Do Tropical Forests Provide a Safety Net? Income Shocks and Forest Extraction in Malawi

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Abstract

We use seasonal household data on income shocks and forest extraction to study how households in Malawi use forests to cope with income shortfalls. In particular, we study household response to receipt of a positive income shock delivered in the form of a technology assistance package. We estimate a random-effects model of forest extraction to examine whether household forest use is responsive to income shocks received in a prior period. We also measure the extent to which households subsequently save out of transitory income. Findings indicate that forest extraction by asset-poor households was more responsive to income shocks than forest extraction by better-off households. Findings also suggest households save out of transitory income, and in the process accumulate physical assets that may reduce their dependence on forests for weathering subsequent income shocks. Results show how policies aimed at poverty alleviation among those living adjacent to tropical forests can also alleviate forest pressure.

JEL classification: O13; O16; Q12

Keywords: risk, consumption smoothing, saving, poverty, deforestation, Malawi

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1. Introduction

In rural parts of low-income countries income and consumption risk are pervasive among the poor, and markets that serve to mitigate income shocks—such as those for insurance and credit—are generally absent, ill functioning, or inaccessible to the most vulnerable groups. Research has pointed to the potential negative consequences of adverse income shocks to nutrition and health status (Foster 1995; Sahn 1989) and excess mortality (Rose 1999). More optimistically, a variety of coping mechanisms often emerge to protect consumption when households experience idiosyncratic or covariate shocks. Examples of such mechanisms include precautionary saving of grain, livestock, and financial assets (Paxson 1992; Udry 1995), borrowing in informal credit markets (Besley 1995; Udry 1994), remittances from family members or relatives residing elsewhere (Rosenzweig 1988), and reallocation of household labor from the family farm to the wage labor market (Kochar 1999; Rose 2001).

In the literature, the use of household assets for coping with income shocks has received much attention (Deaton 1992; Fafchamps et al. 1998; Paxson 1992; Rosenzweig and Wolpin 1993; Udry 1995). When borrowing is difficult or impossible, there are strong incentives for precautionary saving: building up assets that can be drawn down in difficult times. Studies in African countries indicate that livestock are a key asset used by rural households to protect consumption in difficult times (Dercon 1998; Fafchamps et al. 1998; Kinsey 1998). These studies also show that this shock-coping mechanism is less accessible for the very poor.[1] Data

[1] "Shock-coping mechanism" is here distinguished from "risk-coping mechanism". The former refers to actions taken by households to protect consumption in the face of income shortfalls. The latter refers to mechanisms used to cope with risk ex ante, for example crop diversification.

from Malawi's Integrated Household Survey (IHS) show that 26 and 40 percent of rural households in the bottom and top income quintile own livestock (cattle, goats, and sheep) respectively (PMS 2001). The same survey indicates limited access to formal and informal credit sources for consumption smoothing purposes. Thus, coping mechanisms, such as livestock purchases/sales or credit market transactions, may be less available for very poor households in rural Malawi.

The central hypothesis of this paper is that, in forested regions, an important way poor rural households cope with adverse income shocks is by temporarily increasing rates of forest extraction. Several characteristics of tropical forests help explain why the poor may rely on forests to cope with negative income shocks. One, forests in low-income areas are often held under state or communal tenure with forest resources essentially freely available to local populations. Two, extraction of forest goods generally requires little in the way of financial and physical capital (Neumann and Hirsch 2000). Three, forest resources are diverse, providing a range of products and opportunities for income generation. Finally, forest products are often available at times when other income sources are not, for example when crops fail (Byron and Arnold 1999; Pattanayak and Sills 1999).

While it has often been said that forest resources provide the rural poor with a safety net (Byron and Arnold 1999; Warner 2000), the empirical literature on the issue remains thin. Two econometric analyses that have investigated this issue concern the Peruvian (Pattanayak and Sills 1999) and Brazilian Amazon (Takasaki et al. 2002). Pattanayak and Sills (1999) estimated Negative Binomial count models and a Tobit model of household forest collection behavior (N = 325). The dependent variables were reported and imputed number of forest collection trips and time spent on forest collection during the year. The empirical model included a measure of risk (the coefficient of variation of households' reported manioc output of previous years) and a shock variable (household reported agricultural production shortfall). The study found a positive association between risk and the number of forest collection trips. Results also showed a positive association between reported agricultural shortfall and forest collection.

Takasaki et al. (2002) examined several strategies used by Peruvian smallholders (N = 300) to cope with covariate and idiosyncratic income shocks. These shock-coping strategies included forest product gathering and fishing. They found that forest product gathering was important for coping with covariate flood shocks, with 22 percent of sample households reporting gathering as a coping mechanism. Using a two-stage Tobit model, they also found that those households employing natural resource extraction to cope with covariate flood shock tended to be those possessing relatively few physical assets and having relatively more adult household members. The findings of Pattanayak and Sills (1999) and Takasaki et al. (2002) provide evidence that in some tropical areas poor households use forests to cope with risk ex ante and shocks ex post.

Three questions motivate the analyses of this paper. One, when faced with adverse income shocks, do households at the forest margin use forests to protect consumption? Two, are the asset poor more dependent on forests for coping with such income shocks than the better off? And three, do households save out of transitory income, and in the process accumulate physical and financial assets that improve their ability to weather subsequent income shocks? These questions are addressed by estimating random-effects models of forest extraction and livestock saving using seasonal household data from Malawi. For each analysis, a positive shock measure is used reflecting whether or not a household received an agricultural assistance package consisting of a free packet of seed and fertilizer (a "starter pack). Taken together, the results of the paper suggest that policies that help to alleviate asset poverty among those living adjacent to tropical forests can potentially yield outcomes that alleviate pressure on forests and improve the welfare of rural households.

2. Study area and data

Data for this study come from a survey of three villages in southern Malawi. Data were collected at monthly intervals between June 1999 and August 2000. Villages were selected to represent three forest management types and a spectrum of market access. Village 1 is ten kilometers from a tarmac road and adjacent to a state forest reserve managed by the Forestry Department. Village 2 is a Village Forest Area (VFA) managed by a village headman and a committee of twelve village leaders. Located 20 kilometers from a tarmac road and the nearest town, Village 2 is rather remote, but it is close to Mozambique (5 kilometers), where agricultural commodities can be purchased at prices well below those prevailing in Malawi. Village 3 is adjacent to a tarmac road linking it to Blantyre (Malawi's largest urban center) 40 kilometers away. Forest access in Village 3 is de facto open access. The entire sample consists of data from 99 randomly-selected households, representing 12 percent of the total village population in the three villages.

2.1. The Income Shock Measure

The income shock measure used in the study is receipt of a "starter pack". The Starter Pack Scheme (SPS) was a government-run, free-inputs program that ran in 1998/1999 and 1999/2000. Under the SPS, all of Malawi's estimated 2.86 million smallholder households were entitled to receive a starter pack containing hybrid maize seed and chemical fertilizer sufficient to plant about 0.1 hectare. Grain legumes were also included to add nitrogen to the soil and provide an alternative source of food and income. The SPS was aimed at promoting food security, increasing productivity of the staple crop maize, and improving soil fertility (Longley et al. 1999).[2]

The starter pack was a positive shock to income for recipients. The net contribution of the starter pack at the household level was an estimated 3.5 50 kg bags of maize in 1998/99 and 1.4-2.4 50 kg bags in 1999/2000 (NSO 2000 and Sibale et al. 2001 cited in Levy and Barahona 2002). Its estimated monetary value in 1998 was greater than the annual cash income of many poor households (Blackie et al. 1998).

The starter pack shock was idiosyncratic because not all households received one. Starter pack distribution proceeded well overall, but a few problems were encountered. For example, some households received more than one starter pack, and other households did not receive a pack (Longley et al. 1999). In the three villages for this study, 68 percent of sample households received a starter pack in 1999/2000. Corresponding percents of households that received packs in Villages 1, 2, and 3, were 28, 97, and 86 percent respectively. The relatively low percentage of households receiving a starter pack in Village 1 is largely explained by the breakdown of the lorry carrying starter packs destined for the village; some of the packs were stolen while the lorry was being repaired. With packs in short supply, many sample households in Village 1 found that their names were not on the registration list when they showed up at the distribution site.

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[2] The starter pack concept emerged in a Rockefeller Soil Fertility Research Network paper (Mann 1998) and was further developed in a Malawi Maize Productivity Task Force (MMPTF) discussion paper (Blackie et al. 1998).

The starter pack shock is also idiosyncratic, because households used their starter packs differently. Most households used their packs in their gardens, but some sold their starter packs. A survey in rural Malawi found that few sample households that used the starter packs in their gardens followed recommended use (Longley et al. 1999). For example, some households used only the chemical fertilizer or only the seed. The main extension tool of the SPS was a leaflet with written information on recommended plant spacing, fertilizer application, etc. Many farmers could not read the instructions, and some that could found the instructions confusing (Cromwell et al. 2001).[3]

Starter pack receipt should provide a useful shock measure for at least two reasons. First, starter pack receipt is truly a shock to income because it was unpredictable. Household members had limited information available to make judgments concerning the likelihood of receipt of a starter pack. They knew only whether a starter pack was received in the previous year and heard from other villagers, radio announcements, and field assistants compiling registration lists that the SPS was continuing in the current year. Prior to distribution of the packs, households were probably hopeful, but it is unlikely that they changed their behavior until they actually received their starter packs.[4] A second reason starter pack receipt should be a useful shock measure is that

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[3] The Targeted Inputs Programme (TIP), the follow up to the SPS, improved on the SPS in some key ways. For example, on-farm demonstration plots in villages instructed farmers in proper use of inputs and open-pollinated seed, which can be recycled up to three years, replaced hybrid seed (Levy and Barahona 2002).

[4] This is different from the situation where the shock is, say, weather and household behavior may be influenced by subjective beliefs about moments of the outcome distribution.

it can be situated in time. During the study year, starter packs were received around the end of the non-agricultural period. If households changed their behavior due to starter pack receipt, we expect this to have occurred sometime during the agricultural period.[5]

2.2. Forest Extraction in the Study Area

Use of forest resources is common at the study sites. During the survey year, all sample households collected firewood, 12 percent cleared forest for farmland, and 75 percent had cash earnings from forest-based occupations. An index was calculated for the quantity of scarce forest resources (wood and bamboo) extracted by sample households for commercialization. The forest extraction index provides a measure of the impact on forest condition of household participation in forest occupations.

Figure 1 shows moderate temporal variability in forest extraction over the survey year. Seasonal variability of forest use is common in the developing world for several reasons (Byron and Arnold 1999). One explanation relates to changes in labor availability over a typical year. At the study sites, forest extraction was relatively low during the agricultural period due to a peak in demand for household labor for cropping activities (see Figure 1). Forest extraction was higher in the non-agricultural period when labor was more available. A second reason for seasonality of forest use is that some forest activities are easier to perform at certain times of year. Figure 1 shows that charcoal sales were relatively low in the agricultural period which is also the rainy season; this reflects difficulties with kiln management in rainy conditions. A third

[5] It is also possible that response to starter pack receipt was delayed beyond the time period of the household survey data.

explanation is variable demand for forest products across seasons. For example, brick making peaks in the non-agricultural period when home construction/repair is common.

Another plausible explanation for observed variability of forest extraction over the survey year is that it reflects household ex ante or ex post responses to income variability. One way that risk-averse households try to mitigate risk ex ante is by choosing a portfolio of activities. Diversification of income is common in rural parts of sub-Saharan Africa, but it can be costly because expected returns are often sacrificed for lower risk (Barrett et al. 2001). Forest use is often characterized as low-return, and it should be less risky than agriculture due to the diversity of forest products available year round; it may offer an important means to cope with risk (Pattanayak and Sills 1999).

Households may also use forests to cope ex post with unanticipated income shortfalls. For example, in the event of an adverse income shock, households may temporarily increase forest extraction to earn cash to buy food. Recent research indicates that one of several important mechanisms that poor households use to cope with shocks is temporary labor supply adjustment (Kochar 1999; Rose 2001). While these studies concern the wage-work sector, in tropical forest areas the forest sector may play a similar role. In the introduction, some factors were listed in favor of tropical forests as an accessible shock-coping mechanism: communal tenure often means forest resources are essentially freely available to local people, forest extraction requires limited financial and physical capital, and forest resource diversity implies a range of income-earning possibilities that can be engaged in when the need arises. By contrast, asset liquidation or credit market transactions may not be a possible means to smooth consumption for the very poor who possess few liquid assets and face collateral-related borrowing constraints. For the very poor at the tropical forest margin, key assets possessed are household labor and adjacent forests. In summary, one might hypothesize that forests provide poor households living at forest margins with a means to cope with risk ex ante and shocks ex post. The empirical analysis below focuses on testing the hypothesis that poor households use forests to cope with shocks ex post for a sample of Malawian smallholders.

3. Income shocks and forest extraction

3.1. Empirical model

The empirical model used to examine whether households use forests to cope with income shocks is a random-effects Tobit model of forest extraction. Tobit analysis is necessary because some households in the sample did not have earnings from forest occupations. The Tobit technique accounts for this truncation in the dependent variable. The regression equation is:

$$Q_{it} = \gamma_0 + \gamma_1 D_t + \gamma_2 p_i + \gamma_3 H_{it} + \gamma_4 \theta_{it} + \gamma_5 W_{it} \cdot \theta_{it} + \varepsilon_{it} \qquad (1)$$

where subscripts i and t denote households and time (the agricultural period and the non-agricultural period); and Q is the quantity of forest products extracted for commercialization.

Explanatory variables are defined as follows: $\boldsymbol{D}$ is a set of village-season binary variables; p is the relative return to labor in forest occupations (compared with maize production);[6] $\boldsymbol{H}$ is a vector of variables reflecting household asset endowments (including age

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[6] The price of maize is observed only in households that sold maize and net hourly returns to forest occupations are observed only in households engaging in these activities. But even when a household chooses not to participate in a given activity, it faces an opportunity price in that sector. For this reason, omitting observations from the equations due to missing price information would bias our results; therefore we impute prices and net hourly returns where they

and education of the household head, number of female and male household residents, farm size, and the value of farm animals);[7] θ is a binary variable that equals one if the household received a starter pack and zero otherwise; and $W \cdot \theta$ is an interaction term equal to the value of farm animals times the starter pack variable. Data availability precludes the inclusion of other income shock variables related to health status and weather, for example. In the regression equation, ε is assumed to be a random error with zero expectation. Our selection of explanatory variables is consistent with other econometric studies of how low-income farm households' land and labor allocation decisions impact the environment (e.g. Coomes et al. forthcoming; Coxhead et al. 2002; Pichon 1997; Shively and Pagiola forthcoming).

The empirical model is used to test the hypothesis that household forest use responds to income shocks. In the situation here, where the shock is a positive one, households experiencing a shock may temporarily reduce forest extraction relative to those households that did not receive a starter pack. A test of this hypothesis is a test of $\gamma_4 < 0$. The starter pack is assumed to be uncorrelated with other income shocks. If this assumption holds, then γ_4 represents household response to receipt of the starter pack. However, if the starter pack is highly correlated with other shocks, then γ_4 denotes the net response to the correlated income shocks. Also of interest to this study is the sign of γ_5. If $\gamma_4 < 0$ and $\gamma_5 > 0$, then forest extraction of asset-poor

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are missing. Missing prices and returns were imputed using sub-sample ordinary least squares (OLS). See Fisher et al. 2002 for details on the imputation procedure and results from the regressions used to derive replacement values.

[7] Note that while ***H*** is time subscripted, only the farm size and animal holdings variables varied during the survey year.

households is more responsive to starter pack receipt; this may indicate that the poor are more dependent on forests for coping with income shocks than the better off.

3.2. Empirical results

Feasible generalized least-squares (FGLS) estimates of the forest extraction equation are presented in Table 1. Despite the small sample, we find that ten of the parameter estimates are statistically significant at the 90 percent confidence level (including two of the village-season binary variables). In the discussion that follows we focus on results for the income shock (starter pack) variables.

Findings indicate that, controlling for other key explanatory variables, households that received a starter pack had lower rates of forest extraction than households that did not receive a pack, all else being equal. This finding may be indicative of the use of forests for coping in difficult circumstances, because we observe higher forest extraction among households that were relatively more vulnerable to having low income, that is, starter pack non-recipients. That being said, to the extent that households used the starter pack in their garden, the observed difference in forest extraction among starter pack recipients and non-recipients should in part reflect the need to use complementary inputs, namely household labor, with the starter pack inputs. [8]

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[8] It could be argued that the observed difference in forest extraction reflects only the need for complementary labor for maize production, that is, the starter pack does not represent a shock to income. This does not seem plausible given results from estimation of a system of labor share equations for forest use, maize production, wage-work, and self-employment using the Malawi household data. The binary starter pack variable was included in the regressions and was weakly

The interaction term ($W \cdot \theta$) is positive and statistically significant at the 90 percent confidence level. This suggests that forest extraction of the asset-poor households was more responsive to starter pack receipt than forest extraction of the better off, all else equal. A plausible interpretation is that households that are poor in physical assets have little option but to use forests to smooth consumption, but as households acquire liquid assets such as livestock, they become less reliant on forests for coping with income shortfalls.

Results suggest that starter pack receipt may have had favorable consequences for forest condition: as mentioned above, starter pack recipients were observed to have extracted forest resources at a lower rate than non-recipients. This result, however, must be qualified. Recall that the forest extraction variable is the quantity of forest resources extracted for cash income generation; the variable does not include forest clearing or firewood collection for home use. In another paper using the same dataset (Fisher and Shively 2003), we conclude that receipt of a starter pack had no measurable effect on forest clearing and was associated with a relatively small increase in the demand for firewood for cooking.

4. Income Shocks and Household Savings

Two key findings from the previous section motivate the analysis of this section. One, starter pack receipt was found to reduce forest pressure. We argue that this is in part a reflection of reduced need to use forests to earn money to buy food. Two, forest extraction of asset-poor households was more responsive to starter pack receipt. In this case we contend that this reflects

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significant in the forest labor share equation. The starter pack variable had a positive correlation with the maize labor share and a negative correlation with the self-employment labor share.

a greater dependence by the poor on forests as a means of coping with income shocks. Hence, income programs such as the SPS can have a direct effect on forest condition. In addition, the SPS could have an indirect effect on forest condition if starter pack receipt helped households to acquire some forms of physical capital that enable them to, over time, move away from their use of forests for coping with shocks. We investigate this conjecture below.

4.1. Empirical Model

We examine whether households save out of transitory income with use of an empirical model that draws on the work of Udry (1995) who investigated household saving responses to adverse shocks using data for two periods of a single year from northern Nigeria. In the consumption smoothing literature, saving is commonly measured as the difference between observed income and observed expenditures. In the absence of complete expenditure data, we use livestock (cattle, goats, and pigs) saving which is equal to expenditures minus income in each period (agricultural and non-agricultural). In rural parts of Africa, the acquisition of cattle and small stock continue to be one of the most important forms of wealth accumulation (Dercon 1998; Fafchamps et al. 1998; Kinsey et al. 1998). In southern Malawi, cattle accumulation is limited by the scarcity of land. Only six sample households owned cattle at the start of the survey year. Goat ownership was more common and represents an important form of household savings in the study area. Goats are a relatively liquid asset that can be sold in response to price signals, to smooth consumption, buy farm inputs, or provide the financial capital to start up a business.

We assume that livestock saving (S) is a linear function of household-level variables ($\boldsymbol{H}$) that determine the level of the household's permanent income and indicate the stage of the household in its life cycle (including age and education of the household head, number of female and male household residents, farm size, and iron sheet roofs—a measure of past wealth). Saving is also assumed to be a function of transitory idiosyncratic income shocks, captured by a binary variable for starter pack receipt (θ) and interaction terms of starter pack and wealth indicators ($\boldsymbol{W}\cdot\theta$). Finally, saving may depend on the season of the year and location-specific factors such as typical weather conditions and market access; and so we include five village-season dummy variables (***D***) in the model. The regression equation is:

$$S_{it} = \alpha_0 + \alpha_1 H_{it} + \alpha_2 \theta_{it} + \alpha_3 W_{it} \cdot \theta_{it} + \alpha_4 D_t + u_{it} \qquad (2)$$

where subscripts *i* and *t* denote households and time (agricultural and non-agricultural period); and *u* is a random error with zero expectation.

4.2. Empirical Results

Feasible generalized least squares results for livestock saving are presented in Table 2.[9] Findings are consistent with simple models of consumption smoothing: households subjected to

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[9] The random-effects model is more efficient than fixed effects and can include time-invariant predictors (Greene 2000; Hsiao 1986), important for the analysis here since the data span a single year. A drawback is that estimates will be inconsistent if important sources of variation in the dependent variable are omitted from the estimating equation (Greene 2000; Hsiao 1986). Hausman's Chi-square tests for fixed versus random effects. The calculated test statistic is 10.25 for the livestock saving equation, and the 95 percent critical value for the Chi-square with eight degrees of freedom is 15.51. The null hypothesis that there is no systematic difference between fixed- and random-effects estimates cannot be rejected. This suggests that the random-effects model is a good choice for estimation of the livestock saving equation.

positive income shocks (starter pack recipients) have higher saving rates; or at least these households have lower dissaving rates on average, since we observe livestock decumulation for many sample households. For the "average" household with farm size of 1.27 hectares and owning 0.11 iron roofs, the marginal effect of starter pack receipt on livestock saving is MK294, about equivalent to the price of a young goat during the survey year. It is interesting that wealthier households, as measured by farm size and iron roof ownership, saved less out of starter pack-induced income compared to households that are poor in these assets. It may be that other forms of saving, such as grain or cash, are more important than livestock saving for wealthier households in the sample. In sum, the results presented in Table 2 suggest that starter pack recipient households saved a portion of their additional income in the form of livestock savings, which is suggestive of precautionary saving. This is important since livestock accumulation can assist households in coping with income shocks in subsequent periods. In the next section, results of the two analyses are integrated into an overall story of the potential effects of positive transitory income on forest condition and household welfare in rural Malawi.

5. Conclusions, discussion, and extensions

This paper examined links between income shocks and forest pressure in southern Malawi. We estimated a random-effects Tobit model of forest extraction to examine whether households living at the tropical forest margin depend on forests to cope with income shocks. Results indicate that rural households rely on forests for coping with income shocks and that asset poor households are more dependent on forests for shock coping. We then estimated a random-effects model of livestock saving to examine whether households save out of transitory income.

Results show that households experiencing a positive income shock, measured by starter pack receipt, had higher livestock saving, all else being equal.

Our results can be integrated into the following story of how income shocks relate to forest use. To begin, consider the receipt of the starter pack: this was a positive shock to income for recipients because it increased the income-earning capacity of households that used the starter packs in their gardens, and it provided a direct income boost for those who sold their packs. Income shocks can give rise to a number of behavioral responses, and in this study we observe two. First, we see starter pack recipients reducing their levels of forest extraction, compared with non-recipients. This suggests that positive income shocks may help to reduce forest pressure in the short term. This study parallels, in reverse, findings reported by Pattanayak and Sills (1999) and Takasaki et al.(2002), where adverse shocks lead households to temporarily increase rates of forest product extraction. We also observe starter pack recipients saving a portion of the starter-pack induced income in the form of livestock. This indicates that positive income shocks may assist households in acquiring some forms of physical capital that can enable them to move away from their use of forests for coping with shocks in the future. In the long term, this can yield favorable outcomes for tropical forests. In fact, as mentioned earlier, our analysis shows that households better endowed in livestock wealth are less dependent on forests for shock coping.

The story that emerges from the analyses of this paper has important implications for policies directed at tropical forest conservation and rural livelihoods. On the one hand, the study sends a cautionary message for policy makers and others concerned with the fate of Malawi's forests given that adverse income shocks, rather than positive shocks, are the norm in tropical countries. On a more positive note, results of the paper suggest that policies that help to alleviate asset poverty in tropical forest areas can potentially yield outcomes that reduce pressure on forests and at the same time improve rural household welfare. It is important to note, however, that studies from tropical forest areas show that alleviation of asset-poverty constraints can increase or reduce forest pressure (Wunder 2001). Future theoretical and empirical work addressing this issue is recommended to improve our understanding of the specific conditions that favor complementarities between asset-poverty alleviation and forest conservation. In future empirical studies, we recommend that analysts use: (a) panel data spanning several years, (b) a more complete measure of saving than livestock saving, for example, important omissions in our study are grain saving and cash saving, and (c) additional shock measures, such as those related to human health and weather variation.

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Table 1. Feasible generalized least squares results for the forest extraction equation [a]

Variable	Coefficient (stand. error)
Constant	3120.44 (2399.08)
Natural log of the ratio of forest returns (MK/hour) and maize returns (MK/kg) [b]	* 1618.83 (210.13)
Age of the household head by category (1=15 to 24 years; 2=25 to 34; 3=35 to 44; 4= 45 plus) [c]	149.94 (1933.51)
Age of the household head squared	-318.92 (351.52)
Education of household head by category (0 = no schooling, …, 9 = completed secondary school)	* -991.70 (221.82)
Female household residents (women and school-age girls, with girls valued at half an adult equivalent)	* 636.29 (250.75)
Male household residents (men and school-age boys, with boys valued at half an adult equivalent)	* 1267.53 (283.65)
Farm size (hectares) at the start of the period	* 555.41 (322.32)
Value of cattle, goat, pig, and poultry holdings (MK) at the start of the period	* -48.76 (11.22)
Starter pack receipt (0=No, 1=Yes)	* -1553.07 (873.88)
Interaction term (starter pack receipt times value of animal holdings)	* 29.38 (14.63)
Number of observations	198
Log likelihood	-1034.06

a. Additional regressors not shown in the table are five village-season binary variables.

b. Includes imputed values for missing observations. For details see Fisher et al. (2002).

c. Age is a categorical variable in this dataset because respondents generally were not aware of their age. Our approach was to estimate age by reference to a list of historical events.

d. We scaled this variable by dividing by the average poultry price.

* indicates significance at the 90 percent confidence level.

Table 2. Feasible generalized least squares results for the livestock saving equation [a]

Variable	Coefficient (stand. error)
Constant	352.16 (709.78)
Age of the household head by category (1=15 to 24 years; 2=25 to 34; 3=35 to 44; 4= 45 plus) [c]	-9.04 (546.69)
Age of the household head squared	5.22 (95.34)
Education of household head by category (0 = no schooling, …, 9 = completed secondary school)	63.24 (54.11)
Dependents (young children and elderly)	* -174.32 (59.57)
Female household residents (women and school-age girls, with girls valued at half an adult equivalent)	74.77 (59.12)
Male household residents (men and school-age boys, with boys valued at half an adult equivalent)	-50.32 (72.45)
Farm size (hectares) at the start of the period	* -420.03 (65.57)
Iron sheet roof (indicator of past wealth)	* 320.96 (189.86)
Starter pack receipt (0=No, 1=Yes)	* 804.29 (237.79)
Interaction term (farm size times starter pack receipt)	* -365.06 (90.88)
Interaction term (iron roof times starter pack receipt)	* -393.04 (216.80)
Number of observations	198
R-square within	0.43
R-square between	0.57
R-square overall	0.53

a. Additional regressors not shown in the table are five village-season binary variables.

Figure 1. Seasonal variability of forest extraction for commercialization,

sample households 1999/2000