliro, food insecure households participate in the program to gain access to the forest reserves. In contrast, the weak enforcement of rules does not compel food insecure households in Liwonde to participate in the program. This is another indication of access being enhanced through participation in Chimaliro, while it has the opposite effect in Liwonde.

As mentioned earlier, forest products especially NTFPs help to fill gaps in local food supplies during the rainy season. These findings indicate that the livelihood of food-insecure households, especially among households in Chimaliro would have worsened if households did not participate in the program to gain access to forest outputs from the forest reserves. These findings are consistent with the ‘gap filling’ or ‘safety net’ role of forests (Byron and Arnold, 1999; Angelsen and Wunder, 2003).

In Liwonde, many people are engaged in the selling of fuelwood and curio products by the roadside as they have small land holdings and are unable to produce enough food (especially maize. Thus, households are involved in such businesses ‘not out of wish’, but as the only source of income to support their families. Since participation in forest-related businesses conflict with the conservation objectives of the FCM program (and due to weak enforcement of rules) most traders refrain from participating in the program as implied by the negative coefficient for the variable, participation in forest business.

The coefficients for all asset variables have the expected negative signs in Liwonde implying that asset holdings reduce the incentives among households to participate in the program. These results contrast those for Chimaliro where household assets have strong positive effects on participation. Results from the first and second stage show a negative correlation between household assets and both *forest use* and *forest dependence,* implying that asset-rich households are less likely to exert pressure on forest reserves in Chimaliro. In the same way, one would have expected less need among asset-rich households to participate in the scheme. One possible explanation could be that most asset-rich households are influential and have strong ties with the ruling elite. As such, they hold important positions in the FCM schemes that compel them to participate in the program to fulfill their village obligations.

Another explanation could be that asset-rich households participate in the scheme for social capital such as personal interest, self-esteem, respect or personal sacrifices other than the short-term benefits consistent with our theoretical model. The finding of a positive effect of woodlot ownership on participation in Chimaliro indicates that personal interest in forests motivates them to participate in the program. During project inception, the government distributed free seedlings to interested households to establish their own woodlots. This suggests that the distribution of seedlings has had a motivating effect on household participation in the program. This is further supported by the higher percentage of participants in Chimaliro (28%) who established private woodlots than in Liwonde (10%).

We included binary variables for co-management blocks to control for the differences in the condition of the forest resources and local policy environment (e.g., size of the blocks, species composition and density, access rules, benefit and cost-sharing arrangements and leadership) that condition participation across blocks. The results indicate that these location-specific factors are also important in influencing household participation decisions.

6. CONCLUSIONS

Applying an endogenous sample selection model of participation on household-level data from Chimaliro and Liwonde under pilot co-management program in Malawi, we find that forest dependence has contrasting effects on participation between the two sites. The extent to which high forest dependency leads to more or less participation depends on the relative importance of forests on the local people's livelihood, the degree of market integration, existence of social capital within the local community and the local economic environment.

Evidence for Chimaliro indicates that where forests have primarily a gap filling and safety net role, high forest dependency induces higher rates of participation, and that social (capital) variables namely past group experience, years of residency, tribal cohesion and *group pressure* are important in inducing greater participation among households. However, the finding of a strong negative effect of the interaction between *forest dependence* and *group pressure* on *participation* implies that high forest dependency beyond the current 'safety net' or 'gap filling' level is likely to jeopardize the effectiveness of *group pressure* or 'social capital' in sustaining the program. As a result, the existing norms of cooperation that makes the FCM program in Chimaliro to be among the most successful devolution programs in Africa (Kayambazinthu 2000) may dissipate, as people increasingly become more forest dependent.

In Liwonde, with more commercial uses of forests and a more heterogeneous social context, high forest dependency reduces the incentives among households to participate in the program, depicting an institutional failure (Dasgupta, 1996). The restrictions that the FCM program imposes on participating households as discussed earlier, imply that people make considerable sacrifices to participate in the scheme. Since forests are an integral part of rural livelihood in Liwonde, most households especially among small collectors and traders cannot afford the cost of restrained forest use in the interest of conservation. As such, they refrain from participating in the scheme. Besides, social heterogeneity, market integration and the commercialization of forest products destroy the traditional norms of cooperation in forest conservation such that free-riding behavior takes over and dominates.

Evidence presented in this study raises several important issues that are critical to consider in designing FCM schemes. Overall, this study has revealed that the present institutional arrangements for managing forest reserves in Malawi perform differently in disparate conditions depending on the degree of social capital and forest dependence. In particular, our findings reveal that FCM program is not very effective in preventing further degradation of forest resources by the local people, at least in Liwonde. This calls for a reconsideration of the policies to pay attention to the short-term needs of the local people. The distribution of benefits between the central government and villagers is one of the critical aspects that can enhance the benefits people derive from participation. Another aspect is the importance of linking participation in the FCM program to other complementary livelihood interventions in order to reduce pressure on the forest reserves.

Another policy implication of the results is the need to constrain free riding behavior by conceding greater autonomy and legal support to the FCM structures. In this way, the local villagers will be empowered to effectively deal with the free-rider problem. Finally, since forest co-management program in Malawi is in its formative years, to gain more insights on how devolution policies contribute to rural poverty reduction, further work is needed to establish how forest revenue of participating households have changed due to the program, and how the benefits (income) from the FCM program are distributed among different groups of households. This analysis is vital for designing appropriate interventions to mitigate the negative effects of future devolution programs targeting the most vulnerable households.

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Appendix A: Summary statistics for overall means

	Chimaliro[b]		Liwonde[b]	
	ALL	Std. Err.	ALL	Std. Err.
Individual characteristics				
Age of household head (years)	46.02***	1.017	41.120	1.054
Formal education (yes=1)	0.902***	0.021	0.729	0.032
Household characteristics				
Household type (Female=1)	0.243	0.030	0.231	0.030
Household size	5.590	0.155	5.070	0.160
Gender ratio (adult female ratio)	1.189	0.064	1.144	0.058
Duration of food insecurity (months)	3.837	0.296	7.121***	0.120
Observed share of forest income	0.020	0.003	0.230**	0.022
Household assets				
Woodlot ownership (Yes own=1)	0.580***	0.035	0.246	0.031
Land holding size (ha)	5.641***	0.324	2.342	0.125
Livestock ownership(Yes own=1)	0.420**	0.035	0.296	0.032
Social (capital) variables				
Migration status (non-migrant=1)	0.462***	0.035	0.352	0.034
Duration of residence (years)	33.941***	1.276	24.331	1.189
Group pressure (actual/potential participants)	0.653***	0.021	0.204	0.009
Tribal cohesion (Belong to main tribe=1)	0.800***	0.028	0.327	0.033
Past group experience (Yes=1)	0.283**	0.032	0.101	0.021
Spatial and market variables				
Distance to forest product market (km)	8.757***	0.317	4.711	0.309
Firewood price (MK/m^3)	65.65	2.042	201.10***	3.762
Distance to forest reserve (km)	1.186***	0.101	0.459	0.040
Forest business (Participate=1)	0.522	0.035	0.844***	0.026
No of observations	205		199	

**P<0.10, **P<0.05, ***P<0.01; [a] Stars (*) indicates that the means are statistically different between reserves.*