Agricultural Subsidies and Forest Pressure in Malawi's *Miombo* Woodlands

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This paper examines impacts of an agricultural subsidy program on forest pressure in Malawi. Using household survey data, we measure the effect on forest product marketing and on forest clearing of Malawi's Starter Pack Scheme (SPS). Regression results show households receiving a free packet of hybrid maize seed and chemical fertilizer (a "starter pack") had lower levels of commercial forest extraction than nonrecipient households. In addition, no measurable effect of starter pack receipt is found on forest clearing decisions, suggesting the program raised agricultural output without encouraging agricultural expansion. Findings thus indicate potential modest improvement in forest condition due to the SPS.

Key words: Africa, agricultural intensification, conservation and development, Malawi, tropical deforestation

Introduction

In many tropical countries, policies to intensify agricultural production are being implemented for the dual purposes of economic development and forest conservation. Few would dispute that technological progress in agriculture can foster food security and economic development in low-income settings. However, the degree to which agricultural intensification can help to alleviate tropical forest decline remains unclear (Angelsen and Kaimowitz, 2001). On the one hand, intensification appears to be a potential forest-saving alternative to extensive forms of agriculture such as shifting cultivation. However, new technologies typically render agriculture more profitable, and can thereby increase the incentives to clear forests for farmland (van Soest et al., 2002). From a theoretical perspective, the impact of technological change in agriculture on tropical deforestation is indeterminate. Market conditions, institutional factors, and the characteristics of agricultural technologies all influence outcomes (Angelsen and Kaimowitz, 2001; van Soest et al., 2002). Empirical studies confirm that contextual factors such as these matter. In some situations agricultural intensification has been found to decrease forest pressure (Godoy et al., 1997; Shively, 2001), and in others to increase it (Foster, Rosenzweig, and Behrman, 1997; Perz, 2003).

Agricultural intensification can also impact forests indirectly, in ways other than altering land uses. In tropical countries, many farm households earn income from selling forest products (Cavendish, 2000; Fisher, 2004; Godoy et al., 2002; McSweeney, 2002), often because farm production is insufficient to provide food self-sufficiency year round (Byron and Arnold, 1999). In these settings, agricultural intensification, by making farming more profitable, should increase households' incentives to work on-farm and may therefore reduce labor allocation to forest product commercialization.

This analysis tests whether subsidy-supported agricultural intensification has influenced Malawian smallholders' decisions to clear forest and market forest products. The Starter Pack Scheme (SPS) entitled all of Malawi's smallholder households to receive an agricultural assistance package consisting of free seed and fertilizer (a "starter pack"). Previous evaluation studies suggest the program improved national- and household-level food security (Levy, Barahona, and Wilson, 2000; Longley, Coulter, and Thompson, 1999), but it is unclear whether this occurred solely through intensification of existing agricultural land or through agricultural expansion. We evaluate the SPS from a conservation perspective, asking whether improved access to modern inputs increased or decreased forest pressure. Although the SPS was not intended as a forest conservation program, other agricultural intensification programs in Malawi are proposed for such a purpose. Evidence on the forest impacts of the SPS can therefore provide useful lessons for future conservation-development efforts in Malawi and elsewhere.

Much of the existing literature on smallholder-led deforestation has tended to focus either on forest clearing (Godoy et al., 1997; Shively, 2001) or on fuelwood collection (Amacher, Hyde, and Kanel, 1996; Heltberg, Arndt, and Sekhar, 2000). This study explores the effects of improved access to agricultural inputs not only on smallholders' decisions to convert forests to farmland but also on their decisions to extract forest products for commercial purposes. The remainder of the paper proceeds as follows. First we provide background information on Malawi's forests and recent agricultural developments leading up to the SPS. A simple conceptual framework is then presented that is useful for analyzing the effects of the SPS on forest clearing and on forest product commercialization. This is followed by a description of the study area and presentation of our empirical approach. Results are reported from multivariate regression models of forest clearing and forest product commercialization. Concluding remarks are given in the final section.

Study Area

Background on Malawi's Forests

Malawi's forests are dominated by closed, deciduous woodlands known colloquially as *miombo*. These woodlands are the most common vegetation type in central, southern, and eastern Africa (Campbell, Frost, and Byron, 1996). They provide wildlife habitat and a wide range of products and services essential to the well-being of rural people (Cavendish, 2000; Dewees, 1994; Fisher, 2004). Across sub-Saharan Africa, the interplay of forest dependence, rapid population growth, poverty, and weak forest management has resulted in highly degraded forest landscapes. In Malawi, for example, over 95% of existing woodland cover has been heavily modified by intensive use (Dewees, 1994). A

recent estimate for the country's deforestation rate is 2.4% per annum, the highest for southern Africa [United Nations Environment Programme (UNEP), 2002].

The key threat to Malawi's forests is clearing for agricultural expansion [Government of Malawi (GOM), 1998a]. Malawi's highly dualistic agricultural sector includes estate and smallholder subsectors. Estates grow mostly cash crops on their relatively large landholdings and have leasehold or freehold tenure. Estates cleared large tracts of forest prior to 1994 when the number of estates and the size of existing estates grew considerably. This expansion often involved the alienation of customary forest land (GOM, 1998a). Currently, estate expansion is strictly controlled and has relatively little impact on forest resources. At present, the main agents of deforestation are smallholder farmers.

The overwhelming majority of Malawi's farmers are smallholders who grow mainly food crops—especially maize, the staple crop—on customary land for which they do not possess ownership or title. Smallholder agriculture is characterized by small size of landholdings; low agricultural productivity due to slow adoption of improved techniques and the single short growing season each year; and heavy reliance on the labor of household members, especially women (Ng'ong'ola, Kachule, and Kabambe, 1997). With limited possibilities to intensify production, farmers often have little option but to clear forest to grow maize and other crops to feed their families. And in many communities, forests are held under state or communal tenure with resources essentially freely available to local populations, due to government failure to enforce property rights or weakened traditional systems of resource regulation (GOM, 1998a; Place and Otsuka, 1997).[1]

Forest conversion is associated with soil erosion, loss of habitat for plant and animal species, and reduced availability of wood (GOM, 1998b). Most land-based species, especially large mammal species, have been seriously affected by habitat loss and human activity (Glavovic, 2003). In some parts of the country, the impact of forest degradation on wildlife populations has been so severe as to precipitate trans-location of forest species in an attempt to protect remaining populations (Munthali and Mkanda, 2002).

Another key factor in the decline of Malawi's forests is intensive wood extraction. About 90% of the country's total energy needs is provided by biomass (GOM, 1998a). Tobacco and tea estates also use large quantities of wood for curing and constructing storage sheds, representing about 30% of total wood demand (GOM, 1998a). Moreover, the productivity of *miombo* woodlands is generally low. At current levels of demand, wood harvest rates far exceed sustainable yield. Malawi's Forestry Department estimates that the deficit for woodfuels rose from 1.6 to 4.9 million cubic meters between 1983 and 1990 (GOM, 1998b). In addition to over-harvesting, destructive harvesting techniques have been reported—for example, trees being felled for firewood and collectors destroying coppices from stumps and saplings, which are required for natural regeneration (Knacck Consultants, 1999). More worrisome is charcoal burning, which often involves clear-felling of indigenous trees on customary land.

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[1] Forest resources are not freely available simply because they are held under communal tenure. In many societies, forests have been sustainably managed by long-standing, community-based management systems in which norms and rules define community members' rights to use specific forest resources (Fortmann and Bruce, 1998). Such systems can be transformed, however, into de facto open access in the face of market, population, and modernization pressures (Blaikie and Brookfield, 1987).

Recent Agricultural Developments and the Starter Pack Scheme

Food security in Malawi depends on production of the staple crop—maize. As opportunities for land-extensive agricultural growth fade, use of improved maize technologies has become essential to produce enough maize to feed Malawi's people. In the early 1990s, it appeared Malawi would experience a "delayed Green Revolution," as evidenced by increased use of hybrid maize seed and chemical fertilizer among smallholder farmers (Smale, 1995; Heisey and Mwangi, 1997). Underpinning this diffusion was provision of credit at subsidized interest rates, subsidization of input prices, and establishment of producer price supports for maize (Zeller, Diagne, and Mataya, 1998). Not surprisingly, these policies contributed to large budget deficits. In response, by the late 1990s, Malawi was implementing agricultural marketing reforms that included liberalization of input and output marketing by government parastatals, elimination of input subsidies, currency devaluation, a rescinding of the ban on smallholder burley tobacco production, and liberalization of all agricultural output prices (Masters and Fisher, 1999).

An unintended consequence of reforms and other concurrent events was the creation of incentives for farmers to expand maize cultivation, rather than intensify production. Fertilizer and maize seed prices increased substantially in the 1990s, owing primarily to a series of currency devaluations. The price of maize also rose so that input-output price ratios were lower in the late 1990s than in the early 1990s (Masters and Fisher, 1999). This relative-price change should have favored increased use of modern inputs. However, for the majority of Malawi's smallholders who are net buyers of maize, higher maize prices translate into lower incomes (Peters, 1996) and less cash available for farm input purchases (Blackie et al., 1998). At the same time, massive loan defaults led to a collapse of the national credit system, virtually eliminating access to credit for smallholders.

Since the mid-1990s, smallholders' use of chemical fertilizer and hybrid maize seed has declined markedly. This presents a serious problem in Malawi, where infertile soils and degraded seed stocks result in low crop yields in the absence of improved inputs (Whiteside and Carr, 1997). By the mid-1990s, Malawi faced a food security crisis with a food deficit of several hundred thousand tons a year (Masters and Fisher, 1999).

In this context, the Malawi government implemented the Starter Pack Scheme (SPS) during the 1998/99 and 1999/2000 agricultural years. All of Malawi's 2.8 million smallholder households were entitled to receive a starter pack containing hybrid maize seed and chemical fertilizer to plant about 0.1 hectare. The SPS was aimed at promoting food security, increasing maize productivity, and improving soil fertility. SPS evaluations indicate that the net contribution of starter packs at the household level was an estimated 175 kilograms of maize in 1998/99 and 70–120 kilograms of maize in 1999/2000 (Levy and Barahona, 2002). Nationally, maize production increased from 1.5 million tons in 1997/98 to 2.1 and 2.2 million tons, respectively, in 1998/99 and 1999/2000. In part, these increases can be traced to favorable weather, but they also reflect the success of the SPS. Maize surpluses led to a reduction in the price of maize, further improving food security for the large proportion of farm households who are net buyers of maize (Levy and Barahona, 2002).

In sum, evidence points to positive short-term impacts of the SPS on national and household food security. Longer-term benefits are possible if the program, by introducing many farmers to modern inputs, stimulated future demand for these inputs
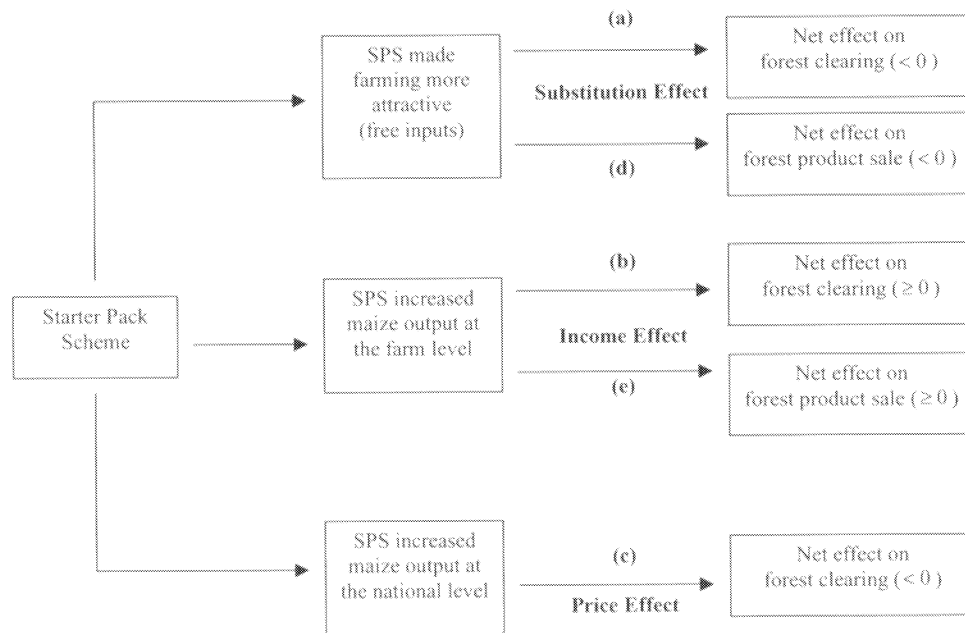
Figure 1. Substitution, income, and price effects of the SPS on forest clearing and forest product marketing

(Mann, 1998). Below we evaluate the SPS from a conservation standpoint, asking if improved access to seed-fertilizer technology changed smallholders' incentives to exploit forests.

Conceptual Framework

The potential impact of a starter pack on forests can be analyzed with the conceptual framework provided in figure 1, which highlights substitution, income, and price effects on labor allocation. In the discussion that follows we address these separate effects, focusing on forest clearing and on forest extraction.

Potential Effects of the SPS on Incentives to Clear Forest

Consider first the pathway marked (a) in figure 1. By providing free inputs to a farm household, farming was made more attractive in the short term. Because the starter pack included fertilizer, labor requirements for a given area of land should have increased to some extent. For a few farmers who could afford to hire laborers, it is possible that the SPS increased maize production via an expansion of cultivated area. But for the majority of smallholders who were seasonally constrained in household labor and lacked resources to hire laborers, use of a starter pack would have necessitated a reduction in labor allocated to forest clearing, namely by encouraging a substitution of effort away from forest clearing. Following this logic, the effect of the SPS via pathway (a) is denoted as negative (< 0).

Turning to the income effect on forest clearing, pathway (b), households receiving a starter pack achieved improved food security and higher income. Economic theory posits that as household incomes rise, demand for leisure will also rise. But, the influence of income changes on household labor allocation is sensitive to several factors including income level (Ashenfelter and Heckman, 1974). Most Malawi smallholders have annual incomes that are insufficient to secure their family's basic needs. Consequently, starter pack recipients most likely continued to devote labor to productive activities rather than increasing their leisure time. Moreover, the rise in income could have improved work capacity somewhat, possibly leading to an increase in forest clearing. For these reasons, we expect the starter pack to have either increased labor allocated to forest clearing or left it unchanged. Therefore, pathway (b) is marked as nonnegative (≥ 0).

Finally, the SPS precipitated a change in the implicit price, or value, of forest clearing, which is designated as pathway (c) in figure 1. The logic is as follows. The SPS boosted national production of maize. The large maize harvest in 1998/99, attributed in part to the SPS, depressed maize prices. This price reduction, in turn, reduced incentives to clear forest for farmland in the following production year, 1999/2000. We thus mark pathway (c) as negative (< 0). Considering paths (a), (b), and (c) together, the SPS could have increased or reduced incentives to clear forest, or left them unchanged, depending on the relative magnitudes of the income, substitution, and price effects. The actual effect is an empirical matter.

Potential Effects of the SPS on Incentives to Market Forest Products

In the case of forest product commercialization, the substitution effect, designated by pathway (d) in figure 1, should have been negative. Households receiving a starter pack would have had incentives to allocate more labor to farming and less to other activities such as forest product marketing. In other words, they would have substituted labor away from forest product sale as the returns to allocating labor to agriculture rose. As for the income effect, indicated by pathway (e), we expect a nonnegative relationship for the same reasons outlined above for the case of forest clearing. For instance, an increase in income induced by starter pack receipt could have been used, in part, to finance forest enterprises through purchase of forest tools. The combined effects of (d) and (e) are ambiguous.

Figure 1 underscores the difficulty in assessing, a priori, the impacts of a program such as the SPS on incentives to clear forest and market forest products in rural Malawi. Conditioning factors such as technology characteristics (e.g., size of the starter pack), market conditions, farmer characteristics (e.g., net sellers versus net buyers of maize), property regime, and initial resource stocks should have influenced farm-level outcomes. These effects are measured empirically below.

Data and Methods

Data for this study come from a household survey completed in three villages in southern Malawi between June 1999 and August 2000. Southern Malawi ranks highest in the country in terms of poverty incidence, population density, and scarcity of forest resources (GOM, 1998b; National Economic Council, 2000). Research villages were selected to represent the main forest management types in Malawi and provide a

spectrum of market access. Village 1 is 10 kilometers from a tarmac road and town and adjacent to the Mulanje Mountain Forest Reserve (MMFR), one of 71 gazetted forests managed by the Forestry Department.[2] Together these managed forests represent 22% of forest cover in Malawi. Households in this village have access to relatively abundant forest resources, ranging from *miombo* woodland at the base of Mulanje Mountain to pine and eucalyptus plantations to afro-montane forest near the mountain's summit. Markets for non-timber forest products and timber are relatively well developed.

In Village 2, *miombo* woodland on customary land is managed as a Village Forest Area (VFA) by the village head and a committee of village leaders. In Malawi, 50% of forest area is on customary land (GOM, 1998a). The VFA system, in which communities set aside woodland areas for conservation purposes, was initiated in the 1920s, and rekindled recently by the Forestry Department (Place and Otsuka, 1997). Located 20 kilometers from a tarmac road and town, Village 2 is remote, but only 5 km from Mozambique, where agricultural and forest goods can be purchased at prices below those in Malawi.

The little remaining *miombo* woodland on customary land in Village 3 is de facto open access due to the breakdown of traditional authority in recent years, characteristic of many customary forests in Malawi (Place and Otsuka, 1997). A substantial portion of communal woodland in the village has been cleared, mainly for agriculture and charcoal burning. Most charcoal sold in Malawi's major cities is produced by local people in surrounding rural areas (Makungwa, 1997). Village 3, adjacent to a tarmac road linking it to Blantyre (Malawi's largest city) 40 kilometers away, is well positioned for charcoal marketing.

The entire sample consists of data from 99 randomly selected farm households, representing 12% of the total population in the three villages. During the study period, residents of sample households were interviewed on a monthly basis on a wide range of topics such as forest use, household assets, income/expenditures, food security, and agricultural production. Some of the methods used to ensure the collection of quality data included close supervision of enumerators by the lead author, interviews with groups of household residents to obtain more complete information, and separate interviews with women and men when this was judged to be conducive to respondents' willingness to disclose sensitive data.

Village differences in forest use are detailed in table 1. Although forests are a key potential source of farmland, forest clearing was common only in Village 3. Inter-village differences may reflect existing forest management institutions. The few remaining trees on common land in Village 3 are, in principle, controlled by the village head who must be consulted when individuals seek to fell trees to open up gardens or to burn charcoal. In practice, however, communal land appeared to be treated as open access in Village 3, largely because the village head was viewed by residents as somewhat weak and ineffectual. By contrast, enforcement of rules prohibiting forest clearing in Villages 1 and 2 seemed relatively effective.

An index was calculated for the quantity of scarce forest resources (wood and bamboo) extracted by sample households for commercial purposes. Mean values are provided in table 1. There are several plausible explanations for observed differences across villages.

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[2] Since 2001, the MMFR has been co-managed by local people and the Forestry Department.

Table 1. Mean Values for Selected Forest Use Indicators, Sample Households 1999/2000

Activity	Village 1	Village 2	Village 3	All Villages
Main cooking fuel is wood (%)	100	18	100	69
Purchased wood (%)	18	63	36	39
Cleared forest (%)	3	0	50	12
Area cleared (ha)[a]	0.30	—	0.26	0.26
Wood extracted for marketing (kg):	1,092	200	11,009	2,953
Drink and food (kg)[b]	136	9	41	66
Bricks and crafts (kg)[c]	40	89	0	50
Firewood and bamboo (kg)	41	102	1,105	301
Timber (kg)[d]	875	0	0	345
Charcoal (kg)[e]	0	0	9,862	2,192
Planted trees in past 5 years (%)	31	71	64	54
Number of trees planted	10	9	19	12

[a] Mean values are for those households that cleared forest during the survey year.

[b] Includes items which use wood as a key input: *masese* traditional beer, *kachasu* dry spirit, etc.

[c] Forest-based crafts found at the study sites are: bamboo baskets and mats, grass brooms, wood-fired clay pots, wood crafts.

[d] Includes timber sales, and employment as pit sawyers and plant transporters (manual transport from pit sawing sites to the roadside).

[e] Includes sales of own-produced charcoal as well as charcoal resale.

First, during the survey year, the Village 2 headman appeared more successful at reducing forest access compared with the Forestry Department in Village 1 and the head in Village 3. Second, Village 2 has neither accessible timber (as in Village 1) nor access to urban charcoal markets (as in Village 3); therefore, demand for forest access may be lower in this village. Finally, only Village 3 households engaged in charcoal burning; this activity is the most degrading of forest resources in the study area (table 1).

Our empirical analysis involves estimating equations for forest clearing and forest resource extraction. We employ Tobit models because many households in the sample did not clear forest and some did not market forest products. The Tobit technique accounts for censoring in the dependent variables. The regression equations are:

$$(1) \qquad Q_F = \beta_0 + \beta_1 \mathbf{I} + \beta_2 p + \beta_3 \mathbf{H} + \beta_4 \theta + \varepsilon;$$

$$(2) \qquad \Delta A = \alpha_0 + \alpha_1 \mathbf{I} + \alpha_2 p + \alpha_3 \mathbf{H} + \alpha_4 \theta + \nu,$$

where Q_F is quantity of wood extracted for commercialization divided by household population, and ΔA is forest area cleared per household resident. Our analysis focuses on commercial forest activities rather than subsistence forest use, because the former tend to be more degrading than the latter and are easier to track.

Explanatory variables are defined as follows. A set of binary variables for residence in Village 1 and Village 2 is represented by $\mathbf{I}$, and p is the relative return to labor in forest occupations (compared with maize production).[3] The vector $\mathbf{H}$ includes variables

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[3] The price of maize is observed only in households that sold maize, and hourly returns to forest occupations are observed only in households engaging in these activities. We impute missing prices and net hourly returns with subsample ordinary least squares (OLS). Details are available from the authors upon request.

that reflect household characteristics (age and education of the household head, share of men among household members, and farm size per household resident). The variable θ is an indicator variable for whether the household received a starter pack. Table 2 provides descriptive statistics for the explanatory variables.

The starter pack variable θ deserves additional discussion. Starter pack distribution was carried out by government officials with the assistance of several nongovernmental organizations using registration lists compiled by field assistants. While all smallholder households in Malawi were entitled to receive a starter pack, only 68% of sample households received one in 1999/2000. Corresponding percentages of households receiving packs in Villages 1, 2, and 3, were 28%, 97%, and 86%, respectively. The relatively low percentage of households receiving a starter pack in Village 1 is 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.

Nationally and across the study sites, most households used all or part of their starter packs. Two sample households reported they did not use the starter pack; one sold the contents and the other saved the contents for use in the following agricultural year. A key question is whether starter pack receipt and use was a random event. In a related paper using the same data set (Fisher and Shively, 2005), we examine whether starter pack recipients and nonrecipients differ systematically on a set of observables by estimating Probit models in which starter pack receipt is the dependent variable. Findings from this exercise indicate that starter pack recipients and nonrecipients do not differ systematically on the variables included in the models, with the exception of village of residence. The forest extraction and forest clearing models [equations (1) and (2) above], by including binary variables for village of residence, account for potential bias related to the association between place of residence and probability of starter pack receipt.

Results

Statistical results are reported in table 3. In both regressions, several point estimates are found to be individually different from zero at a 90% confidence level. Calculated Wald statistics shown at the bottom of the table provide support for the hypothesis of joint significance of the explanatory variables. We control for village effects by including binary variables for residence in Village 1 and Village 2. Forest clearing is found to be positively associated with Village 3 residence, all else equal. Households in Village 3 also had higher levels of forest extraction than their counterparts in Villages 1 and 2.

Findings indicate that households with higher returns to labor in forest occupations relative to maize production had higher levels of forest extraction per person and cleared more forest per household resident. The latter finding may indicate that forest clearing decisions are driven mainly by potential profits from charcoal marketing, with farmland being a joint product of the charcoal burning process.

To assess the extent to which forest use changes over the life cycle of the household head, binary variables for householder age are included in the model. Little statistical support is found for a hypothesis that age influences decisions to clear forest or extract forest resources. However, education is shown to reduce rates of forest resource extraction. Specifically, households with a head having some formal education extracted fewer forest resources compared to households with a household head who never attended school.

Table 2. Descriptive Statistics of Explanatory Variables

Variable	Mean or Frequency	Standard Deviation
Village 1 residence	0.39	—
Village 2 residence	0.38	—
Ratio of forest returns to maize returns [a]	0.45	0.54
Household head aged less than 35 years [b]	0.24	—
Household head aged 35–44 years	0.13	—
Household head had some schooling	0.64	—
Share of men in household (no. men/household size)	0.17	0.20
Farm size (ha/person)	0.33	0.32
Household received and used a starter pack	0.66	—

[a] Includes imputed values for missing observations for forest and maize returns. (Details of the imputation procedure are available from the authors upon request.)

[b] In the data set, age is a categorical variable because many respondents were not aware of their age. Therefore, we estimated age with reference to a list of historical events.

Table 3. Tobit Results for the Forest Extraction and Forest Clearing Equations

Variable	Forest Extraction (kg/person)		Forest Clearing (ha/person)	
	Coefficient (Std. Error) [a]	Marginal Effect	Coefficient (Std. Error) [a]	Marginal Effect
Constant	722.430* (359.811)		–0.027 (0.041)	
Village 1 residence	–1,078.516* (358.509)	–310.972	–0.140* (0.036)	–0.007
Village 2 residence	–1,075.967* (403.744)	–308.162	–0.459* (0.098)	–0.026
Ratio of forest returns to maize returns	1,299.456* (432.716)	394.988	0.030* (0.018)	0.002
Household head aged less than 35 years	–73.160 (241.531)	–21.977	0.029 (0.035)	0.002
Household head aged 35–44 years	301.670 (475.748)	98.491	0.050 (0.050)	0.003
Household head had some schooling	–345.879* (210.315)	–108.515	–0.045 (0.040)	–0.002
Share of men in household	149.094 (494.669)	45.319	0.117 (0.079)	0.006
Farm size per capita	–821.059* (420.195)	–249.573	0.062 (0.045)	0.003
Starter pack	–478.023* (244.177)	–152.869	–0.027 (0.041)	–0.001
Wald Statistic [b]	0.023		0.000	

Note: An asterisk (*) denotes statistical significance at the 90% confidence level.

[a] Standard errors reported in the table use the Huber/White heteroskedasticity-consistent estimator of variance.

[b] This is the *p*-value of the Wald test for joint significance of all explanatory variables.

Adult male labor is crucial for participation in the more degrading forest occupations (charcoal burning and timber extraction), and land clearing is generally a male-specific task in the study area. For this reason, we include in the regressions a variable for the proportion of adult males in the household. Parameter estimates for the male labor variable are positive in sign for both models, but the coefficients are not statistically significant at standard test levels.

A priori, one might expect farm size per household resident to provide a good indication of a household's agricultural capacity and degree of food security (Peters, 1996). Households with relatively small landholdings per capita should have both the need and the capacity to engage in forest product sale or forest clearing. Findings reveal a negative and statistically significant association between farm size and forest resource extraction.

Turning to our policy variable, holding other things constant, households receiving a starter pack had lower forest resource extraction than households that did not receive a pack. The marginal effect of the starter pack variable computed at the sample mean is – 153 kilograms per person.[4] Using this information in conjunction with the average household size (4.9 people), we calculate that during the study year starter pack recipient households extracted about 750 kilograms less of forest resources compared with households that did not receive a starter pack. This amount of wood is equivalent to about five months of firewood to cook a rural Malawian family's meals. For the forest clearing equation, the parameter estimate for the starter pack variable is very small in magnitude and is not statistically significant at standard test levels (p-value = 0.519), indicating starter pack receipt had essentially no measurable effect on forest clearing.

Taken collectively, findings suggest the SPS may have had modest favorable consequences for the condition of Malawi's forests. Our research results are consistent with a few earlier studies reporting that in certain situations agricultural intensification can reduce forest pressure (Godoy et al., 1997; Shively, 2001), and they are consistent with other research from Africa showing deforestation tended to increase when chemical fertilizer became more costly or scarce (Lee, Ferraro, and Barrett, 2001).

Conclusion

This study has examined the environmental impact of Malawi's Starter Pack Scheme (SPS), a free-inputs program aimed at promoting agricultural intensification. Increasingly, agricultural intensification interventions have dual purposes of agricultural development and environmental conservation. Yet theory and evidence of agriculture-environment tradeoffs from low-income areas underscore the challenges to the effective design of these programs and the need for careful research and observation prior to implementation (Lee, Ferraro, and Barrett, 2001).

Household survey data from southern Malawi were used to evaluate the SPS from the standpoint of forest conservation, asking whether improved access to modern inputs changed incentives for households to exploit forests and, if so, whether this led to an increase or a decrease in forest pressure. Our study focused on two distinct sources of

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[4] In the Tobit framework, a change in the independent variable is decomposed into two separate effects: the effect on the conditional mean of the dependent variable in the positive portion of the distribution, and the impact on the probability that the observation falls in that part of the distribution (see Greene, 2000).

forest degradation: forest clearing for agricultural expansion and forest product extraction for commercialization. Receipt of a free packet of hybrid maize seed and fertilizer (a "starter pack") had no measurable effect on the forest clearing decision. In other words, inputs appear to have led to intensification of existing farm land, rather than area expansion. Results also show that households receiving a starter pack had lower levels of commercial forest product extraction than their cohorts who did not receive free inputs, all else equal. In tandem, findings suggest that the SPS may have had a small but beneficial impact on forests. Our interpretation of the findings is that a starter pack made a household's labor relatively more valuable in farming, leading to a reallocation of effort away from forest degrading activities. Alongside evaluation studies that document positive impacts of the SPS on agricultural output and food security, these findings indicate possible agriculture-environment complementarities in Malawi.

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