Welfare Implications of Tropical Forest Conservation: The Case of Ruteng Park

by
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Abstract

In 1993, the Indonesian government established the Ruteng Nature Recreation Park in western Flores. Subsequently, the government banned all timber extraction in and around the park's sub-tropical forest to promote biodiversity and watershed protection. This study quantitatively examines the role that tropical forest conservation has on the development of the local economy, and tests hypotheses regarding the local use of and dependence on the tropical forest. Microlevel data is taken from a rich socioeconomic survey administered to local Manggarai households residing within the park's buffer zone. This information is used to quantify the size of forest incomes, and to estimate a household profit function to characterize forest use, test for wealth differences, and identify policy levers for Ruteng Park. Given the large number of households without forest profits or an observable reservation price, a sample selection model ("Heckit analysis") is used on the forest profits censored data. Results indicate that there is a significant reliance on the forest, as forest products make up approximately 30% of total income. Furthermore, poorer households disproportional depend on forest access than do their wealthier counterparts. The policy options explored include limiting forest entry, via a tax or subsidy system.

Introduction

There is much debate over the influence tropical forest conservation has on local economies. Conservation programs are preferred to generate benefits (particularly globally) that greatly outweigh the costs, however, their success depends critically on how these programs affect the wellbeing of the local people. If a program provides a wealth of benefits to the world as a whole, but fails to better or retain, the welfare of those reliant on the resource, it will be unsustainable. Without adequate compensation, local populations have little incentive to facilitate forest conservation and change their behavior, which is often steeped in tradition.

Previous research has analyzed watershed protection benefits, ecotourism, and the potential of Ruteng Nature Recreation Park located in Flores, Indonesia (Pattanayak, 1997). An economic welfare analysis of logging has not been conducted, though data about the logging community in Ruteng was collected by Kramer et al. (1997). The average logger admitted to spending about 14 days a month in the forest cutting and processing timber, which totals 84 trees per year per logger. Thus, even with the harvesting ban there appears to be a large amount of income derived from illegal harvesting, which would disappear if the ban was *effectively* enforced.

This study quantitatively examines the role that tropical forest conservation (Ruteng Park) has on the development of the local economy (Manggarai), and tests hypotheses regarding the local use of and dependence on the tropical forest. The objectives of this project are three-fold. First, it addresses how an effective timber ban affects the well being of the timber harvesters. It is assumed that well being can be measured as a function of profit (total revenue minus total costs), so welfare losses can be measured as the difference between the current and an assumed no-harvest profit level. Secondly, the distributional effects are examined. This includes how particular socioeconomic factors influence the level of loss, and which economic class stands to lose the most. The third objective is to determine if any policy adjustments might mitigate the loss, perhaps through a transfer mechanism or an alternative policy.

Background

The Ruteng Nature Recreation Park (Taman Wisata Alam Ruteng or TWAR) was created in 1993, on the western side of Flores, Indonesia. The park is 32,246 hectares, with a 56,000 hectare buffer zone

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surrounding the park. Consequently, there are about 17,000 indigenous Manggarai inhabitants residing within the buffer zone (Kramer, et al. 1997). The area is mainly a sub-tropical forest, that is rich with biodiversity. Ecotourism is a planned park activity, as it is believed its presence will stimulate the local economy. Therefore, it is important that endemic species of cave bats, Komodo rats, monkeys, wild boar, civets, cobra, and vipers have ample habitat. The terrain is extremely steep, as the park is located on the tops of several volcanic ridges that is the source of many rivers and streams. The forest plays a central role in watershed protection.

The majority of Manggarai people are farmers who grow a variety of crops, including coffee, rice, bananas, cassava, and vanilla. Since coffee is only harvested three months a year and is the main revenue generator, other sources of income are extremely important (Ministry of Forestry, 1995). Timber harvesting provides additional income for a significant number of the population. All timber harvested comes from government owned forests, which includes the park reserve. The timber is processed into boards and beams, and is sold as construction lumber to local government agencies, churches, and private builders (Ministry of Forestry, 1995).

In 1989, the government banned timber extraction within several government owned forests and included Ruteng Park in 1993. The ban was aimed to protect the park's 12,800 hectares of accessible forested lands (Ministry of Forestry, 1995). The ban, however, has not been very effective. The government has failed to adequately enforce the logging ban and illegal harvesting continues.

Assuming an effective ban is feasible and is achieved, the benefits and cost of such a policy are numerous. The ecotourism industry will benefit by accruing amenities, and other communities (some far downstream from the forest) will benefit through carbon sequestration, biodiversity preservation, and watershed protection. The increased watershed protection will also specifically benefit the local farming community (Pattanayak and Kramer, 1997). The loggers will gain little that will translate into real benefit, and stand to take the most substantial loss. The majority of loggers surveyed did express concern for the forest system, but 26% felt that the timber regulations were not warranted. Therefore, the majority of the costs will be borne by the logging community who derive their income from timber harvesting and processing. For example, if harvesting of construction wood is effectively banned, it is estimated that 9.2 million dollars (US) will be lost over a 30 year period (Kramer, et al. 1997).

Theoretical Framework

The Profit Function

In order to determine a representative logging household's level of welfare, or utility derived from the production, sale, and consumption of park's resources, a profit function is developed. Specifically, the profit function is used to determine the level of household forest dependency and the associated welfare. Forest dependency is positively related to quantity of timber extracted, thus to timber profits. Profit level can be used to proxy welfare, as profits to the household are a function of benefits net of costs. Profits were modeled as a function of several exogenous variables and determined as (Sadoulet and de Janvry, 1995):

$$\pi = p'q(p,w,z,f(b)) - w'x(p,w,z,f(b))$$

where q is the vector of output quantities, x is the vector of input quantities, z is the vector of fixed factor quantities, f(b) is accessible forest size given the existence of a ban (b), p and w are the output and input prices, and where $q(p,w,z,f(b))$ and $x(p,w,z,f(b))$ are the output and input supply functions (respectively). If an effective ban (strictly enforced, unlike the current situation in Ruteng) exists, then $b = 1$, so that $f = 0$, thus $q = 0$ or that there will be no output supply of forest products, so that $\pi(p,w,z,f(1)) = 0$, and $\pi(p,w,z,f(0)) - \pi(p,w,z,f(1)) = \text{loss}$. Profits are maximized when the first-order condition of the profit function is set to zero and solved for the respective variables.

Household Production Theory

In this study, household production theory is applied to describe the relationship between household behavior and forest dependency. The use of household production theory is necessitated as the households examined exhibited simultaneous production and consumption decision making behavior (Pattanayak and Kramer, 1998). That is, households are both producers and consumers of products that do not always have completely functioning markets. Then it follows that production and consumption activities are not separate, and the relevant price is some household specific price and not the market price. A perfect market requires that "all prices are exogenous to the household and all products and factors are tradable with no transaction costs"(Sadoulet and de Janvry, 1995). These choices are to be made independently of one another, and their only "linkage" is through the level of income generated by the production process (Sadoulet and de Janvry, 1995).

Given the imperfect market structure, demand-side socioeconomic factors are included into the profit model (Pattanayak and Kramer, 1997). Education, household labor availability, non-agricultural activities, agricultural productivity, and household wealth (among others) appear to significantly influence forest dependency when markets are incomplete (Gunatilake, 1998). Therefore, profit becomes a function of prices, wages, environmental factors, and household characteristics. Additional socioeconomic characteristics are used to test differences in dependency between the two wealth groups (high and low).

Empirical Model

Sample Selection Model

A censored regression model is used to estimate the statistical relationship between forest profits (forest dependency) and prices, wages, household's head years of logging and education, village forest size, average age of the household, and a wealth dummy variable. A censored regression model is used when information about the dependent variable is missing, yet there is information available for the independent variables. In the Ruteng case, forest profits are given for 49 out of the 97 observations, thus there appears to be some sample or self-selection bias. Forest profits are known for the actively harvesting/collecting households, but the "reservation" price, or the minimum profit that non-harvesting household require to harvest is not (Pindyck and Rubinfeld, 1998). A censored regression model is preferred over an ordinary least-square estimated model since ordinary least-square estimation will yield heteroscedastic ($E(\mu_i) \neq 0$) estimators which are biased and inconsistent. With the Ruteng case, heteroscedasticity (non-constant error variance) exist due to the self-selected problem noted above.

The censored regression model can be calculated using a two-stage estimation technique, first suggested by Heckman (1979), which has been shown to produce efficient and consistent estimators. Heckman argued that specification error could be effectively eliminated if the values of the omitted variables are estimated, and then used as model regressors. First, Heckman suggested the estimation of the model using probit analysis to calculate the probability of a response or in the Ruteng case the probability that a household actively harvests timber or collects fuel wood. Probit analysis calculates estimators via a maximum-likelihood function, which has been shown to create efficient and consistent estimators of β and σ. The probit maximum-likelihood function will yield estimates of β /σ, thus predicted values of ϕ_i, Φ_i, and Z_i can be calculated where ϕ_i and Φ_i are, respectively, the probability density of a standard normal variable and the corresponding cumulative distribution function (Heckman, 1979). Probit analysis determines the probability of response.

With ϕ_i, Φ_i, and Z_i determined, the inverse of the Mill's ratio, or the probability of harvesting, λi, is calculated as below.

$$\lambda_i = \frac{\phi(Z_i)}{1-\Phi(Z_i)}$$

λ_i "is a monotone decreasing function of the probability that an observation is selected into the sample, $\Phi(-Z) = (1-\Phi(Z_i))$. In particular, $\lim_{\Phi(-Z)\to 1} \lambda_i = 0$, $\lim_{\Phi(-Z)\to 0} \lambda_i = \infty$, and $\partial\lambda_i/\partial\Phi(-Z)<0$ (Heckman, 1979)."

In the second stage of the estimation technique, λ_i is added as an additional model regressor to accommodate self-selection bias. Since 'λ_i predicted' approaches 'λ_i actual' as sample size increases, the mean of μ_i is normalized to zero and now ordinary least-square estimation will yield consistent estimates of the model parameters (Pindyck and Rubinfeld, 1998).

Two-Stage Estimation using the Cobb-Douglas Form

An empirical counterpart of the theoretical model is presented below. The model form was based on a Cobb-Douglas profit function, but is estimated using the two-stage estimation technique. The probit regression analysis is defined as

$$\text{Prob}(y_i>0) = \beta + \beta_{Ti} \text{In } P_{Ti} + \beta_F \text{In } P_F + \beta_L \text{In } P_L + \beta_C \text{In } P_C + \beta_Z Z + \text{error}$$

where Z is the vector of capital inputs/socioeconomic factors such that

$$e^{\beta z Z} = e^{(\beta zh\, ZH + \beta\, ze\, ZE + \beta\, zy\, ZY + \beta\, zf\, ZF + \beta\, zw\, ZW + \beta\, zs\, ZS + \beta\, zd\, ZD + \beta\, zg\, ZG + \beta\, zi\, ZI)}$$

Where P_{Ti} is the price of harvested timber products, P_L is the daily wage rate of labor, and Z as the vector of the socioeconomic variables. These variables include average age of household (H), forest size (F), a wealth dummy variable (W), head of household's education level (E), number of years logging (Y), size of household (S), age of the head of household

(D), and whether the household head believed that loggers are often fined or arrested for logging within the park (I).

The second stage estimates the Cobb-Douglas profit function using ordinary least-squares regression, but now includes λ_i, Ordinary least-squares estimation assumes model linearity. The functional form of the Cobb-Douglas model is only linear in parameters. The log linear specification is described as

$$\ln \Pi = \beta + \beta_{Ti} \ln P_{Ti} + \beta_F \ln P_F + \beta_L \ln P_L + \beta_Z Z + \text{error}$$

Such that now

$$\beta z Z = \beta_{zh} H + \beta_{ze} E + \beta_{zy} Y + \beta_{zf} F + \beta_{zw} W + \beta_{z\lambda i} \lambda i$$

Determination of prices, wages, and income
Three timber prices are used in the model. Prices are reported by each logging household as the price per unit of wood sold. For those households who did not specify a price per unit of product an average village price is calculated because it represents the household's opportunity cost of the product –the good may be consumed entirely by the household and would have no explicit price.

Wage are calculated as the opportunity cost of farm wage labor. The labor price is expected to be negatively related to profit. The farm labor wage rate is used as a proxy for the labor cost for the other activities due to the completeness of the data and the reasonableness of the approximate wage rate. Again, if the prices are not explicitly known, a village average is used.

A capital equipment cost is created for tools used for timber harvesting. These tools include axes, hand saws, and parangs (a type of knife used in conjunction with wood processing). The cost is a geometric function of the tool, the tool's age, its value when originally purchased, and the quantity of each tool (adapted from Klemperer, 1996).[3]

Total income is a function of revenues and costs of illegally logged timber products, fuel wood collection, cash crops, livestock, and other wage labor income. For each of the categories, the revenues are simply the product of units produced (collected or grown) and price per unit. This implies that total revenues includes the value of products individual households sold and those that the households consumed. Costs include labor and equipment costs.

Expected Signs of Independent Variables
Prices of the output goods and timber classes were expected to be positively related to profits. Products that are consumed internally, might have a negative relationship. The labor wage is expected to be negatively related to profits as the greater the opportunity cost of labor becomes (higher returns in household activities), the less attractive timber harvesting appears.

Age is measured as the average age of the household. Age may not be linearly related to profits. Age may be positively related to profits until a certain older age when they become less productive (i.e.: a quadratic relationship reflecting life cycle effects).

Education is a measure of the head of household's educational level. Education level is expected to be negatively related to timber profits. As the level of education rises, so do opportunities of other higher paying non-forest related employment. This assumes that education does not focus on methods and techniques of timber extraction, in which case education would be positively related to forest profits.

Years logging is a measure of total experience the head of household's had logging. It is expected that as more experience corresponds to higher profits, as those have mastered techniques and gained knowledge of the location of more, higher quality timber.

Theoretically, forest size could be positively or negatively related to profits. A greater forest size offers a larger quantity of extractable timber. On the other hand, the greater size of protected forest may reflect those vigil village members or park management that conserves forests and regulates harvest more efficiently.

A wealth dummy variable is created to unmask whether forest dependency varies across wealth groups, and to identify the group that would be affected by an enforced logging ban. The variable is based on a number of consumer durables the households owned, which are expected to be negatively related. Gunatilake (1998) contends and demonstrates through regression analysis, that relatively wealthier households pursue employment

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[3] $C = (P*r)\,((1-r)^t)$
Where C is the current year equipment cost, P is the initial purchase price, r is the discount rate, and t is age of the equipment. The discount rate was set at 15%.

opportunities that are more stable and less dependent on the extraction of forest products. Wealthier households collect fewer cheap forest products, as their time is in essence more valuable. That is, the opportunity cost of time for the wealthier households is greater than those of poorer households.
Since the hazard rate is an indicator of the probability that a household will choose timber harvesting or fuel wood collection, the greater the probability, the greater the profits.

Data
Data was collected by Duke University in 1996, in cooperation with the Indonesian Ministry of Forestry, as part of study entitled "Economics of Protected Areas in Siberut and Ruteng." The data consisted of rich socioeconomic data gathered from 97 randomly selected household within five villages (desas) in the Manggarai district of Western Flores. The villages included Desa Carep, Desa Golo Dukal, Desa Pau, Desa Tenda, and Desa Waso.[4] The household surveys were administered by two teams over a two week period in February of 1996. The teams were students selected from the Universitas Nusa Cendana, and received three days of training. The questionnaires were organized into several sections including household characteristics (size, ages, education, housing type, belongings), logging activities, crop and livestock activities, non-timber forest products, other exogenous incomes/wages, and attitudes about the park and the welfare of the forest/environment.

The average head of household's age is 39 years and had on average resided in their respective village for 37 years. The majority of those surveyed have some primary school level education or less (77%) and live in a family of six.

Although logging within the Ruteng and buffer zone is illegal, about three-quarters of those surveyed admit to harvesting and selling timber extracted from the reserve. Most household heads have been logging for 13 years, beginning approximately 10 years before the ban. Of the four timber classes harvested, class one timber (*ajang, ngancar, wuhar, dalo, pinis, lumu, worok*) is the most frequently harvested where each logger spent on average 148 days per year and cut 71 trees.

In addition to cutting, many households collect dead wood which is either sold or consumed for fuel. These fuel wood products, most collected from within the forest or nearby fields, constituted nearly 15% of their yearly income. However, much of the fuel wood does not come from the park, but nearby roadways (Ministry of Forestry).

Axes, manual hand saws, and parangs are the preferred tools for timber harvesting (Ministry of Forestry). Of those surveyed, 34% own at least one axe, 30% own a manual saw (chainsaws are prohibited), and 98% own at least one parang. Many of the tools are relatively old, as it was not uncommon to observe a logger using an axe purchased 20 years ago.

To augment incomes, most households harvest and sell cash crops and livestock. Two-thirds of the households grew some form of crop for the market, including coffee, vanilla, bananas, avocados, ampupu, and acacia. In addition, many raise and sell pigs, goats, chickens, ducks, cattle, water buffalo, and horses.

For some households other sources of income are obtained from farm and non-farm wage labor opportunities, personal Warung or Kiosk, or work on logging crews. The majority work as a wage laborers on someone else's farm.

Results
Forest timber products constitutes a substantial portion of each household's total income. Construction timber (classes I-III) makes up over 21%, with fuel wood constituting an additional 15%. Therefore, over one-third of income can be directly related to the park and its surrounding buffer zone. All other sources of income, cash crops, livestock, and wage labor, devise 64% of total income.

Household income averages 1,837,034 Rupiah. When the data was collected, one US dollar equaled 2,200 Rupiah, thus annual income (US) averages $835. However, median household income is only $287, indicating that the income distribution is quite skewed.

Initially, an ordinary least-square regression analysis was to be performed on the Cobb-Douglas specified model above. The Cobb-Douglas specification is used as a first model approximation, as other model specifications are not possible (i.e.: normalize quadratic) due to degrees of freedom limitations. Upon estimating such a (OLS) model, it is deemed inappropriate as there appeared a large number of censored dependent variables. The model yields biased estimators (estimators being inefficient and inconsistent) making model interpretation difficult.

[4] The background in this section draws from Kramer, et al. 1997.

Due to the heteroscedastic error term, two-stage estimation regression analysis, described in Section 4, is performed using SAS, a statistical software package. The final model results are shown below (only OLS estimates are shown in Table 1).

The probit analysis indicates that prices are a factor in a household's decision to harvest. Class III timber positively influences that decision, while the "other" class exhibits a negative relationship. The longer the head of the household has been logging the greater the probability that the household would log. Also, younger households appear more willing to log. Those wealthier households and those households with large village forests are less likely to depend on forest incomes.

The OLS model is statistically significant, as the model yield a F-value of 6.165 ($p>0.0001$). The independent variables (prices, wages, age, years, wealth, forest size, and the hazard rate), explain slightly greater than 58% of the variation of timber profits (adjusted $R^2 = .588$).

Price of class II timber is significantly related to forest profits, as higher prices correspond with larger profits. Prices have different distributional effects, as described below. Wages are significant and negatively correlated to the household's forest income. If wages (an input) increase, individuals increasing choose to opt out of logging and into more profitable employment opportunities. Years logging by the head of household is both very significant and positively related to profits. The household's average age is negatively related and significant. Forest size demonstrates a significant negative relation with timber profits. The larger village forests are being protected that diminishes the size of the corresponding household forest income. The hazard rate, whose specific task is to normalize the mean of the error to zero, was positively and significantly related to forest profits. The hazard rate was defined as a "function of the probability that an observation is selected into the sample," in this case the sample to log, it should be expected to be positively correlated with profits.

Table 1: Results of OLS estimation

Variable	Parameter Estimate	P-value
Intercept	12.44	0.46
Price Class I Timber*	-1.31	0.22
Price Class II Timber*	2.82	0.06
Price Class III Timber*	0.14	0.86
Labor Wage*	-1.68	0.01
Price ClassI•Wealth	3.67	0.02
Price ClassII•Wealth	-3.36	0.04
Price ClassIII•Wealth	1.57	0.06
Average Age	-0.06	0.01
Years Logging	0.15	0.00
Education	0.32	0.28
Forest Size	0.00	0.01
Wealth	-15.77	0.35
Hazard Rate	1.99	0.00

A distributional analysis is performed to determine the relative impact an effective timber harvest ban would have upon different socioeconomic classes; would the ban effect the poorer segment of the population differently than the wealthier segment? As mentioned above, a dummy wealth variable is included into the model to test for differences between class. The variable is a function of consumer durables (including televisions, radios, kerosene stoves, wristwatches, clocks, and motorcycles), that is, households with a greater number of goods are considered "wealthier." Two classes, an upper and lower, are identified by examining the relative "clustering" effects exhibited when durables are applied to a scatterplot. Essentially, those households without any consumer durables (66%) are considered the lower wealth group, with the remaining (34%) deemed the upper. Using a students t-test it is determined that these are, in fact, two statistically different populations ($p<.0000$).

The slope dummy variables exhibit some interesting results when interacted with timber prices. The expected forest profit level achieved by the wealthier groups is positively influenced by the price of timber Class I and III, meaning a high timber price is correlated with greater forest dependence. However, the wealthier group appears to rely less on the forest with respect to class II timber. Forest dependence increases as the price of timber class II increase for the lower wealth group.

A second, more robust and comprehensive, distributional analysis is performed using the Chow test. Three regression models are created and assessed. A "pooled" model is similar to the one specified above, except the dummy variable is removed. A "high wealth" and "low wealth" model

* In Cobb-Douglas specification this variable and forest profits are estimated in log form.

incorporates the same variables as the pooled model, but each wealth model is estimated using only those observations from the respective high or low wealth group.

Chow (1960) specifies a method to examine whether an economic relationship "holds for two different groups of economic units" by asking if "subsets of coefficients in two regressions are equal." The Chow procedure tests if

$$y_1 = \chi_1\beta_1 + \mu_1$$

$$y_2 = \chi_2\beta_2 + \mu_2$$

The null hypothesis is $\beta_1 = \beta_2$, and the Chow test statistics has a F-distribution with k and $(n_1 + n_2 - 2k)$ degrees of freedom and is defined as

$$F_{chow} = \frac{(\mu'\mu - \mu_1'\mu_1 - \mu_2'\mu_2)/k}{(\mu_1'\mu_1 + \mu_2'\mu_2)/(n_1 + n_2 - 2k)}$$

Where $\mu'\mu$ is the sum of squares with $n_1 + n_2$ degrees of freedom, $\mu_1'\mu_1$ is the sum of squares with n_1 degrees of freedom, $\mu_2'\mu_2$ is the sum of squares with n_2 degrees of freedom, k is the k-1 coefficients plus the intercept. In the Ruteng case $\mu'\mu$ (81.7) is associated with the pooled model (both socioeconomic groups included), $\mu_1'\mu_1$ (21.4) is associated with the low wealth regression model, and $\mu_2'\mu_2$ (1.7) is associated with the high wealth regression model.

The Chow statistic yields an F-ratio of 8.1657 with (9,35) degrees of freedom. It is highly significant ($p<0.0000$). The null hypothesis that $\beta_1 = \beta_2$, or that the low wealth population is not significantly different from the high is rejected. There appears to be a significant negative relationship between household wealth and level of forest dependency.

The high wealth group is sensitive to price changes of Class I timber from the forest, and to some degree to Class III timber, but less to the price of Class II timber. The low wealth group exhibits greater sensitivity only to the price of Class II timber. This is interesting, but perhaps not all too unexpected. Wealthier households have been thought to have a relative easier time finding other stable, better paying income opportunities. Class I timber is the better quality, high paying timber product which may explain why the wealthier groups specifically target it rather than the lower paying Class II and Class III. Selling Class II and III timber yield incomes lower than could be earned from harvesting and processing Class I timber or working in other sectors. The lower wealth group have fewer non-forest related income opportunities, so the prices of the less profitable timber classes appear to be more of an important factor in their level of dependency on the forest.

Conclusion

Only a few studies have quantitatively examined the role tropical forest conservation has on the development of the surrounding local economy. This study provides a rigorous assessment of the influence Ruteng Park and its surrounding forests have on the local population, including testing hypotheses regarding forest use, wealth differences, and policy implications. A household survey conducted in Flores, Indonesian provides the basis for the analysis. Forest dependence, proxied as forest profits, is modeled as a function of timber prices received from the sale of timber products, labor wages, household characteristics, wealth differences, and environmental factors. A two-stage regression technique is used to estimate model parameters.

The model parameters of the forest profits function have the theoretically appropriate signs and statistical significance. Prices of the timber classes are positively related to forest profits, but have different distributional effects. Wages, defined as the opportunity cost of logging, is negatively correlated to forest dependency. Increased wages in non-timber related sectors appear to pull household away from the relatively less profitable timber industry. Socio-economic variables, such as average household age and logging experience, influence forest profits, thereby indicating incomplete labor market situation. Larger village forest size corresponds with smaller forest dependence, suggesting that some villages have already responded to fears of over-exploitation by enacting their own limited forest access policy. Distributional analysis reveals that forest use and reliance is not uniform among wealth groups. Poorer households depend more heavily on forest access than their wealthier counterparts. Furthermore, wealth groups appear to target different timber classes as the wealthier group is most sensitive to changes in the price of Class I timber–the higher priced timber.

Current levels of timber extraction are considered unsustainable by those familiar with the forest resource, however a complete and effective timber ban would significantly harm the welfare of the local Manggarai population. Of those survey, 29% of respondents believed their children or grandchildren will be loggers and 26% felt that there are sufficient forests and that government regulation is not warranted. The Ministry of Forestry contends that a well controlled selective harvest could be sustainable. The household's sensitivity to prices, as illustrated by the model results, suggests that logging pressures could be alleviated by the establishment of a government sponsored tax or subsidy price system. Taxing ecological sensitive timber classes would decrease the real price received by a household, thus making them less profitable. In the interest of distributional fairness, given that a poorer household rely more heavily on forest profits, taxes could be levied on those sensitive timber classes mainly targeted by the wealthier group. A price subsidy could be applied to the more ecologically abundant timber classes making them more attractive to extract. Perhaps the best use of government funds would be to invest in non-timber sectors. Subsiding factor inputs, such as providing low cost fertilizer or agricultural equipment, effectively increases profits in the agricultural sector and raises the opportunity cost of labor used in logging. Subsiding inputs may also be less of an administrative burden than enacting a comprehensive tax system.

In addition, households express an interest in a limited access forest program in which a logger would have to purchase a permit to log. The data reveals a positive correlation between forest profits and the amount a household is willing to pay for an annual permit[5]. This system would essentially allow the poorer, more forest dependent households to continue harvesting while also providing rent for their use. The rent might be used to alleviate additional transitional frictions. The permits represent an extra cost on an already poor segment of the population, but there is no reason to believe this will negatively affect forest profits as the limited access program will lessen the competition between loggers for the higher priced, higher quality class I timber.

In conclusion, an effective timber ban will reduce an average household's annual income by 21%. This will cause a dangerous situation, both politically and environmentally. Without adequate compensation or without an increase in employment opportunities households have little incentive to respect or obey conservation policies and the burden is heavier on the poor. Further research needs to be performed to define the extent of deforestation, and thus to calculate a baseline for a maximum sustainable harvest. This study suggests correctly instituted market based incentives can effectively reduce harvesting pressures while providing distributional equity. A household's responsiveness to timber prices and willingness to pay to participate in a permitting program demonstrates that economic incentives may work and such economic analysis is useful for formulating tropical forest conservation policies.

[5] This was measured by an open-ended contingent valuation question administered as part of the Duke Study.

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