PANEL DATA EVIDENCE ON UPLAND AGRICULTURAL LAND USE IN THE PHILIPPINES: CAN ECONOMIC POLICY REFORMS REDUCE ENVIRONMENTAL DAMAGES?

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How do farmers in poor, remote upper-watershed areas of developing countries respond to price signals? Until relatively recently, it was widely assumed that most upland agriculture was primarily for subsistence. If correct, this has important implications for the design of upland development programs, as subsistence farmers, by definition, are beyond the reach of economic policies, and programs addressing upland poverty alleviation or environmental protection must depend on direct interventions. Such interventions, including command and control policies to conserve natural resources, remain at the core of most resource conservation strategies in countries of the humid tropics.

In this respect, most upland development and conservation strategies no longer reflect the reality of upland agriculture. While pockets of pure subsistence production persist in least accessible regions, road and other infrastructure improvements have brought the majority of upland farmers into contact with markets and thereby have transformed the basis of production decisions. Accumulating evidence indicates that farmers in remote areas are increasingly willing to specialize in production of commercial crops and rely on markets to supply household food needs. This engagement with the market increases the spatial and sectoral "reach" of economic policies. Market-based policies are generally cost-effective relative to direct measures, so for policy makers, commercialization expands the upland policy toolkit.

In this article, we investigate the determinants of land-use decisions made by farmers in an upland area of Philippines. Our goal is to quantify land-use responses to economic signals, especially agricultural prices, and thereby to shed light on the impacts of policies affecting such prices. We use a decade-long panel of farm-level data on agricultural practices and prices. We find that prices do indeed matter to upland land-use decisions, and thus that policy reforms, such as those required by accession to the WTO, may be influential if indirect determinants of land-use patterns in these politically and environmentally sensitive areas.

Markets, Policies, and Land Use in the Uplands

The isolation of upland farmers from markets has diminished in the past generation, due in part to links created by migrants, and in part to infrastructural improvements. Coxhead, Rola, and Kim, using primary data from traders and wholesale markets, established that farm markets in the study area of this paper are integrated, and further, that local producer prices are determined exclusively by prices in external markets. This finding forms one link in a chain relating farmers' actions to a set of macroeconomic determinants. The other link, which we now explore, is that from farm-gate price signals to farmers' decisions.

In a precursor paper, Coxhead, Shively, and Shuai (hereafter CSS) examined farm-level

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land-use decisions and related them to expected levels and variances of prices and yields, input prices, and quantities of fixed factors such as family labor. Their findings confirmed the price-responsiveness of land-use decisions; however, prices were found to have relatively small land-use effects. If true, these results indicate a role for price policy, but not a highly influential one. CSS, however, used a short series of observations on highly heterogeneous farms, concerns which motivate the present study. Moreover, lack of wage data precluded any labor market analysis.

This article extends CSS in several important ways. We use a longer data series, and so can control for farm-specific effects. We now have a wage series and data on key crop price policies. We take account of censoring and panel data properties in the data.

Over time, Philippine domestic prices of corn, vegetables, and some other important upland crops have been subject to import-substitution policies applied as tariffs, state trading, and/or outright import bans. These have raised producer prices substantially above world market equivalents (Coxhead 1997; David). Under the terms of its accession to the WTO, the Philippines "tarrificated" all such restrictions in the mid 1990s, but for some crops, the implied tariff has remained high. This is clearly the case for corn, the crop grown most widely in uplands; the nominal protective rate for corn has remained high, and even risen, since WTO accession (figure 1).

The empirical exploration of links between national markets and policies and upland land uses has only a few antecedents in Philippines. Findings based on farm-level data have awaited the accumulation of time series, and are therefore very recent and for the most part tentative (CSS; Shively and Pagiola).

Why is it important to quantify upland farmers' responses to policies? We hypothesize that these policies are responsible, at least in part, for the substitution of corn and some vegetable crops for other land uses, including perennials such as coffee, a shift that has increased deforestation and intensified the mining of upland soils. If so, then policy reforms could have large environmental impacts at low cost relative to the usual site-specific approach to sustainable upland development. Our goal is to discover whether prices, which transmit the effects of policy changes, induce significant land-use responses once other determinants of behavior are taken into account.

The Model

We assume that farm households choose land-use strategies consistent with profit maximization over time, based on per-period net farm income. In the short run, they are constrained by the quantity of land they control, its characteristics (soil quality, climate, distance to market, etc.), and their labor endowment, which experience indicates differs from generic hired

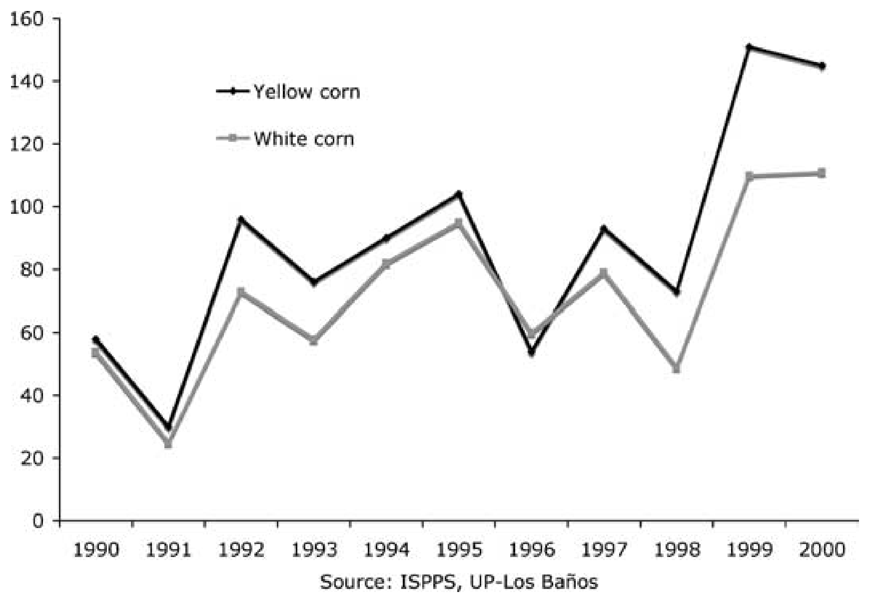

Figure 1. Nominal protection rate (%) for corn: Philippines, 1990–2000

labor in embodying specific management knowledge. In any period, the whole of the land area need not be farmed; some may be fallow. While we observe this in our data, farmers give many reasons for fallowing, sometimes citing soil fertility, and at other times the difficulty of obtaining seed, inputs, or labor. Our model does not attempt directly to model the fallowing decision, nor soil quality dynamics; rather, we restrict ourselves to asking what governs the choice of land cultivated to crops.

By profit maximization, land in each period is fixed in total quantity but allocable across crops. Let land per crop in period t be given by A_{jt}, and define vectors of crop prices $\mathbf{p_t}$, wages and input prices $\mathbf{w_t}$, and conditioning variables $\mathbf{z_t}$. Then

$$(1) \qquad A_{jt} = A_{jt}(\mathbf{p_t}, \mathbf{w_t}, \mathbf{z_t}).$$

Farm decisions are subject to exogenous changes in product and input prices and in exogenous or predetermined factors including farm size, family labor force, and weather. At the intensive margin, farmers adjust labor and input use by crop. Between the intensive and extensive margins, they adjust land allocation among crops. At the extensive margin, they alter the total area of the farm that is cultivated in a given period.

We expect total farmed area to increase with output prices and decline with input prices. Allocation of land to individual crops should be positively (negatively) related to expected own (cross) price or yield. Higher wages are likely to reduce profitability and thus to reduce land in crops; the extent of the wage effect should vary with the labor intensity of production. Increases in family labor likely increase land demand, especially in management-intensive crops.

In our data set, farmers allocate land mainly between corn and vegetable production. Vegetable crops are considerably more management-intensive than corn, so whereas corn production can be expanded by hiring more labor (given land), the same may not be true of vegetables. Conversely, relaxing the land constraint (given family labor) should expand corn area, but may leave vegetable production unchanged if the household cannot provide matching managerial resources. The land and labor constraints indicate a short-run model. Empirically, if these constraints bind, we can draw inferences about the incentives for farmers to take steps to relax them, following a shock of a given kind.[1]

Data

The data come from a group of villages located in Lantapan municipality, located in the upper Manupali River valley in central Bukidnon province, northern Mindanao Island. The area is typical of those that just two generations ago comprised the Philippines' internal frontier. The landscape climbs from river flats (500–600 masl) to steeply sloping mountainsides (1,100–2,200 masl). Sparsely settled in the 1950s, Lantapan's population increased at an average annual rate of 4.16% in 1970–80 and 4.0% in 1980–90; only in the 1990s did this growth converge on the national rate of 2.35%.

Total area farmed in the municipality increased faster than population, and this expansion occurred at the expense of primary forest and other perennial crop and agroforestry systems (Coxhead and Buenavista, Chapter 1). The main crop grown by area is corn; other crops vary in importance by location, with sugarcane dominant in the lower watershed, and vegetables in the upper.

We conducted a series of farmer surveys in the dry seasons of even-numbered years from 1994 to 2002—a total of five observations per household. Sample farms are drawn from nine villages in the middle and upper regions of the watershed. The surveys elicit information on the household composition, farm production and input use, land-use history, sales; nonfarm income; and farmers' perceptions of erosion and soil degradation as well as their expectations on types of crop to be grown and crop prices in the next cropping season (for survey methods and summaries of findings from individual rounds, see Coxhead 1995 and Rola et al.). The original sample size was 190, later reduced to 120. Several other observations have been lost for reasons beyond our control.

Estimation and Results

While several crops are grown in the study site, our analysis concentrates on corn and

[1] In the later years of the panel, introduction of banana plantations encouraged some households to rent land out. Extending the model to include this rental decision is a refinement that we address in ongoing research.

Table 1. Summary Statistics of Variables: Lantapan, 1994–2002

Variable	Mean	SD
Total area planted (ha)[a]	1.16	1.45
Area of corn (ha)	1.02	1.46
Area of vegetable (ha)	0.14	0.33
Total farm area (ha)	2.68	2.95
Relative expected corn revenue (pesos/ha)	20.00	7.38
Relative expected vegetable revenue (pesos/ha)	44.80	30.08
Relative wage[b] (pesos/day)	0.17	0.02
Slope of the land (%)	16.38	10.70
Average distance from national road (km)	2.86	3.64
Years of education of the household head	6.28	3.43
Number of adults in the household	3.31	1.93
Age of the household head	44.39	11.79
Total number of observations	592	

[a]Sum of corn and vegetable area.
[b]Average wage in each village.

vegetables, two enterprises for which land area per farm fluctuates from year to year. Table 1 provides a summary of the main variables used in the analysis. In estimating land demand functions, the data present a number of challenges. First, the data are censored: many observations have zero land allocated to particular crops. For corn about 25% of observations are zero; for vegetables, the figure is almost 70%. Hence, estimators based on linear methods are inconsistent. Second, since the data form a panel, controlling for unobserved household specific effects and dynamics is a challenge in nonlinear models such as Tobit. Third, price data are drawn from local market surveys and thus exhibit no cross-sectional variation. For a model containing several prices and few time periods, degrees of freedom become very limited. Fourth, land-allocation decisions are arguably not independent, implying that single equation estimation is inefficient. Finally, there is attrition in the data set, some of which is likely endogenous. The survey started with 190 farm households, but in 1996 the sample size was reduced to 120. In subsequent years another 20 households have dropped out of the survey.

In this article we deal with parts of the first three issues. The land allocation involves corner solutions; this censoring requires a Tobit estimator. However, there are additional complications. Empirical work using panel data must deal with problems of unobserved heterogeneity such as in soil quality, managerial ability etc., and dynamic feedback effects. It has proved very difficult to address both these features together (Hu), let alone to take account also of the interdependence of error terms across equations. In this article, we restrict the analysis to a random-effects Tobit model (estimation of a dynamic model is left for future work). This model permits the capturing of individual-specific effects, assuming these to be uncorrelated with explanatory variables.[2]

Third, we deal with the lack of cross-sectional price variation by substituting expected revenues for prices in the land-demand functions. There are several studies that make use of expected revenue or expected return instead of output prices, as explanatory variable (e.g., Arnberg; Holt; McGuirk and Mundlak). Using production data, we estimate revenue per hectare as a function of farm area, slope, education, distance, soil conservation, household labor, age, tenure, and location and year dummies. We then predict the expected revenues for all farms based on these estimates. This permits us to construct the expected revenues for those farms with zero land allocation to a particular crop.

Assuming strict exogeneity, for each crop we estimate the following model (suppressing crop subscripts)

$$
\begin{aligned}
(2)\qquad & A_{it} = \max\,(0, \mathbf{x_{it}}\boldsymbol{\beta} + c_i + u_{it}) \\
& u_{it} \mid \mathbf{x_i}, c_i \sim \text{Normal}\left(0, \sigma_u^2\right) \\
& \qquad\qquad \text{for } \mathbf{x_i} = [x_{i1}, \ldots, x_{iT}] \\
& c_i \mid \mathbf{x_i} \sim \text{Normal}\left(0, \sigma_c^2\right)
\end{aligned}
$$

for $i = 1, \ldots, N$ households, and $t = 1, \ldots, T$ periods, where A_{it} is land area planted to corn

[2] The assumption that error terms are uncorrelated with explanatory variables is one drawback of random effect models. In order to overcome the assumption of zero correlation, Wooldridge suggests a Chamberlain-like model that allows individual specific effects to be correlated with x's, albeit linearly. Unfortunately, this fix involves dropping time-invariant explanatory variables. The fixed-effects approach is another method to address this problem. However, in contrast with linear models, in fixed-effects Tobit models the individual-specific effects cannot be swept away, and hence the parameters cannot be estimated consistently for a finite time period (see Hsiao). Honoré developed a fixed-effects Tobit estimator that is consistent and asymptotically normal. However, his approach requires trimming observations in such a way that the symmetry lost by censoring can be restored, and consistency and normality are established only for a sample size greater than $N = 200$.

Table 2. Random-Effects Tobit Estimates of Land-Allocation Decisions

	Corn Area		Vegetable Area		Total Area	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Farm area	0.404***	0.020	−0.006	0.016	0.379***	0.014
Corn revenue	0.015**	0.008	−0.045***	0.009	0.006	0.007
Veg. revenue	−0.005**	0.002	0.007***	0.002	−0.004*	0.002
Wage	−1.570	1.939	−7.440***	1.814	−2.855*	1.634
Slope	−0.015**	0.006	−0.009*	0.005	−0.021***	0.005
Distance	−0.116***	0.018	−0.024	0.015	−0.107***	0.014
Educ. of HH	0.005	0.018	0.017	0.015	0.011	0.015
Fam. labor force	−0.026	0.027	0.057***	0.023	0.002	0.023
Age of HH	−0.011*	0.006	−0.009*	0.005	−0.013***	0.005
Constant	1.032**	0.464	1.695***	0.404	1.689***	0.385
σ_c	1.037***	0.080	0.479***	0.063	0.935***	0.048
σ_u	0.810***	0.036	0.585***	0.038	0.703***	0.027
ρ	0.621	0.045	0.402	0.070	0.639	0.032
Log likelihood	−754.824		−340.862		−738.162	
Wald stat ($\chi^2(9)$)	491.06***		48.76**		909.01***	
No. of observations	580		580		580	

*, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

or vegetables, $\mathbf{x_{it}}$ is the vector of explanatory variables; and $\boldsymbol{\beta}$, σ_u^2, and σ_c^2 are parameters to be estimated. We also estimate an equivalent model for total crop area. Each dependent variable is estimated as a function of prices, technology, and other conditioning variables. We assume total farm area to be exogenously fixed in the short run. The explanatory variables are total farm area, expected per hectare corn and vegetable revenues, wages, average slope, distance from the national road, age and education of the household head, and number of adults in the family. Price and value variables are normalized by fertilizer price. Estimation uses the *xttobit* procedure in STATA version 7. Each land-allocation equation is assumed independent, and we estimate the model equation by equation.[3]

The estimation of marginal effects in the random-effects Tobit model poses its own problems, since these by definition involve unobserved individual effects. In practice, marginal effects are estimated by making normalization of the individual-specific effects such as $E(c) = 0$ (Wooldridge, p. 22). It follows that:

$$(3) \qquad \frac{\partial E(A_{it}\,|\,\mathbf{x} = \bar{\mathbf{x}}, c = 0)}{\partial \mathbf{x_{jt}}} = \Phi(\hat{\boldsymbol{\beta}}'\bar{\mathbf{x}}_{\mathbf{it}}/\sigma_u)\beta_{ij}$$

where $\bar{\mathbf{x}}_{\mathbf{it}}$ is the sample mean and Φ is the CDF of a standard normal distribution.

Table 2 shows the random-effects Tobit estimates of our model; table 3 shows the key results in elasticity form. Crop area responses to expected revenues are positive for own-price and negative for cross-price terms. Wage rises have negative effects on area planted, most

Table 3. Elasticity Estimates from Random-Effects Tobit Model

Variable	Corn Area	Vegetable Area	Total Area
Elasticity at sample means			
Farm area	0.905	−0.021	0.811
Corn revenue	0.258	−1.238	0.100
Veg. revenue	−0.169	0.422	−0.127
Wage	−0.225	−1.733	−0.391
Slope	−0.212	−0.200	−0.271
Distance	−0.276	−0.092	−0.245
Educ. of HH	0.029	0.150	0.054
Fam. labor force	−0.071	0.257	0.007
Age of HH	−0.396	−0.538	−0.465
Elasticity at means if land allocation is positive			
Farm area	0.665	−0.007	0.697
Corn revenue	0.189	−0.383	0.086
Veg. revenue	−0.124	0.131	−0.109
Wage	−0.165	−0.536	−0.336
Slope	−0.156	−0.062	−0.233
Distance	−0.203	−0.028	−0.211
Educ. of HH	0.021	0.046	0.046
Fam. labor force	−0.053	0.079	0.006
Age of HH	−0.291	−0.166	−0.400

[3] The independence assumption leads to an efficiency loss. One can use Shonkwiler and Yen's two-step method to overcome this drawback; however, this approach does not account for interdependence between land-use choices in the first stage.

especially in the labor-intensive vegetable enterprise. Larger family labor endowments are significantly associated with greater area planted for vegetables, where management is important, but not for corn. For the total area planted, increases in expected corn revenue cause area to increase, while wage rises reduce it.

These estimates robustly complete the chain of causation between national markets or policies and upland land allocation. Output prices have a clear and unambiguous effect on demand for agricultural land: higher prices lead to area expansion, other things equal, and to intensification of production on existing farms. Given that upper-watershed production is more land-intensive than in lower areas for the same crops, market or policy shocks that raise prices of corn or vegetables (i.e., that turn the terms of trade in favor of upland agriculture) result in reduced fallow and greater pressures for deforestation.

Higher wages also have a strongly negative effect on land demand. This result, together with that of family labor on vegetable area expansion, indicates that labor market events influence the expansion of upland farming in our study site. In the later years of the sample, strong nonfarm job expansion outside the watershed has been associated with rising farm wages. This trend is now seen clearly to have slowed—and perhaps helped to reverse—the expansion and intensification of upland farming.

Discussion

Our econometric findings corroborate and strengthen those of several earlier papers. They also help clarify the environmental effects of trade and agricultural policies, real wage growth and internal migration, and macroeconomic policies affecting the prices of tradable farm outputs and inputs. These variables may all have direct and significant effects on the total area of upland agriculture, and also on the allocation of upland land by crop. These results are in turn important for the design of policies and projects directed at upland development and the conservation of forest, land, and water resources.

The WTO compliance requires that the Philippines scale back agricultural tariffs over time; the book value of the corn tariff is supposed to fall to 50% by 2005 from its current value of nearly 100%. By how much will this affect upland land use? If our findings are representative, tariff reduction in corn will reduce domestic price by 25% and corn area by 6.5%; in our sample about 0.065 ha per farm, or about 45,000 ha in Mindanao and 225,000 ha nationally. Total farm area in upland could fall by about 2.5%. If this land is retired into less erosive uses, these changes will reduce deforestation pressures, loss of soil fertility, and downstream or offsite damages.

This effect will be even greater if trends in world markets and/or Philippine trade policy raise demand for unskilled and semi-skilled labor in nonfarm sectors. The Philippines is now an important supplier of labor-intensive goods such as garments, electrical machinery and components, and of services such as call centers, to world markets. Expansion of these labor-intensive industries applies upward pressure to low-skill wages and encourages outmigration by members of farm families, both directly for employment, and indirectly for education and training. If wages rise by 25%—about half the rise seen over one decade in our data—corn area could fall by about 5.6% per farm, or almost 200,000 ha nationally, and total area farmed in uplands by almost 10%. This is a reduction in agricultural area comparable in magnitude to that experienced in Thailand during that country's economic boom from 1988 to 1996 (Coxhead and Jiraporn).

Of course, these numbers are at best indicative. Even so, their magnitudes indicate clearly the potential for national policies to alter demand for agricultural land in uplands. The commercialization of upland agriculture has created a powerful set of instruments by which to influence the use of scarce natural resources in the Philippine economy. Policy reforms, and economic growth in general, are likely to have much greater, longer-lasting, and more cost-effective impacts on the management of the upland resource base than are many location-specific "sustainable agriculture" projects, replicated many times over.

References

Arnberg, S. "Estimating Land Allocation Using Micro Panel Data Controlling for Yield Expectations and Crop Rotation." SOEM publication no. 47. Copenhagen: AKF Forlaget, 2002.

Coxhead, I. "A Baseline Economic Survey of the Lantapan Agricultural Economy." SANREM CRSP Philippines: Social Science Working Paper No. 95-1, 1995.

——. "Induced Innovation and Land Degradation in Developing Countries." *Australian Journal of Agricultural and Resource Economics* 41(1997):305–32.

Coxhead, I., and G. Buenavista, eds. *Seeking Sustainability: Challenges of Natural Resource Management in a Philippine Watershed*. Los Baños: Philippine Council on Agricultural Research, Natural Resources and Development, 2001.

Coxhead, I., and J. Plargpraphan. "Economic Boom, Financial Bust, and the Decline of Thai Agriculture: Was Growth in the 1990s Too Fast?" *Chulalongkorn Journal of Economics* 11(1999):76–96.

Coxhead, I., A.C. Rola, and K. Kim. "How Do National Markets and Price Policies Affect Land Use at the Forest Margin? Evidence from the Philippines." *Land Economics* 77(2001):250–67.

Coxhead, I., G.E. Shively, and X. Shuai. "Development Policies, Resource Constraints, and Agricultural Expansion on the Philippine Land Frontier." *Environment and Development Economics* 7(2002):341–63.

David, C.C. "Agriculture." In A. Balisacan and H. Hill, eds. *The Philippine Economy: Development, Policies, and Challenges*. New York: Oxford University Press, pp. 175–218.

Honoré, B.E. "Trimmed LAD and Least Squares Estimation of Truncated and Censored Regression Models with Fixed Effects." *Econometrica* 60(1992):533–65.

Holt, M.T. "A Linear Approximate Acreage Allocation Model." *Journal of Agricultural and Resource Economics* 24(1999):383–97.

Hsiao, C. *Analysis of Panel Data*, 2nd ed. Cambridge, U.K.: Cambridge University Press, 2003.

Hu, L. "Estimation of a Censored Dynamic Panel Data Model." *Econometrica* 70(2002):2499–517.

McGuirk, A., and Y. Mundlak. "The Transformation of Punjab Agriculture: A Choice of Technique Approach." *American Journal of Agricultural Economics* 74(1992):132–43.

Rola, A.C., D.D. Elazegui, M.M. Paunlagui, and E.P. Tagarino. "Socio-Demographic, Economic, and Technological Profile of Farm Households in Lantapan, Bukidnon, Philippines: 1995." SANREM CRSP-Philippines Research Report, July 1995.

Shively, G.E., and S. Pagiola. "Agricultural Intensification, Local Labor Markets, and Deforestation in the Philippines." *Environment and Development Economics* 9(2004):241–66.

Shonkwiler, J.S., and S.T. Yen. "Two-Step Estimation of a Censored System of Equations." *American Journal of Agricultural Economics* 81(1999):972–82.

Wooldridge, J. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press, 2002.