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HOUSEHOLD ECONOMICS OF AGRICULTURE AND FORESTRY IN RURAL VIETNAM

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To Carina

Contents

Abstract

This is an empirical thesis focusing on agriculture and forestry issues in rural Viet Nam. It contains six chapters of which four are chapters with empirical analysis. One chapter introduces the data and provides an overview of the findings and in the last chapter we briefly discuss the findings.

In the first chapter we briefly explain the area studied and note that forestry and agriculture are of especial importance to the welfare of households, particularly to one ethnic group. We also find that the area is dominated by subsistence farming.

In chapter two, we examine the implications of market failures on the problem of aggregating agricultural production. Usually, to establish a composite agricultural commodity, agricultural production activities are aggregated by the means of prices. Under the assumption that some markets are subject to market failure, households might be restricted in their quest to equalise labour returns. Consequently, aggregating agricultural production is exempted since labour inputs are not perfect substitutes across activities. We find a significant difference between labour returns between the two major crops. This finding has implications for the estimation of labour supply.

The third chapter deals with efficiency in factor allocation between agricultural productions alternatives. We compare returns between two farming systems and find a consistent mark-up for the farming system that requires higher investment and a longer time to mature. This pattern is consistent with a risk premium for the activity that yields higher returns. Thereafter, we test non-linear restrictions on parameter as given by technical rates of substitution equalisation, and find contrary to the difference above that we cannot reject efficient factor input allocation.

The fourth chapter deals more explicitly with forestry issues and the determinants of how households choose from where to collect fuelwood. One of the collection sites is subjected to deforestation and has the character of open access. To model the choice we use a random parameter logit model in which the chosen sites largely is determined by the shadow price of fuel. The model allows us to calculate the cross price effects that can be used to implement policies for impeding deforestation of open access areas. The shadow prices are calculated from a series of collection functions, one for each collection site.

In the fifth chapter we investigate the collection and demand of Non-Timber Forest Products, (NTFP), exemplified by bamboo shoots. We are particularly interested in the incidence of poverty patterns and any potential link between NTFP collection and agricultural production. It is found that wealth levels are inversely correlated with the collection of bamboo, as is the occurrence of cash income, implying that poorer households tend to collect more, while households with cash income sources beside bamboo collection tend to collect less.

We end the thesis with a brief discussion of the findings and attempt to draw some general policy conclusions. We suggest that the forest authority should strive to ease the collection from private user plantations to alleviate the pressure on open access areas. We furthermore believe that the remaining unallocated forest areas subject to deforestation should be especially allocated to the poorer strata. This would stimulate commitment from targeted households.

Keywords: Shadow Wages, Agricultural Production, Market Failures, Developing Countries, Efficiency in Factor Allocation, Property Rights, Deforestation, Random Parameter Logit, Fuelwood, Non-Timber Forest Products, Poverty, Ethnicity

Preface

This work draws upon the knowledge of a large number of people. First, I would like to thank Thomas Sterner who has encouraged me, helped to improve my work, and supported me during burdensome times. Many of the conversations I've had with Fredrik Carlsson and Gunnar Köhlin has given me guidance and inspiration; thanks for being the nicest of guys.

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Chapter 1 Introduction and Summary

This thesis is built upon the cooperation of 300 households in Tan Lac, Hoa Binh in northern Viet Nam who kindly have shared their lives with us (see appendix A for the questionnaire). The study area is located a two-hour car ride southwest of the capital Hanoi. Within the area, the Moung tribe dominates while the Kinh is the second largest ethnical group. Forestry and agriculture are the two most important activities. Some of the forest is subjected to deforestation, in particular the areas characterised by open access use. These areas are presently under the responsibility of state enterprises. The ability to control these resources is however limited. One aim is to investigate what and how policies can be used to protect these areas.

The study area

This section briefly discusses the data and the area from where it was gathered. For more details, see each chapter. The data was collected during late 1998.

Agriculture

The area is best described within the realm of subsistence agriculture. The typical household economy consists of a small, irrigated paddy for subsistence, a vegetable garden, some domestic animals, occasionally sugar cane for cash generation, and a plot with trees. Rice paddy dominates but roughly six other crops can be found. Farm diversification or expansion is mainly towards sugar cane.

There is a relatively sharp division of agricultural labour between males and females. This is what one normally finds in agricultural communities, where sexual division of labour is based on a combination of traditional norms and comparative advantages. Hence, in this area, as elsewhere, weeding and planting are the main responsibility of females, while men conduct much of the harvest, pesticide application and all the ploughing. A similar division can be seen in the context of decision-making. In the area of household stewardship, men are in control of most of the important decisions, that is, those regarding investments in agriculture and forestry.

Erratic income streams from agriculture make some households vulnerable even though the number of households defined as hungry is low. Despite this, one third of all households gather products from the surrounding forests, notably bamboo shoots and mushrooms. Almost none of the observed households have made any investment in fuelwood substitutes such as kerosene or LPG.

Forestry

The reliance on forest products and wood for energy makes forestry activities particularly important to the well being of households. Most of the households are in possession of user rights for land with trees; either plantations or natural forests. Some households have a mix of forest plots. State enterprises still exercise managerial responsibility over some forestland. Though they do not have sufficient resources to control their forest plots efficiently. This has led to a situation similar to open access resource use, of which some households (roughly a third of the whole sample) take advantage and collect either fuelwood or NTFP. The open access forests are subject to deforestation. One policy goal for Vietnamese forest authorities is to halt this deforestation since there are external benefits of conserving the vegetative cover.

In order to combat deforestation activities, The Forest Inspectorate, FI, has granted user rights to households for natural forest plots (previously controlled by state enterprises) achieving low cost protection and distributing resources at the same time. These rights come with managerial duties in the form of protection responsibilities and regulations concerning the productivity of the forest. The user rights for plantations have similar contractual arrangements. Some areas remain open access since they are out of the household's economic reach. Hence, these areas are of prime interest to the FI.

The Household

Three hundred random households were surveyed; see appendix A for details on the household questionnaire and Table 1 for some descriptive statistics. For general information, a community level questionnaire was distributed, see appendix B. The study area is located in the province of Hoa Binh (pronounced Hoa Bing) two hours southwest of Hanoi. We have selected ten villages in three communes in the district of Tan Lac. The area is predominantly hilly but rice farming is still the main agricultural activity.

Table 1 Household characteristics

Variable	Mean	Std dev	Min	Max
Sex of household head (1 = male)	1.1	0.2	1	2
Age of household head (years)	41.4	9.4	21	67
Number of adult males in households	1.8	0.9	0	5
Number of adult females in households	2.0	1.1	0	7
Number of young males in households	0.7	0.8	0	3
Number of young females in households	0.7	0.8	0	3
Number of small children in households	0.3	0.5	0	2
Total number of children	1.7	1.0	0	6
Education of household head	6.4	2.2	1	13
Ethnicity (1=Moung)	0.9	0.3	0	1
Wealth (thousand Dongs)	12830	15396	400	133150

It is possible to grow hill rice and cassava but sugar cane is the crop households find most desirable in an expanded crop mix. This crop can advantageously be grown on flatter land.

Interviews were held on the premises of the respondent. The respondents were mostly the head of the households, with an average age of 41. In some sections however, we queried specifically both household head and his or her spouse. Household heads are mostly males, while females head seven percent of all households.

The average household has 1.7 children, evenly spread between girls and boys, and 3.8 adults of which slightly more than half are females. The variation is higher for females as can be seen in the table. Of the 1.7 children, 0.3 are of rearing age.

As mentioned above, most of the households belong to the Moung tribe (in all over 88 per cent). The average Moung family has less education than families in the other tribe, the Kinh. The number of years of education of the head of the average Moung household is about one year less than the average Kinh head.

The wealth variable consists of the monetary sum of the household's durables such as machines and furniture but also the value of jewellery, see the first section in appendix A. The average household has slightly over twelve million Dongs[1] in durables (no respondent reported any jewellery). The average Moung household has twenty per cent less wealth than has a Kinh household, thus indicating that the Moung are relatively poorer assuming that wealth can be used as a proxy for poverty.

As subsistence households dominate the area, there are few households that supply labour for wage earnings. About thirty households have supplied time for wage compensations, implying that we cannot fully trust market wages to be good proxies for labour productivity.

The land market is also thin; perhaps even non-existent. There is information about the value of the land at the district level but no market transactions are known, thus we are again hesitant to use these average values.

[1] At the time of the survey, one dollar was roughly 14 000 Dongs. The present value is about 15 000 / 1 USD.

Overview of the thesis

<u>Chapter 2</u> Rural Shadow Wages, Labour Supply and Agricultural Production Under Different Crop Mix: Empirical Evidence from Viet Nam

The first chapter deals with the problem of aggregating agricultural production when markets are imperfect. In the presence of market imperfections, fundamental questions must be raised pertaining to labour substitutability. If households are restricted in their crop-growing pattern due to market failures, they are not able to freely allocate their labour over the full spectrum of employment opportunities.

The paper analyses two farming systems instead of using an aggregated agricultural harvest under the presumption that some households are restricted in choosing crop patterns and consequently restricted in their allocation of labour. The farming systems differ in the level of diversification of crops where a limited number of households are able to engage in the more diversified system (two crops: rice and sugar cane) while other households are restricted to cultivate only one of the two (rice).

We find evidence of imperfect substitution possibilities since bootstrapped labour returns differ significantly between farming systems with lower returns for single-crop producers. This implies that on the whole, sample households are unable to adjust their labour supply at the margin and consequently, the use of shadow wages from an aggregated agricultural production is likely to mislead policy conclusions.

<u>Chapter 3</u> Differences in Agricultural Returns: An Empirical Test of Efficiency in Factor Input Allocation using Vietnamese Data.

The second empirical paper tests efficiency in factor allocation between two production possibilities. Empirical studies on household production and consumption are usually based on the premise that the household behaves as if it is one agent, commonly referred to as the unitary model. This assumption has proven to be useful in empirical analysis as an approximation to actual behaviour. In contrast, neoclassical economic theory is based on the behaviour of individuals; there is theoretical justification for aggregation to the household level only under quite restrictive assumptions such as the possibility to aggregate preferences to a representative agent.

This paper can be seen as an attempt to expand this literature by examining households' ability to allocate factor inputs. We pursue this objective using two of the locally most important agricultural products, rice and sugar cane. We test whether the returns and technical rates of substitution from the production functions are equal.

We anticipated difficulty in optimising factor inputs since poor households often lack adequate information. There are different risks involved in the different activities and this should lead to a seemingly sub-optimal allocation of factor inputs. Our results reveal however that we cannot reject that households allocate their factor inputs efficiently. Therefore, we have found some empirical support for models that assume efficiency or more specifically, we cannot deny that these are useful theoretical constructions for empirical analysis.

Chapter 4 *Property Rights and Deforestation: The Choice of Fuelwood Source in Rural Viet Nam Under Ethnical Heterogeneity*

In the third paper, we are interested in how households substitute fuelwood collection sites. The paper analyses the choice of fuelwood collection sources in rural Viet Nam of which one source is subject to deforestation activities. In total, four distinct sources are available of which one is a newly constructed institution - user rights for natural forestland. The analysis of choice is conducted using a logit model with randomly distributed parameters across households. This econometric technique allows us to calculate varying cross elasticity between the open access area and the other sources, enabling policy makers to design effective policy remedies for combating deforestation.

Due to market imperfections, we cannot use market prices in the choice analysis and have therefore calculated shadow prices (and profits) for fuelwood from each source based on separate production functions. This gives us a set of prices used in a random parameter logit estimation of the choice of fuelwood source. We find in particular that households optimise in their choice of fuelwood source and a relatively stronger substitution effect emerges between plantation and open access areas. This implies that a policy change that affects the production of fuel from plantations might be an efficient option. Further analysis of producer surplus measures explains why some forest land, *i.e.* the *OA* was difficult to allocate to households. We suggest that poor households are likely to be more prone to accept some managerial responsibility of *OA* forest resources.

The lowest income and lowest wage households are most reliant on the distant forests and even they find these forests too low-valued to justify protection and management. This implies that the pressure on the remaining unallocated forest will continue and might even increase as population pressure elevates. We anticipate therefore a continuing decline in *OA* stocks. There are however cross effects between collection sites, which can be utilised by authorities to change open access use as to decrease the pressure on *OA* areas.

Chapter 5 *Extractive Non-Timber Values, Cash and Poverty*

Forests can serve as important sources of cash, energy, and nutrient supply particularly for the poorer strata in periods of food shortages. Considering this link between forest production and the agricultural sector, we estimate a collection function of an extractive good in a sample selection framework in which the wealth status, the prime cash source and wage labour are assumed to influence the decision to collect the environmental good. The poverty link is strong and indicates that poorer households are more dependent on the environmental good.

This paper is an attempt to broaden the literature on the use of NTFPs, exemplified by the collection and consumption of bamboo shoots[2]. Besides expanding the literature in general, our contributions are mainly of two sorts. First and foremost, we use an approach that enables us to draw on smaller data sets in our quest for calculating demand elasticities as opposed to using larger and more costly data sets. By the means of implicit shadow prices that vary across households, we are able to estimate demand elasticities for the environmental good. Secondly, we place the collection of the environmental good within its proper framework in an attempt to link poverty aspects and the agricultural sector to the forest sector.

We find that cash generating sources show a congruent and negative impact on the probability to collect. The relative poverty level of the household is negative and significant. Therefore, it seems that environmental good collection is important to households low in wealth and cash generating sources. In the demand analysis, we find the environmental good to be a normal good with almost unity price elasticity. Further analysis of the importance of the environmental good to poor households reveals that on a wealth scale, the environmental good seems to increase in importance as households become relatively poorer.

[2] There are other NTFPs in the area such as mushrooms but observations are too few for making statistical analysis.

CHAPTER 2

Rural Shadow Wages, Labour Supply and Agricultural Production Under Different Crop Mix: Empirical Evidence from Viet Nam

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Abstract

Due to market imperfections, there is a problem of aggregating agricultural production activities. The paper analyses two farming systems instead of using an aggregated agricultural harvest under the presumption that some households are restricted in choosing crop patterns and consequently limited in their allocation of labour. The farming systems differ in the level of diversification of crops where a limited number of households are able to engage in the more diversified system (two crops: rice and sugar cane) while other households are restricted to cultivate only one of the two (rice). This circumstance is likely to be a widespread phenomenon in developing countries. If there is a restriction that limits the choice of crop pattern, production functions for rice and sugar cane must be estimated separately since labour inputs are not substitutes across crops. We find evidence of imperfect substitution possibilities since bootstrapped labour returns differ significantly between farming systems with lower returns for single-crop producers. This implies that households are unable to adjust their labour supply at the margin and hence, the use of shadow wages from an aggregated agricultural production is likely to mislead policy conclusions.

JEL classification: J43, Q12

Keywords: Household Production, Shadow Wages, Labour supply, Aggregation

[3] The author wishes to thank Gautam Gupta, Greg Amacher, Randy Bluffstone and seminar participants for valuable comments.

1 Introduction and Background

Many rural development issues hinge upon how labour returns vary across sex and age. The neoclassical understanding of labour supply, schooling, and fertility relies on our information of labour products. For example, higher female productivity increases the opportunity cost of rearing children and thus, under the assumption that children are normal goods, the demand for children decreases. In many developing countries, labour markets are imperfect and we therefore cannot trust the observed market wages as appropriate proxies for labour returns. Hence, in the absence of well-functioning labour markets, it can be necessary for the sake of policy predictions to estimate the returns to labour by a different tack, for example by the use of agricultural production functions.

Typically there are also other market failures that we meet when studying economic behaviour in developing countries. The most striking of these are; credit market failure and information deficiencies. In the presence of market imperfections, fundamental questions must be raised, especially those issues pertaining to labour substitutability. If households are restricted in their crop-growing pattern due to market failures, they are not able to freely allocate their labour over the full spectrum of employment opportunities. This paper explores this problem and discusses the issue of aggregating agricultural production in the presence of market imperfections. To this end we utilise survey data from rural Vietnam collected in 1998, where some households have been able to diversify their crop mix and increase their profits while poorer households have not reached the same level of diversification.

Early econometric studies of labour products assumed perfect substitutability between labour categories, see for example Lau, Lin and Yotopoulos (1978). In many cases, this is a sensible way to proceed, but as Deolalikar and Vijverberg (1987) showed, perfect substitutability is not always a valid assumption. They discovered that labour was heterogeneous and thus, there is a need to distinguish between hired and family labour. Normally, we also find that even household labour is heterogeneous in the sense that household members specialise in certain activities such as female specialisation in weeding or the relatively higher male involvement in activities such as ploughing where sheer strength is an advantage. This gender-biased pattern is evident in our data where for example the bulk of the weeding is conducted by female labour. Whenever we suspect that agricultural activities are gender divided, the assumption of perfect substitutes might again fail. If labour is gender divided, then male and female labour are better characterised as being complements, therefore we need to separate male and female labour inputs, Jacoby (1993).

We have already implied that in regions where wages are poor proxies for labour returns, adequate estimates of labour returns can instead be obtained by estimating shadow wages using an agricultural production function. As such, this paper is a closely related to Jacoby (1993), which focused on male and female productivity differentials. Jacoby used a price aggregated production function, which in our case, is less suitable since some households do not participate in all markets. There are a number of reasons for not participating in a certain market. First, households might have a set of preferences incompatible with producing a certain crop. Differences in labour returns between a produced crop and an unexploited crop with higher returns are in general contradictory to rationality since households would choose crop patterns to maximise profits. Leaving a positive return to labour untapped is not in accordance with profit maximisation. Second, there might be market failures that either restrict households to enter the production of this particular crop or create an uncertainty in expected outcome of production. The former leads to imperfect labour substitutability between crops and the latter imply that there might be a risk premium difference between crops. Under these two latter circumstances, the analysis of labour returns would benefit by using separate agricultural production functions, one for each group of crops to which market failures are insignificant. The motivation for this is simple, but strong since the problem is general in a developing country setting; if a household is not active in a certain market due to market imperfections, labour inputs are not substitutes between production possibilities. Under these circumstances we would find a difference in returns between restricted and un-restricted crop cultivation, presumably with higher returns to the more risky activity, if such risk difference exists.

Thus, what follows is that the presence of market imperfections raises the question of how we aggregate agricultural production over a sample of households, which includes both unrestricted and restricted households, since by implication inputs are not perfect substitutes. Consequently, we cannot aggregate over the whole sample using prices to create a composite output good. It is possible to aggregate outputs only if all households participate in all output markets or if all markets clear.

Given the above, this paper hypothesises that: If households face market imperfections we are likely to find a wedge between labour returns for households which are engaged in the diversified system (rice and sugar cane) as compared to those households which are restricted to only rice. Hence, if we can find evidence that there are significantly different rates of return to labour, we must question recent studies that use an aggregated approach.

Taking market imperfections seriously has qualitative implications for labour supply estimations that uses shadow wages from an aggregated agricultural production function, see further Jacoby (1993), Skoufias (1993) and Abdulai and Regmi (2000). To test our hypothesis we use household data on agricultural production from northern rural Viet Nam, see below in Section 3 for a closer inspection of the data set.

We find in particular that labour returns of males and females living in diversifying households are significantly different from and higher than households with a single crop. This finding supports suggestions made by our theoretical model and raises serious questions regarding the aggregation of agricultural output into one composite production function under market imperfections. Further, it seems that for this data, labour supply is in general bending backward, see Rosenzweig (1980) for a similar result. The paper is organised as follows: the next section presents the theoretical model for our purposes. Section 3 gives a description of the data set. In sections 4 and 5, we present our empirical approach and findings. The paper ends by summing up the results and policy implications.

2 The Model

The model presented below is a modified version of the household model in Gronau (1980), edited by Jacoby (1993), and later used by Skoufias (1994) and Abdulai and Regmi (2000), in which two persons, male and female jointly make decisions on resource allocation. In our setting we define two types of households: One type has a farming system that consists of only a single crop, or a home farm production, which can be thought of as a subsistence crop, Q_P^R, even though we allow for the possibility of producing a marketable surplus[4]. The second type of household has been able to extend its production of food to also include a cash crop, Q^S. We define this farming system as

[4] For a list of notation, see Table A1, appendix A.

more diversified. The incentive to invest in a diversified system, it is argued, stems from relatively higher profitability, sufficient to cover for any potential increment in risk due to a longer gestation period.

We assume that conversion from a single crop system to a diversified farming system is costly and requires that households to be in possession of sufficient endowments or resources, $\boldsymbol{R}$, to cover investment outlays, foregone food output (under conversion from food production to cash crop production), and other relevant resources needed to change the crop pattern but also information of preferential differences. The elements in $\boldsymbol{R}$ thus describe the factors that affect the decision to engage in the diversified cultivation. To capture that some households do not have diversified, we include a constraint $Q^S \geq 0$.

Labour might be gender specialised implying that labour is heterogeneous. We do not allow for hired-in labour in our analytical model, such as in Deolalikar and Vijverberg (1987), but this is likely to be of minor importance since hiring in is unusual. We do though allow for selling labour to the market. The shallow labour market provides one argument for the model being non-separable[5]. Labour market participation is limited for both sexes but more outspoken for females. As in many other developing country settings, we assume therefore that there is a labour market constraint that limits households in supplying labour to the labour market, see Skoufias (1994) and Benjamin (1992). The labour market constraint is: $L_i^M \geq 0$, for $i=\{m, f\}$ where f is female and m is male.

Household members allocate their time endowment (T_i) over four activities; leisure (L_i^l), home farm production (L_i^R), market work (L_i^M), and cash crop work (L_i^S). A marketable surplus, market work, cash-crop sales, and exogenous income V generates income so that a market composite good $\boldsymbol{D}$ can be purchased. Home farm production is described by a well-behaved production function, $Q_P^R = Q_P^R\ (L_i^R,\ \boldsymbol{E}^R |\ \boldsymbol{h}\ )$ where $\boldsymbol{E}^R$ is a vector of non-labour inputs. $\boldsymbol{h}$ is household or individual characteristics. Households are occasionally able to produce a marketable surplus of the subsistence crop at a market price p^R equal to $p^R(Q_P^R - Q_H^R)$ where Q_H^R is the amount of home-produced food consumed within the household. In line with Gronau (1980), we assume that Q_P^R is perfectly substitutable with the market purchased good D and in principle with the agricultural cash-commodity as well. Hence, $C = D + Q_H^R$ is a composite good in the utility function. The cash crop production is given by a likewise well-behaved function $Q^S(L_i^S, \boldsymbol{E}^S | \boldsymbol{h}, \boldsymbol{R})$, where $\boldsymbol{E}^S$ is all non-labour inputs at price p^E.

Effective wages within the households might differ between market observations W_i and family labour due to transaction costs and labour quality differentials. The price of the agricultural commodity is set as the numeraire. Households choose C, L_i^j where $j = \{R, S, M, l\}$, so as to:

$$Max\ U(C, L_i \mid h) \tag{1}$$

subject to:

$$C = D + Q_H^R \tag{2a}$$

$$Q_P^R\ (L_i^R, \boldsymbol{E}^R | \boldsymbol{h}) \tag{2b}$$

$$D = Q^S(L_i^S, \boldsymbol{E}^S | \boldsymbol{h}, \boldsymbol{R}) + p^R(Q_P^R - Q_H^R) - p_E E^k + W_m M_m + W_f M_f + V \tag{2c}$$

$$\sum_{ij} L_i^j = T_i \tag{2d}$$

$$L_i^M \geq 0 \qquad i = m, f \tag{2e}$$

$$Q^S \geq 0 \tag{2f}$$

where $k = \{E, s\}$. After substitution, the above gives the following Lagrangean:

$$L = U(D + Q_H^R,\ L_i^l \mid h) + \lambda [\ Q^S(L_i^S, \boldsymbol{E}^S | \boldsymbol{h}, \boldsymbol{R}) + p^R(Q_P^R - Q_H^R) - p_E E^k + W_m L_m^M + W_f L_f^M + V - D] + \mu_i L_i^M + \varphi Q^S$$

Assuming the household member participates in non-leisure activities we have after some simplification the following relevant[6] optimal conditions:

[5] Non separability means that decisions on production and consumption are considered simultaneously.
[6] Given the objective, we present only those conditions including labour.

$$\frac{\delta U / \delta L_i}{\delta U / \delta C} = W_i + \frac{\mu_i + \varphi}{\lambda} = W_i^* \qquad (3)$$

Equation (3) shows the marginal rate of substitution between leisure and consumption if households do not engage in Q^S and this equals the relevant shadow wage for non-diversified farmers, see (4).

$$\frac{\delta Q_P^R}{\delta L_i^R} = W_i^* \qquad (4)$$

$$\frac{\delta Q^S}{\delta L_i^S} = W_i + \frac{\mu_i}{\lambda} \qquad (5)$$

Equation (5), however, gives the shadow wage rate given that the household is engaged in the diversified farming system. As is readily seen, shadow wages differ between households with different level of diversification.

There are several alternative wage rates in this model depending on what type(s) of labour the household member supplies and this is in the essence why we cannot add these production functions and estimate an aggregated model. First, if the member supplies labour to all three income-generating activities, μ_i and φ are zero as required by the complementary slackness conditions, then consequently the relevant shadow wage is equal to W_i, or the market wage for member *i*. If on the other hand, member *i* is engaged only in the cash crop and home production (μ>0, φ=0), then the shadow wage depends on the size and sign on the Lagrangean multiplier. The same principle is true for individuals that are engaged in only home production and market labour and then we have μ=0 but instead $\varphi > 0$. In a model without the last constraint (2f), marginal products $\partial Q^S / \partial L_i^S$ and $\partial Q_P^R / \partial L_i^R$ would be equal to one and the same shadow wage. However, since there is a constraint in producing the agricultural cash crop we cannot equate these two marginal products. This implies that L^R and L^S are not substitutes. In other words: $\partial Q^S / \partial L_i^S$ is not defined for households without diversified farming. This implies that less diversified households are restricted in their labour allocation due to preferences or market effects.

The model implies that we can test for example if households with both sugar cane and rice enjoy the same returns to labour in both production functions, and also if households with home production (rice) and market work receive similar returns as they enjoy from their labour input as market wages. Further tests can be done on the inequalities between levels of labour returns from rice and sugar cane and ongoing market wages when households are not participating in the labour market, see Table 1.

In the empirical section, we perform these tests using bootstrapped two sample *t*-tests. Over the whole sample our hypothesis foretells $\partial Q^S / \partial L_i^S > \partial Q_P^R / \partial L_i^R$ but in fact, even households with the diversified farming system, we might find that $\partial Q^S / \partial L_i^S > \partial Q_P^R / \partial L_i^R$ is optimal due to the requirement of a risk premium necessary to cope with the potential risk involved. This could be explicitly incorporated in the theoretical model above, but we avoid doing this since it is well known from Sandmo(1971), Batra & Ullah (1974), and Stiglitz(1974), that riskier production tend to have higher returns due to too low levels of inputs.

Table 1 Testable restrictions

Activity	*Potential Tests*	
L_i^j >0	μ =0, φ =0	labour returns (rice &sugar)= market wage
L_i^M >0, L_i^R >0	μ =0, φ >0	labour returns (rice)= market wage
L_i^R >0, L_i^S >0	μ >0, φ =0	labour returns (rice)= labour products (sugar)
		labour returns (rice, sugar)≠ market wage (likely)
L_i^R >0	μ >0, φ >0	labour returns rice ≠ on going market wage or sugar cane returns
	(likely)	

The equilibrium conditions above imply a non-separable model. However, assuming the household's budget set is a convex set, we can linearise the budget constraint at the optimal point, see Moffitt (1990), and Jacoby (1993) using the relevant shadow prices. Hence, the slope of the tangency point of the household budget constraint is equal to the shadow wage, W_i^* of which the empirical counterpart is the appropriate labour return. Using this insight and following the methodology developed by Jacoby (1993), we can redefine the household full income Y^*, for households with L_i^M = 0:

$$Y^* = \max\{\pi^S\} + \max\{\pi_P^R\} + L_i^m + W_i + V \quad (6)$$

where π^S, and π^R are the associated profits of producing the cash crop and the home farm produce. Using shadow prices in the utility maximisation problem above yields a standard separable model, but in our case, there is an entry restriction that restrict households from entering the sugar cane market. Consequently, in the labour supply analysis we cannot sum up total labour supply across households since each household faces a different option set of where to allocate their labour. We need instead to estimate separated labour supply functions. In general, the labour supply functions are likely to depend on both male and female wage levels, Jacoby (1993). The labour supply for individual *i* to farming system *j* is taken to be:

$$LS_i^j = LS_i^j(W_i^{j*}, Y^* \mid h) \quad (7)$$

where W_i^{j*} is the relevant shadow wage for individual *i*.

3 Markets

Credit Market

Before we explore the data used in this study, let us briefly present some issues in connection with inefficient local markets. Since agricultural income streams are erratic, credits are occasionally necessary for smoothing consumption. A credit is furthermore required to cover investment demands that cannot be furnished by cash outlays. Credit markets are known to be imperfect in poor countries, Dasgupta (1993), and Viet Nam is no exception in this regard. It is widely known that the Vietnamese banking system is inefficient, Griffin (1998). At the prevailing interest rates, the supply of credit only covers about 28% of total demand, thus leaving an excess credit demand of a factor 3.5, Cao (2001), implying that the cost of taking a loan is too low. Simultaneously, households prefer not to save in saving accounts but to keep their excess cash elsewhere due to low after tax interest rates -in real terms occasionally below zero, thus, creating little or no incentive for increased saving rates. This obviously sustains the shortage of capital. For differences in interest rates between private moneylenders and the State Bank, see Table B1, in appendix B.

Land Market

Though there are indications of a developing land market, see Griffin (1998), such indications are not apparent in our study area. We find official district statements about the value of land, but enumerators report that there are simply no transactions within the study area. Hence, the land market seems very thin or perhaps even non-existent.

Labour Market

The market for wage compensations is likewise thin. Of roughly 1200 adults, only 120 individuals or 10 per cent joined the labour market during the previous season and then only occasionally. The participation is also highly skewed across population centres, with one village having almost a third of the total reported labour supply for wage claims.

In sum, we can conclude that neither of these markets seems to be operating near efficiency levels.

4 The data

The data is from a survey conducted during the fourth quarter of 1998[7]. It contains 300 randomly sampled households spread over three communes, see Table 2 for descriptive statistics for the main variables. For other variables, see appendix C. Four observations were deleted due to missing observations. The area is located in the hilly district of Tan Lac, Hoa Binh province roughly thirty kilometres southwest of Hanoi, Viet Nam. Variations in climate factors such as rainfall and temperature are unknown but believed to be small across the sample.

[7] The writer is indebted to Dr Tran Thi Que of the Centre for Gender and Sustainable Development in Hanoi for supervising the data collection.

In total, there are about 12,500 households in the area of which roughly 11,700 have their primary income from agriculture. Two ethnic groups are represented, Kinh and Moung of which the Moung are in majority. Rice paddy is the predominant agricultural activity though sugar cane cultivation however is the major cash crop. Households in villages with any significant agricultural diversification normally diversify from rice production towards sugar cane production.

Table 2 Agricultural Statistics

Variable	*Mean*	*Std. Dev*	*Min*	*Max*
Rice: Output /year (000 Dongs)	2995	1883	500	10800
Male Labour (days/month)	18.8	13.9	0	72.7
Female	23.5	16.7	0	98.8
Pesticide (000 Dongs/year)	19.4	27.9	0	400
Fertilisers (kg)	280.2	231.0	0	2100
Irrigation (000 Dongs/year)	75.4	67.3	0	360
Capital (000 Dongs/year)	1322.7	2686.1	200	30000
Rice Land (m^2)	3323.1	1379	998	10000
Sugar Cane:				
Output	2145	3145	200	30000
Male Labour	23.9	20.2	5.5	98
Female Labour	22.2	19.7	4.6	148
Pesticides	15.8	28.9	0	240
Fertiliser	230	646	0	5840
Capital (000 Dongs)	132	420	0	4500
Sugar Cane Land	1343	1348	100	10000

Aggregation of labour was carried out by gender. In the questionnaire, we asked for eight different labour categories. Males tend to supply slightly less labour to rice than females while this pattern is reversed for sugar cane inputs. Labour values are monthly averages over the calendar year, while other information is based on yearly values. Two inputs were frequently reported as zero in rice cultivation (capital and pesticides) and one in sugar cane (fertiliser). In one commune, households reported zero irrigation. Since the rice grown is not hill rice farmers need irrigation to cultivate it, consequently, irrigation is not an option but rather a necessity. In order not to lose too much information we decided to dummy the villages in this commune. Irrigation values are intended to reflect the cost of irrigating the rice fields.

All non-labour inputs are reported in Vietnamese Dongs,[8] except fertiliser. Capital measures the capital used during the previous year and includes productive capital such as harrows and ploughs. The values are based on farmers' perceptions of the value. In both our production functions, we have used the value of production as the dependent variable. In rice production there is a small variability in prices of output with mean price 1750 Dongs per kilogram. The lowest reported price is 1500 Dongs and the highest is 2000 Dongs. In sugar cane production, farmers face the same price.

5 Empirical Strategy

The general empirical specification of Q^j is the translog form:

$$\ln \tilde{Q}^j = \alpha^j + \sum_a \beta_a^j \ln X_a^j + \frac{1}{2} \sum_a \sum_b \beta_{ab}^j \ln X_a^j \ln X_b^j + \xi^j h^j + \varepsilon^j = f(X^j, h^j) \tag{8}$$

where $\tilde{Q}^j$ is either $\tilde{Q}_P^R$ or $\tilde{Q}^S$, and depicts the empirical counterpart of Q_P^R and Q^S. $X_{a,b}$ are inputs to the production and α, β, and ξ are parameters to be estimated, and ε^j is the error term.

In the rice estimation the inputs are our two labour categories; males and females: L_m^R and L_f^R that are the focus of this study; land, *A*; irrigation, *I*; pesticides, *P*; fertilisers, *F*; and capital, *K*. As we mentioned in the data section, relatively many households have reported zero inputs of pesticides and capital. We used a maximum likelihood procedure in Stata to estimate a logarithmic variable with zero skewness[9], Stata (1999). This procedure was used for capital *K* and pesticide *P* and the results were subsequently used in an initial estimation. But this estimation was outperformed (measured by Aikakes and Schwartz information criteria) by one in which dummies replaced the variables with frequent zeros.

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[8] One USD is about 15000 Dongs

[9] In fact this transformation is just as arbitrary as adding the value one to the variable, which is commonly found in the literature, see for example Jacoby (1993). The formula is *newvar*=ln(*oldvar*-*k*) and choosing *k* using Newton's optimisation method.

To fit the sugar cane production, we proceeded along the same route and attempted to transform variables with frequent zeros, but all three inputs in $\boldsymbol{E}^{S}$ are in fact relatively frequently reported as zero. The estimation using transformed variables rendered results of input returns that were highly unlikely and simply unrealistic. We settled therefore to include dummies for capital, pesticides, and fertilisers.

We assume that farmers are maximising expected profits (due to a stochastic production) and from the results in Zellner et al (1966), OLS estimation will then be consistent and unbiased. Examples of this solution are numerous and often implicitly produced in several studies, see Jacoby (1993), Skoufias (1994), Abulai & Regmi (2000), Dadkhah & Zahedi (1986), and Mundlak *et al* (unknown date of publishing). This requires that man-made errors are independent of natural stochastic events and then, the returns to inputs cannot be determined until after inputs are employed. To control for unobserved effects such as ability or management skills, we include in both estimations: years of education for household head and spouse, sex of household head, and the number of adults in the household.

6 Empirical Results

A. Rice

We start by discussing rice production. The ordinary least square estimates of our translog estimation are shown below in Table 3. We detected heteroscedasticity and consequently used the consistent sandwich estimator, White (1980). We reject the Cobb-Douglas form [F (16, 269) = 2.26] indicating that this functional form might be too restrictive. A Ramsey test of omitted variable showed that we could not reject the hypothesis that the estimation has no omitted variables. In order for the production function to be homothetic we require that $\sum_{a}\sum_{b}\beta_{ab} = 0$ and for homogeneity of degree one, $\sum_{a}\beta_{a}$ must equal to one. Imposing linear restrictions on the estimates can test whether these two qualifications hold. In the present case, we reject that the rice production function in Table 3 is homothetic but not that it is homogenous of degree one. We have included four village dummies in our estimation all of which lie within one commune Tu Ne. As mentioned above, these are, included to control for the zero reported values in irrigation.

The interpretation of the variable estimates cannot be untangled directly since we need to consider the interaction terms as well. If we start with the variables included in $\boldsymbol{E^R}$, we have found that our returns to factor inputs of land, *A,* and fertiliser *F* are 0.47, thousand Dongs per square meter rice land added and 1.5 thousand Dongs per Kg fertilisers, respectively while the elasticity of output with respect to land is 0.59. Both marginal effects are declining.

Table 3 Rice Production Estimates

Variable	*Estimate*	*Variable*	*Estimate*
Males L_m^R	0.33 (0.53)	$A^R \times L_f^R$	0.079 (0.072)
Females L_f^R	0.47 (0.55)	$\boldsymbol{A}^R \times \boldsymbol{Fe}^R$	0.31** (0.11)
Fertilisers Fe^R	-2.3** (0.70)	$\boldsymbol{A}^R \times \boldsymbol{I}$	0.032 (0.07)
Land A^R	4.22** (2.2)	$A^R \times A^R$	-0.32** (0.15)
Irrigation I	-0.23 (0.50)	Dummy Pesticide	0.011 (0.067)
$L_m^R \times L_m^R$	0.0038 (0.03)	Dummy Capital	0.049 (0.057)
$L_f^R \times L_f^R$	-0.012 (0.02)	Soil quality	0.16* (0.08)
$Fe^R \times Fe^R$	-0.00085 (0.019)	Head's education	0.016 (0.01)
I^2	0.0015 (0.017)	Spouse's education	-0.015 (0.012)
$L_m^R \times L_f^R$	-0.024 (0.04)	Sex of household head	-0.0030 (0.14)
$L_m^R \times \boldsymbol{I}$	0.011 (0.022)	Adults	.010 (0.020)
$L_m^R \times \boldsymbol{Fe}^R$	0.12** (0.05)	Village 21	0.18 (0.06)
$L_f^R \times \boldsymbol{Fe}^R$	-0.064** (0.029)	Village 22	0.45** (0.07)
$L_f^R \times \boldsymbol{I}$	-0.06** (0.03)	Village 23	0.58** (0.08)
$\boldsymbol{Fe}^R \times \boldsymbol{I}$	-0.010 (0.03)	Village 24	0.55** (0.24)
$A^R \times L_m^R$	-0.12 (0.08)	Constant	-8.4 (7.76)

Nobs=296, R-sq=0.66, F=34.04 Dependent variable is log of rice output.

These effects are however of minor interest to us and for expositional brevity we devote the rest of this section only to marginal effects from our labour inputs presented in

Table 4. The calculations of returns to inputs are based on (9), see below[10]. The results are in monetary terms since we have a value as our dependent variable.

$$\frac{\partial Q^{j}}{\partial X_{a}} = \left[\beta_{a}^{j} + 2\beta_{aa}^{j} + \sum_{b} \beta_{ab}^{j} \ln X_{b}^{j} \right] \frac{\hat{Q}^{j}(\boldsymbol{X}^{j})}{X_{a}^{j}} \tag{9}$$

where the $\hat{Q}^{j}$ depicts predicted values.

Table 4 The Average Value of Marginal Products, Rice (at sample means)

Input	*Value (thousand dongs)*
Male Labour	3.6
Female Labour	5.8

There is a relatively high difference between male and female labour which implies that female labour is more productive than male labour -in values, 5.8 and 3.6 thousand Dongs per day for females and males respectively. The higher relative value of female labour compared to male labour is found elsewhere; see for example, Alderman *et al* (1995), who found higher female products. But the result contrasts with that of Jacoby (1992, 1993). Obvious explanations of different marginal products are quality differentials between male and female labour.

B. Sugar Cane

Our data contains 170 households with a complete description of sugar cane cultivation efforts. Our objectives concerns the whole sample, and since only a fraction of the total sample of 295 households (one additional observation was deleted due to missing values) produce sugar cane, we must raise the question as to whether or not our sugar cane cultivators represent a random sample; in the theoretical section, we argued that the there is indeed a non-random selection since some households are restricted in the potential desire to invest in the cash crop. Consequently, we suspect that the

[10] As indicated by the superscript the same principle is used in the calculation of sugar cane returns as well.

determinants of the diversification decision affect the sample selection of present sugar cane producers. Under sample selection bias we cannot use ordinary least square without getting biased results and therefore employ the Heckman technique when we estimate the sugar cane production function, which corrects the OLS estimation for potential non-randomness, Heckman (1976). This technique allows us to test whether the resource constraint ***R***, significantly affects the decision to invest in sugar cane cultivation since we can include the elements in ***R*** while controlling for other important factors that might have an impact on the investment decision. In short, our empirical counterpart of Q^S is given by: $\tilde{Q}^S(L_i^S, \boldsymbol{E}^S|\boldsymbol{h}, R)$, where $\tilde{Q}^S$ is the value of sugar cane produced during the last year; $\boldsymbol{E}^{\boldsymbol{S}}$ depicts the non-labour inputs; L_i^S is a labour input. The Heckman model is estimated by maximum likelihood and based on the following two econometric equations:

$$\tilde{Q}^S = f(X^j, h^j) + u_1 \qquad \textit{[regression model]}$$

where f is the translog specification as in equation 8 above. The dependent variable $\tilde{Q}^S$ is only observed if:

$$\alpha^S + \gamma^S \mathbf{z}^S + u_2 > 0 \qquad \textit{[selection model]}$$

with u_1~N(0, σ), u_2~N(0, 1), corr(u_2 , u_2) = ρ where **z** represents the independent variables giving the probability to be a sugar cane producer including the elements in ***R***. The Greek letters α, β, γ and ρ, are being estimated. Error terms are corrected for heteroscedasticity by using White (1980) robust errors.

The factors of production in sugar cane cultivation are mainly male and female labour, L_m^S and L_f^S, and land A^S, with fertilisers, pesticides and total capital, (F^S, P^S and K^S) as additional inputs. As mentioned, we encountered a multitude of zero values in all three inputs in $\boldsymbol{E}^{\boldsymbol{S}}$. We attempted therefore to transform these variables according to the procedure outlined above. The ML procedure did not convert for capital and thus we needed to replace capital use with a dummy.

Table 5 Sugar Cane production estimates

Variable	*Estimate*
Regression eq	
Male labour, L_m^S	1.22**
	(0.6)
Female labour, L_f^S	-0.67
	(0.5)
Land A^S	-0.88
	(0.96)
$L_m^S \times L_m^S$	-0.03
	(0.04)
$L_f^S \times L_f^S$	-0.03
	(0.04)
$A^S \times A^S$	0.10
	(0.7)
$L_m^S \times L_f^S$	-0.1*
	(0.06)
$L_m^S \times A^S$	-0.1
	(0.08)
$L_f^S \times A^S$	0.18**
	(0.08)
Dummy Fertiliser	0.22*
	(0.13)
Dummy Capital	0.03
	(0.09)
Dummy pesticides	0.07
	(0.1)
Cropping year	-0.23
	(0.15)
Soil quality	0.010
	(0.012)
Head's education	-0.014
	(0.015)
Spouse's education	0.018
	(0.012)
Sex of household head	-0.31
	(0.21)
Adults	0.010
	(0.027)
Constant	7.2**
	(2.3)
Selection equation	
Household size	0.023
	(0.03)
Wealthy	0.51**
	(0.14)
Agricultural Land	0.000020**
	(0.00003)
Agricultural Land squared	-3.5e-10
	(2.66e-10)
Moung	-0.64**
	(0.17)
Age of household head	-0.16**
	(0.04)
Age squared	0.0018**
	(0.0004)
Head's education	0.00038
	(0.02)
Spouse's education	0.061**
	(0.023)
Population density	0.0016
	(0.023)
Constant	3.12**
	(0.81)
ρ (sample selection indicator)	-0.49**
	(0.21)

Tot Nobs 295 Uncensored 170; Ll= 310.2; Chi2 (13)=291.3. Dependent variable is log of sugar cane output.

As for the other transformed inputs, fertiliser and pesticide, we noted that returns to these were extreme and generated a non-monotonic function on the female labour. Relying on our own judgement, we decided to replace fertilisers, pesticides and capital with dummies. We control for the crop cycle by using a dummy indicating whether farmers are in the early cycle, which means in practice that their labour input is significantly higher while output is still mediocre.

i) Investment decision

In our theoretical model we argued that there are important resource constraints that prevent households from initiating the diversified production; these are of two kinds. First, we have a set of preferences that can affect the decision to cultivate sugar cane; these variables describe household characteristics. Second, we argued above for the need to control for resource availability, such as land and labour availability; and equally important is that the ability to cope with a reduction in cash flow during the cash crop's maturity period. We argue that the wealth level is likely to be a good proxy for this ability and therefore an important element of $\boldsymbol{R}$. However, one can argue that the wealth level is endogenous to the cultivation of sugar cane, thus we reverted to a ranking system which is a historical account of the wealth status of the households. We assume that this ranking system is not endogenous to the present cropping pattern.

In Table 5, we give the sample selection estimation of sugar cane production. We find several variables significant in the selection equation. When we ran the probit in isolation, it received a pseudo R-square of 0.125. Our indicator of labour availability is positive but insignificant. This is not however the case for agricultural land, which indicates that the more land the household has, the higher the probability that the households engage in sugar cane cultivation. Notably, we find that the wealth-ranking variable is significant and positive, implying that wealthier households have an increased probability of investing in sugar cane. Given the low propensity to save, which leads to credit shortage, wealth becomes an important resource to draw upon when investing in investment-intensive crops. The population density is included to cover for economic development. The impact from the density is positive as expected but does not significantly affecting the decision to grow sugar cane.

On the preference side, we see that if households belong to the Moung tribe, they are less likely to cultivate sugar cane. It is known that the Moung prefer to live further away from roads, and consequently they possess land that is less attractive for sugar cane cultivation. Kinh people however, tend to settle along roadsides that are more suitable locations for sugar cane production. Our effort to include the age of the household head was successful insofar it is significant. The negative sign must be considered as expected. Given the rather high intensity of labour input early in the cultivation cycle, older households might be less advantageous for growing sugar cane.

ii) Regression analysis

As in the estimation of the rice cultivation, we cannot detect the marginal effects directly but must disentangle them by using (9) above. Homotheticity is not rejected. Our estimation of sugar cane production inhibits decreasing returns of scale of 0.62. The dummy for crop cycle is found to be significant and with a negative sign and it controls for the particular stage the farmer is in the three-year crop cycle of sugar cane.

Again, given the functional form, we need to calculate the returns using (9) above. Returns are given monetary terms. The calculated marginal product of male labour is evaluated at sample means, 8.5 thousand Dongs per day see Table 6, while female labour receive 6.6 thousand Dongs per day.

Table 6 Value of Marginal Products of Sugar Cane Inputs (at sample means)

Variable	*Value*
Male Labour	8.5
Female Labour	6.6

The difference between the two returns is not very large and gender differences in labour returns are not unusual, see Jacoby (1993), Alderman *et al* (1998) as we mentioned above.

C. Testing theoretical restrictions

We are now in a position to test the implications of the theoretical model above using our empirical results. Our marginal returns to labour are relatively complex functions and the calculated values are not straight-forward applicable to *t*-tests. We have therefore used the bootstrap method to calculate new standard deviations for the returns (evaluated at sample mean) that are subsequently used in the *t*-tests. In Table 7, we present the bootstrapped values of the marginal products.

Table 7 Bootstrap Values of Labour Returns (at sample means)

Variable	*Rice*	Sugar Cane
Male Labour	2.6	8.4
	(8.6)	(8.4)
Female Labour	6.5	7.4
	(7.3)	(11.5)

Std deviations within parenthesis

First, we tested the equality of means between rice and sugar cane by a two sample *t*-test, on the values as given in Table 7 and found no evidence that they are equal. We could reject equality for both male and female return at five per cent. Hence, it seems reasonable to state that the overall mean between the two farming systems are indeed different and that the returns are larger for the diversified farming system. The spread of female return is substantial however as indicated by the higher standard deviation. The tests are calculated irrespective of the household's labour allocation patterns. The higher return from sugar cane might be due to the necessity of earning a risk premium.

We will proceed with more detailed tests, guided by our theoretical results in section 2 to see if there is a persistent pattern of return differences. In Table 8 we find our bootstrap values used in the *t*-test statistics. Two tests were conducted with less than fifteen observations (noted *small* within square brackets). Hence, these results might be unreliable and we are therefore hesitant to state anything firmly about tests [C] and [E].

Table 8 Restriction tests using bootstrapping[£]

Labour Activity	*Restrictions / Tests*	*Results*
$L_f^R > 0,\ L_f^S > 0$	[A] $(Q_{L_f}^R = Q_{L_f}^S)$	**Not Rejected**
$L_m^R > 0,\ L_m^S > 0$	[B] $(Q_{L_m}^R = Q_{L_m}^S)$	**Rejected**
$L_f^M > 0,\ L_f^S > 0$	[C] $(Q_{L_f}^S = W_f)$	**Not Rejected** *[small sample]*
$L_m^M > 0,\ L_m^S > 0$	[D] $(Q_{L_m}^S = W_m)$	**Rejected**
$L_f^M > 0,\ L_f^R > 0$	[E] $(Q_{L_f}^R = W_f)$	**Not Rejected** *[small sample]*
$L_m^M > 0,\ L_m^R > 0$	[F] $(Q_{L_m}^R = W_m)$	Rejected

[£] Within parenthesis [A] $Q_{L_f}^R$ give the returns' formulae for female labour to rice production, the same principle applies throughout the table

In Table 8, all male tests show a rejection of equal returns, while all female tests show the opposite. Therefore we can say little about the general pattern since it is relatively blurred. What we can say is that considering that two tests are conducted with a relatively small sample, the pattern of difference seems to empirically outweigh the non-rejected cases. Obviously, we need to be cautious since data inconsistencies might be the source of the divergence of returns. Nevertheless, it seems as if there are difficulties in equating returns across farming systems.

The rejection of test [B], suggests that farms with a diversified farming system are unable to equate their male labour returns between rice and sugar cane. If we can trust our estimates this implies that our theoretical model might be unfit to arrest what seems to be a restriction within the sample of diversifying households leading to these households supplying too little labour to sugar cane. There are a number of potential motivations for this behaviour; of which one plausible explanation already mentioned above refers to a need for having a risk premium in order to compensate for the risk involved in the sugar cane investment.

These findings suggest that aggregating labour input without due concern to the market surroundings is indeed problematic and might lead to biased estimates of the labour supply function.

D. Estimating Labour Supply

In our analysis of labour supply, the theoretical model presented above calls the inclusion of shadow wages and household income *Y* given by equation (6). *Y* is calculated using village wage averages and household specific costs of inputs. The results from section *C* above imply that households are not able to equate labour returns in our two crops' productions. This fact tells us to separate labour supply equations. The empirical counterpart to (7), is specified in linear form:

$$\begin{aligned} LS_f^j &= \alpha_f + \beta_f W_f^* + \beta_{mf} W_m^* + \beta_f^j Y^* + \beta_h^j \boldsymbol{h} + \varepsilon_f^j \\ LS_m^j &= \alpha_m + \beta_m W_m^* + \beta_{fm} W_f^* + \beta_m^j Y^* + \beta_h^j \boldsymbol{h} + \varepsilon_m^j \end{aligned} \tag{12}$$

where α and β are parameters to be estimated. The estimates β_i gives the uncompensated own wage effect and β_{mf} and β_{fm} give the uncompensated cross-wage effect for male and female respectively. We cannot utilise our calculated shadow wages directly since these are not exogenous to LS^j and we have subsequently used the *IV* technique and incorporate the predicted values of respective shadow wage in each of the labour supply functions. ***h*** is a vector of household characteristics. The instruments used are different to those in ***h*** in LS^j. The household income Y^* does not have to be instrumented since we have calculated this by using village shadow wage averages.

We correct for any potential sample selection bias by using a two stage "Heckit" model. The selection equation is found in table D1, appendix D. The choice of variables in ***h*** relies to a great extent on Jacoby (1993 and Skoufias (1994) who used age and age squared, and a wealth level. We furthermore include whether there is a household member with a disability. The presence of a disabled household member could have an impact on the hours supplied to work, however the sign is chiefly an empirical question since we can think of plausible scenarios explaining both a positive and a negative effect. We have also tested for the number of small children within the family under the assumption that this would decrease the amount of labour supplied, (especially females labour) but this had no impact on our estimations.

The IV regressions are presented in Table 9. First, there is a general trend of negative estimates on own uncompensated wage levels, and on own labour supply. All estimates on own labour inputs are negative. This implies that the respective labour supply curve is backward bending similar to Rosenzweig (1980). There is also a significant discrepancy between different point estimates, which indicates that uncompensated wage elasticities are not equal across samples.

Table 9 Labour Supply Functions

Variable	*Male Labour Supply Sugar Cane*	*Female Labour Supply Cane*	*Male Labour Supply Rice*	*Female Labour Supply Rice*
Male Shadow	-0.75**	0.1	-0.01	-0.16**
wage IV	(0.15)	(0.1)	(0.05)	(0.06)
Female Shadow	0.06	-0.11	0.05	-0.06
wage IV	(0.05)	(0.15)	(0.05)	(0.04)
Household Income	0.0002	-0.0003	0.0002**	0.0005**
	(0.0003)	(0.0003)	(0.0001)	(0.0001)
Age	-0.82	4.1**	0.25	2.3**
	(0.82)	(1.2)	(0.54)	(0.66)
Age squared	-0.008	-0.04**	-0.001	-0.02**
	(0.01)	(.01)	(0.006)	(0.008)
Wealthy	-3.4	-12.5**	-7.8**	-10.7**
	(.3.9)	(6.0)	(2.1)	(2.4
Ability	-0.54	3.1**	-1.4	0.33
	(0.66)	(1.3)	(1.3)	(0.7)
Mills Ratio	-11.2*	-21.7**		
	(6.4)	(8.5)		
Constant	21.0	-58.9**	15.5	19.3
	(17.4)	(26.1)	(12.0)	(15.2)
	Nobs 164 R^2 = 0.51	Nobs 161 R^2 = 0.1	Nobs 295 R^2 = 0.06	Nobs 295 R^2 = 0.19

*, ** implies significance at 10 and 5 per cent resp.

Cross wage effects are not statistically significant in three out of four cases consequently we are hesitant to agree with Skoufias (1994) who claims that studies that restrict cross wage effects to zero are necessarily subjected to specification error - it seems that the severity of dropping cross effects depends very much on the actual setting. Two estimates of the household income effects are different from zero (in male and female rice labour supply) and suggest that in terms of utility, leisure is not a normal good. The other income estimates are not statistically verified.

Our results also reveal that males and females in wealthy households seem to work significantly less than males and females in other households. This result is consistent with all but males' labour supply to sugar cane. Another interesting difference between male and female supply functions is that females living in diversified households where at least one household member has a physical disability work significantly more compared to other households, presumably to compensate for labour availability loss.

In sum, it is difficult to state anything general other than the labour- supply curves tend to be backwards bending and potential explanations might include those of Skoufias (1994); he referred to the "broadness" of the dependent variable and that we should not be surprised of backward bending supply curves since there are a great number of activities included on the endogenous side which presumably contain homework, market-, and farm-work.

However, these are only point estimates of variables in levels and we need to calculate the relevant elasticities. We did as mentioned above, and ran 1000 random draws of each equation and calculated the elasticities for each draw. In Table 10, we give the calculated values at sample means.

Table 10 Bootstrap values of elasticities, at sample means

Category	*Rice Labour*	*Sugar Cane Labour*
Male own elasticity	-0.01	-0.39
	(0.04)	(1.3)
Female own elasticity	-0.009	0.28
	(0.01)	(4.2)
Male cross elasticity	-0.03	0.17
	(.03)	(0.78)
Female cross elasticity	-0.008	-0.1
	(.02)	(3.0)
Household income in Male	0.14	0.16
	(0.16)	(0.28)
Household income in Female	0.25	-0.03
	(0.26)	(0.13)

Standard deviations within parentheses.

All values in Table 10 have rather large standard deviations. They all point to backward bending labour supply curves except the female labour supply to sugar cane. The unusually high standard deviation of Females' own elasticity to sugar cane leads us to investigate the confidence interval and as it happens this particular value is due to a few extreme points and without those extreme points the elasticity is indeed negative and about –0.19 but with a standard deviation of a mere 0.4. Similarly, in males cross elasticity in sugar cane, the mean of the 95% confidence interval is 0.03 with Std equal to 0.17. In general, the responsiveness of both labour categories is stronger in the labour supply to sugar cane.

Household income effects differ between crops with a positive income effect in rice cultivation and male labour to sugar cane while it has a negative effect in the case of female labour to sugar cane. This implies a potential distinction for farmers with different farming systems. A similar difference is seen for cross effects but here, the cross effects are negative in rice labour supply while the male cross elasticity is positive in female labour supplied to sugar cane. Thus, in rice cultivation, male and female labour are substitutes while they potentially are complimentary in the cultivation of sugar cane.

7 Conclusions

We have analysed households with different farming systems and have shown that under market imperfections, we cannot easily aggregate agricultural production since households are unable to adjust labour allocation at the margin. The main finding of different shadow wages across the crop's cultivation has implications for a wide body of literature and casts doubts over recent estimates of labour supply functions using aggregated agricultural production. Our results indicate that labour is not necessarily a perfect substitute. We must be aware of the implications from imperfect markets; and any economic conclusions that do not consider these effects might mislead targeted policies.

The higher returns from sugar cane producers might be linked to a risk premium but other explanations are also plausible and refer to constraints in credit or land markets. From a policy perspective, credit market interventions have been a frequently used tool to boost private investments.

We have found backward bending labour supply curves and a relatively stronger responsiveness in labour dedicated to sugar cane production. Labour inputs for sugar cane and rice are indicative of being normal goods.

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Appendix A, Notation

Table A1, Notational description (in alphabetic order)

Notation	*Description*
A^j	Land area of production *j*
a, b	Index for inputs to production
α , β_{ij}	Production parameters to be estimated
C	Capital
D	Composite consumption good
$\boldsymbol{E^j}$	Non-labour inputs
Fe	Fertilisers
φ , μ_i	Complementary slackness conditions
$\boldsymbol{H}$	Household characteristics
I	Irrigation
$I = m, f$	Index of person *i* = male, female
J	Index of farming system *r*, *s* (rice and sugar cane)
L_i^j	Labour *i* to production *j*
$p_Z(Q_P^R - Q_H^R)$	Marketed surplus
p_Z	Price of subsistence production
$\tilde{Q}^j$	Empirical production functions
Q_H^R	Home consumed
Q_P^R	Subsistence production, but we allow for marketed quantities
LS_i^j	Labour supply
T_i	Time endowment for person *i*
V	Exogenous income
Y^*	Full income
W_{ij}^*	Shadow prices of labour for person *i* to farming system *o*.
W_i	Labour wages
$X_{a,\, b}$	Factor inputs

Appendix B, Interest rates

Table B1. Interest Rate levels

Lender	*Average Interest Rate*
State Bank	1.03
	(.24)
Groups	2.6
	(2.2)
Relatives etc	0
Private	4
	(1.4)

Appendix C

Table B1 Agricultural Statistics

Variable	*Mean*	*Std. Dev*	*Min*	*Max*
Ability Dummy	0.09	0.29	0	1
Wealth (000 Dongs)	12830.9	15396.1	400	133150
Household size	5.6	1.8	2	12
Head's years of education	6.3	2.2	0	13
Spouse's years of education	4.8	2.8	0	13
Livestock (000 Dongs)	899	1160	0.36	7578
Adults	3.8	1.6	1	6
Age	41.4	9.4	21	67
Ethnicity	0.88	0.32	0	1
Sex of household head	1.1	0.23	1	2
Population density	231.5	161	63	997
Wealthy	0.12	0.33	0	1
Total agricultural land	22077	17263	1900	188500

Appendix D, Selection equation for Heckit estimation

Table D1, Probit Estimates for Heckit Estimation of Labour Supply

Variable	*Probit estimates male*	*Probit estimates female*
Household size	-.2	.07
	(.06)	(.06)
Ethnicity	.6	-.07
	(.5)	(.5)
Head's education	-.03	.001
	(.04)	(.04)
Spouse's education	-.001	.06
	(.04)	(.05)
Wealthy	.1	-.18
	(.33)	(.37)
Slope agriculture land	-.06**	-.03
	(.02)	(.02)
Population density	.002**	.0006
	(.001)	(.0007)
Head's Sex	-.8*	.3
	(.4)	(.4)
Non sugar cane land	-7e-6	-5e-6
	(.00001)	(.00002)
Non sugar cane land squared	-5e-11	-2e-10
	(7e-11)	(3e-10)
Sugar cane land	.001***	.002**
	(.002)	(.0003)
Disable within family	-.06	-.06
	(.1)	(.1)
Age	-.1	-.001
	(.06)	(.07)
Age squared	.001	-.0002
	(.001)	(.0008)
Value of livestock	-.1	-.008
	(.08)	(.09)
Constant	3.7**	-.7
	(1.6)	(2.3)
Log-Likelihood/Pseudo R^2	-137.9/0.29	-120.5/0.38

CHAPTER 3

Differences in Agricultural Returns: An Empirical Test of Efficiency in Factor Input Allocation using Vietnamese Data

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Abstract

The vast bulk of household economic analysis (both those built upon unitary and cooperative bargaining models) assumes that households achieve Pareto efficient outcomes. Recent empirical findings suggest that household production in a developing setting might perform below efficiency levels. This paper asks whether rural households in Viet Nam allocate their factor inputs efficiently by comparing factor returns and technical rates of substitution (TRS) between production activities. To this end, we estimate two translog production functions, and first test the equality of bootstrapped returns, and second, we use a bootstrapped *t*-test comparing the equality of TRS. Third, we derive a set of non-linear restrictions on our estimated parameters, which, if held would imply that we cannot reject efficiency. The paper concentrates on the allocation of factors between the cultivation of the two most important agricultural crops - sugar cane and rice. Contrary to the recent inefficiency results we find that we cannot reject that households are efficient in their input allocation. Our results are consistent and stable when we use the instrumental variable technique. The findings support the cooperative models found in the intrahousehold literature as well as the unitary model that has dominated empirical household analysis. On a more rudimentary level we find a return markup for sugar cane producers that is consistent with a risk premium. The latter test does not consider the statistical complexity of testing functions however. Implicitly, we have also shown that households react to changes in relative prices.

JEL Classification: D13, D61, Q12
Keywords: Household Production, Allocative Efficiency, Rural Agriculture, Vietnam

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1 Introduction and Background

Empirical studies on household production and consumption are usually based on the premise that the household behaves as if it is one agent, commonly referred to as the unitary model. This assumption has proven to be useful in empirical analysis as an approximation to actual behaviour. In contrast, neoclassical economic theory is based on the behaviour of individuals; there is theoretical justification for aggregation to the household level only under quite restrictive assumptions such as the possibility to aggregate preferences to a representative agent.

Alternatively, models might assume an underlying bargaining process to reach an allocation of resources. A large, influential proportion of these models make use of an efficiency criterion, these models are usually labelled collective models, Chiappori (1997). In fact, both the unitary model and the collective bargaining approach assume that efficient outcomes are reached. The assumption of efficiency has intuitive appeal since being a member of a household implies repeated interaction and it seems plausible that members can find mediating mechanisms to support efficient outcomes. But despite the intuitive appeal, efficiency in factor allocation is not what we normally expect in a developing country setting since there are a number of cases where we envision inefficiency. For example, if risk profiles across activities differ we anticipate that inefficiencies and differences in factor returns exist. These differences in returns are indeed necessary to compensate for risk differences, see Sandmo (1971), and Batra & Ullah (1974), for early theoretical expositions and Stiglitz (1974) for the case of farming. Market failures in general would indeed lead to inefficiency.

Recent literature has rejected demand side implications of the unitary model in favour of the collective approach; see Browning et al (1994), Browning and Chiappori (1998). The empirical literature covering household production is however meagre, one important contribution being Udry (1996). Udry showed that households do not always reach efficient factor allocations in production, thus implying that efficiency-assuming models are rejected and that we should not assume *a priori* that households achieve efficient outcomes; domestic violence is an obvious example of efficiency not being achieved.

This paper can be seen as an attempt to expand this literature by examining households' ability to efficiently allocate factor inputs within the household. We pursue this objective using Vietnamese data on two of the locally most important agricultural products, rice and sugar cane. We test whether the returns and technical rates of substitution from the production functions are equal.

Given our discussion above, we anticipated difficulty in optimising factor inputs since poor households often lack adequate information. There might also be different risks involved in the different activities and this should lead to a seemingly sub-optimal allocation of factor inputs. We thus expected that efficiency was unlikely to hold. Our results reveal however that we cannot thoroughly reject that households allocate their factor inputs efficiently. Therefore, we have found some indirect empirical support for models that assume efficiency or more specifically, we cannot reject that these are useful theoretical constructions for empirical analysis. Note that not rejecting efficiency is not the same as stating that households are efficient, our results might be a consequence of noisy data and thus, inefficiencies might be difficult to verify statistically.

The paper is organised as follows: the next section gives a brief overview of the theoretical underpinnings and the section thereafter describes the data used. In Sections 4 and 5 we present our empirical approach and findings that consist of the econometric estimations of the two production functions and the evaluation of factor allocation. The paper ends by summing up the results as well as offering potential policy implications.

2 Theoretical Setting

We pursue our objective by comparing factor returns and Technical Rates of Substitution (TRS) between production possibilities within the household. In our pursuit, we are implicitly assuming that households maximise a joint profit function π:

$$\pi = p^r f^r(X^r | h) + p^s f^s(X^s | \mathbf{h}) - w_i(x_i^r + x_i^s) \tag{1}$$

which includes our two crop productions, f^t, for $t = \{r$ (rice), s (sugar cane$\}$ at prices p^r and p^s and their associated inputs, x_i^t, where i are inputs at a cost equal to w_i. For more details, see Table 1. We separate labour inputs into male and female input respectively with labour $k = \{m, f\}$ reflecting males and females respectively. Finally, $\boldsymbol{h}$ depicts household characteristics.

If households are efficient, each household should equate the value of marginal returns from inputs to its price and also TRS between production functions. The marginal return of input x_i^t is:

$$p^r \frac{\partial f^r}{\partial x_i^r} = p^s \frac{\partial f^s}{\partial x_i^s} = w_i \tag{2}$$

TRS_{ij}^t, is defined as in Varian (1990):

$$TRS_{ij}^t = \frac{\dfrac{\partial f^r}{\partial x_i^r}}{\dfrac{\partial f^r}{\partial x_j^r}} = \frac{\dfrac{\partial f^s}{\partial x_i^s}}{\dfrac{\partial f^s}{\partial x_j^s}} \tag{3}$$

where x_i^t and x_j^t represent inputs *i* and *j*.

If households in a world of certainty do not reach the equalities in returns and TRS, they would be able to reallocate a fraction of their input and get closer to the production possibility frontier. In practise, we first test whether $TRS_{ij}^r - TRS_{ij}^s = \Phi$ and whether Φ is statistically different from zero, the procedure in testing the returns are the same. We then proceed with testing non-linear restrictions on our parameter estimates. Our tests assume that factor x_i^s is a substitute to factor x_i^r. This is not self evident in the case of land input since one could argue that sugar cane land is not direct convertible to rice paddy. If this is the case, we are not able to test the assumption of efficient factor allocation of land. It is in fact reasonable to assume that sugar cane land is not a substitute to rice land and if the results concerning the land input significantly diverts from other results, we will have empirical support of that this is indeed the case.

We have already implied that we envision inefficiency and that this would occur for example if one of the f^t's would yield an uncertain quantity and from the results of Batra and Ullah (1974), a risk averse farmer will employ lower than optimal quantities of inputs to the riskier production. As a result, the marginal return to the inputs which are employed in too low quantities, would be higher than what would be optimal in a certain world, see also Saha (1994). Hence, finding inefficient factor allocation can be explained by risks differentials in the production activities. As mention above, issues pertaining to data reliability and sufficient noisy data will obviously affect the outcome.

3 The data and description of the sites

The data is from a survey conducted during the fourth quarter of 1998[12]. The entire sample consists of 296 households but for our estimations, only those households with both sugar cane and rice cultivation are of interest, since these households must decide factor allocations between the two production functions. We are therefore left with using 170 households in our econometric estimations.

The area of concern is located in the hilly district of Tan Lac, Hoa Binh province, roughly thirty kilometres southwest of Hanoi. Variations in climate factors such as average and temperature are unknown but believed to be small across the sample. In the area, roughly 11,700 of about 12,500 households have their primary income from agriculture. Two ethnic groups are represented, Kinh and Moung, of which the latter are in majority. Rice paddy is the dominant agricultural activity, though sugar cane cultivation is, the major cash crop. Villages with any significant agricultural diversification normally diversify from rice production towards sugar cane production.

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[12] The author is indebted to Dr Tran Thi Que of the Centre for Gender and Sustainable Development in Hanoi for supervising the data collection.

Table 1 Agricultural Statistics

Variable	*Variable name*	*Mean*	*Std. Dev*	*Min*	*Max*
Rice: Output /year (000 Dongs)	f^r	2995	1883	500	10800
Male Labour (days/month)	L_m^r	18.8	13.9	0	72.7
Female	L_f^r	23.5	16.7	0	98.8
Pesticide (000 Dongs/year)	P^r	19.4	27.9	0	400
Fertilisers (kg)	F^r	280.2	231.0	0	2100
Irrigation (000 Dongs/year)	I	75.4	67.3	0	360
Capital (000 Dongs/year)	C^r	1322.7	2686.1	0	29998
Area cultivated (m^2)	A^r	3323.1	1379	998	10000
Sugar Cane:					
Output /year	f^s	2145	3145	200	30000
Male Labour	L_m^s	23.9	20.2	0	98
Female Labour	L_f^s	22.2	19.7	0	148
Pesticides	P^s	15.8	28.9	0	240
Fertiliser	F^s	230	646	0	5840
Capital	C^s	14	70.6	0	500
Area cultivated	A^s	1357	1332	100	10000
Others					
Livestock (000 Dongs)		2446.1	3149.0	0	20601
Wealth (000 Dongs)		12830.9	15396.1	400	133150
Household Size (No)		5.6	1.8	2	12

Variables with * indicates that they are measured in monetary terms

Some of the variables are self-explanatory, and some deserve additional information. Aggregation of labour for example has been done by gender. In Table 1, we show the descriptive statistics of rice and sugar cane production. Irrigation is measured in monetary units and reflects the costs of irrigating rice fields. Irrigation and land are similar in their characteristics; it might be potentially difficult to change their use in infinitesimal amounts, thus it would be difficult to achieve equalisation of (2). Livestock consists of the value in thousand Dongs of the sum of all livestock. Most of the agricultural inputs were measured in values and not in physical units. For some observations, we noted that inputs were stated as zero so and in order not to lose too many observations during ther logarithmic transformation, we added one to the value. This method is used elsewhere in studies such as Deolalikar and Vijverberg (1987) and Jacoby (1993). The variable with most frequent zeros is pesticide use.

Some villages stated zero irrigation. It is highly unlikely however, that the actual value is zero. To compensate this data deficiency, we have added village dummies. Our capital variable is the aggregate of oxen and other productive capital actually used during the previous agricultural year.

The size of the household measures the number of people living in the house and therefore potentially includes members that have no family links with the household head or spouse. Total agricultural land measures the household's area of cultivated agricultural land and thus does not include forestland.

In both our production functions, we have used the value of production as the endogenous variable. In rice production there is a small variability in output prices with mean of 1750 Dongs per kilogram. The lowest reported price is 1500 Dongs and the highest is 2000 Dongs. In sugar cane production, farmers are facing the same price.

4 Empirical Results

A. Agricultural Production Estimations

Our empirical strategy begins with a full translog specification of the two production functions followed by a stepwise reduction of the number of parameters starting with the estimates with lowest significance[13]. We stopped this process at the point where we could not reject joint significance. This implies the inclusion of estimates that are not statistically verified. The translog form used is specified in general terms as:

$$\ln f^t + \alpha^t + \quad \beta_i^t \ln X_i^t + \frac{1}{2}\ {}_{i}\ \ {}_{j}\ \beta_{ij}^t \ln X_i^t \ln X_j^t + \gamma_n^t h_n^t \tag{4}$$

[13] We have also tried an alternative strategy where we reduced all insignificant squared and interaction terms, and this leads to same results in the subsequent efficiency test.

where X_i and X_j are inputs to the production including our two labour categories, males and females: L^t_m and L^t_f, and four non-labour inputs common to both cultivations: pesticides, P; fertilisers, F; land, A, and capital, C and one unique to rice: irrigation I. We will capture experience and ability by the inclusion of other variables that rightly belongs to the group of household characteristics; one example might be educational levels. For soil quality, we have a dummy variable which shows whether or not the soil quality is above average of a nationwide soil quality index ranging from one to five. To capture village level effects we have also included a village average of the slope of agricultural land's inclination and village dummies. All the non-input related variables are found in the vector $\boldsymbol{h}$ with index $n = \{1, \ldots, N\}$, depicting the elements in $\boldsymbol{h}$.

In Chapter 2, households with both cultivation techniques were found to suffer from sample selection bias. Our present setting is slightly different in that we are only interested in those households that need to optimise factor inputs. Even if we have no justification to consider our 170 households to be non-random it still does not preclude the possibility to have unobserved patterns in our larger sample that correlates with the level of production and this requires us to correct for any sample selection bias.

In our estimations we assume that farmers are maximise expected profits and from the results in Zellner et al (1966); estimation will be consistent and unbiased. This assumption is holds given that we include variables to control for experience, and soil quality. Given stochastic events such as climate variability, farmers can only with uncertainty fulfil profit goals, thus it is likely that farmers face a stochastic production function. In empirical analysis it is praxis to infer this assumption, see for example, Skoufias (1994), Abulai & Regmi (2000), Dadkhah & Zahedi (1986), and Mundlak *et al* (date published unknown). Thus, we assume henceforth that farmers maximise expected profits.

Table 2
Sugar Cane and Rice Production Estimates[£]

Variable [log of output value is depend]	*Rice estimates*	*Sugar Cane estimates*
Male Labour [L_m^t]	0.31*	0.31*
	(0.17)	(0.16)
Female Labour [L_f^t]	-0.22	0.37**
	(0.64)	(0.17)
Fertilisers [F]	0.68**	0.41**
	(0.3)	(0.16)
Pesticides [P]	0.39*	-0.27**
	(0.2)	(0.1)
Capital [C]	-1.3**	0.02
	(0.7)	(0.05)
Land [A^s]	3.0	0.77**
	(3.0)	(0.1)
Irrigation [I]	0.19**	
	(0.06)	
$[L_f^r]^2$	-0.02	
	(0.02)	
F^2	0.01	0.01
	(0.007)	(.01)
P^2	0.05**	0.11**
	(0.03)	(.03)
$[A^s]^2$	-0.23	
	(0.15)	
$L_f^t \times L_m^t$	-0.05	-0.09*
	(0.05)	(.05)
$L_f^r \times A^r$	0.006	
	(0.005)	
$L_m^r \times P$	-0.06	
	(0.04)	
$F \times P$	-0.07**	-0.02
	(0.03)	(0.02)
$C \times F$	-0.07*	
	(0.04)	
$C \times L$	0.21**	
	(0.08)	
$C \times P$		0.03**
		(0.01)
$I \times P$	-0.01	
	(0.02)	
$F \times A^s$		-0.06**
		(0.02)
Cropping cycle		-0.2
		(0.1)
Male education	0.02**	-0.001
	(0.01)	(0.01)
Number of adults	-0.01	0.03
	(0.02)	(0.02)
Sex of household head	0.01	-0.45**
	(0.13)	(0.17)
Village average slope of ag-land	0.0003	0.02
	(0.02)	(0.03)
Inverse Mills Ratio	-0.07	0.005
	(0.07)	(0.1)
Soil quality dummy	0.16*	-0.01
	(0.09)	(0.1)
Constant	-7.3	0.9
	(12.1)	(0.9)
	Nobs = 170, R^2=0.74	Nobs = 170, R^2= 0.76

[£] Village dummy estimates are exempted for brevity reasons, see Appendix B.

A seemingly unrelated regression (SUR) is consistent despite insignificant correlation between the two production functions. We do not aim to discuss production implications of our results since our main objective here is to detect differences in returns and TRS ratios. We correct sample selection bias by using a two-stage model introduced by Heckman (1979), the Heckit model. The probit stage and its results are presented in Appendix A. A Ramsey test revealed that there are no problems of omitted variables in either of the estimations, see Table 2 for the results. The marginal products are calculated using the following formula:

$$\frac{\partial f^t}{\partial x_i} = \left[\beta_i + 2\beta_i + \quad \beta_{ij} \ln x_j\right] \frac{\tilde{f}^t}{x_i} \tag{5}$$

where the tilde indicates predicted values of production *t*. Table 3 show the marginal returns evaluated at sample means. Bootstrapped values are done using 500 runs. All marginal products are declining.

Table 3
Marginal Values at sample means

Variable	*Rice, bootstrap*	*Sugar, bootstrap*
Male Labour	7.9	31.5
	(8.3)	(21.8)
Female Labour	10.3	34.2
	(9.4)	(26.7)
Fertilisers	0.8	6.3
	(0.6)	(2.7)
Pesticides	8.8	22.1
	(10.5)	(10.4)
Capital	-0.1	3.0
	(.1)	(4.6)
Land	30.9	11.0
	(49.4)	(2.8)

Std deviations within parentheses

As can be seen from Table 3, the production is non-monotonic in capital input to rice. The value implies that households are potentially loosing profits by adding capital input to rice. One potential explanation can be that the productive value of capital is sometimes overvalued as respondents might include additional and non-productive values in the capital stock. There are considerable differences between the two production functions; nonetheless whether or not they will be persistent during the course of our paper remains to be seen. The main reason for the uncertainty over our results is that despite the bootstrap technique, the marginal returns are complex functions involving a multitude of estimates, each of which are only certain up to a confidence interval, see further below.

In all but land returns, there are higher returns from sugar cane production. The difference is statistically verified in each of the six cases using a *t*-test. As we have mentioned above, if there is a difference in risk involved, the factor input to the riskier production will be under-represented. This implies in turn that this factor's return will be higher than in a certain world, assuming declining productivities. Risk would therefore potentially explain the discrepancy between sugar cane and rice if sugar cane is more risky than is rice. The higher return from sugar cane would then be needed to compensate the uncertainty and this difference represents a risk premium. Despite its plausibility, we are unable to state whether this is in fact a risk premium or something else. Nevertheless, the differences in return represents a return markup, see Table 4. The pattern of higher returns to sugar cane is substantiated for all but land inputs. This fact can be indicative that land input is not a perfect substitute between rice and sugar cane production.

Table 4, Calculated markup

Factor	*Return markup*
Capital	4.7
	(5.4)
Pesticides	12.0
	(15.7)
Fertilisers	2.5
	(3.6)
Female labour	26.5
	(29.6)
Male labour	22.9
	(23.3)

Std deviations within parenthesis

The return markup indicates that there is a potential need for policies that could eradicate, or at least diminish the difference in returns. Such policies can include increasing the functioning of credit-markets, and alleviate land market transactions.

We need however to remember that the returns are complex functions involving several estimated parameters. The next section is devoted to a more comprehensive test of the TRS equalisation in which we explicitly test the parameters involved. The procedure by which we are testing is tedious and we decided to limit the number of tests by screening bootstrapped TRS equalisation ratios using the *t*-test. This allows us to disregard some ratios that are deemed equal by the *t*-test. In fact, the TRS test circumvents some of the problems of risk premium since we are dealing with quotients.

B. Testing Allocative Efficiency by Comparing of Marginal Rate of Technical Substitution.

We are now in a position to calculate whether households are successful in TRS equalisation. The first part of this section tests whether the differences between TRS ratios, the Φ, are significantly different from zero, hence we have:

$$TRS_{ij}^{r} - TRS_{ij}^{s} = \Phi \tag{6}$$

Thereafter, in the latter part of this section we proceed with testing non-linear restrictions of parameter estimates derived from the TRS equality.

Table 5
TRS equalisation Tests

Test: $TRS^{rice} \sim TRS^{sugar}$	*Number*	*H0 Φ =0* *[Prob >| t |]*		*Dominating sign of* Φ
$\frac{\partial f^r}{\partial L_m^r} / \frac{\partial f^r}{\partial L_f^r} = \frac{\partial f^s}{\partial L_m^s} / \frac{\partial f^s}{\partial L_f^s}$	[2]	0.72	**Not rejected**	None
$\frac{\partial f^r}{\partial L_m^r} / \frac{\partial f^r}{\partial F^r} = \frac{\partial f^s}{\partial L_m^s} / \frac{\partial f^s}{\partial F^s}$	[2]	0.31	**Not rejected**	None
$\frac{\partial f^r}{\partial L_m^r} / \frac{\partial f^r}{\partial P^r} = \frac{\partial f^s}{\partial L_m^s} / \frac{\partial f^s}{\partial P_f^s}$	[3]	0.03	Rejected	Negative
$\frac{\partial f^r}{\partial L_m^r} / \frac{\partial f^r}{\partial C^r} = \frac{\partial f^s}{\partial L_m^s} / \frac{\partial f^s}{\partial C^s}$	[4]	0.3	**Not rejected**	None
$\frac{\partial f^r}{\partial L_m^r} / \frac{\partial f^r}{\partial A^r} = \frac{\partial f^s}{\partial L_m^s} / \frac{\partial f^s}{\partial A^s}$	[5]	0.001	Rejected	Negative
$\frac{\partial f^r}{\partial L_f^r} / \frac{\partial f^r}{\partial F^r} = \frac{\partial f^s}{\partial L_f^s} / \frac{\partial f^s}{\partial F^s}$	[6]	0.31	**Not rejected**	None
$\frac{\partial f^r}{\partial L_f^r} / \frac{\partial f^r}{\partial P^r} = \frac{\partial f^s}{\partial L_f^s} / \frac{\partial f^s}{\partial P^s}$	[7]	0.06	Rejected	Negative
$\frac{\partial f^r}{\partial L_f^r} / \frac{\partial f^r}{\partial C^r} = \frac{\partial f^s}{\partial L_f^s} / \frac{\partial f^s}{\partial C^s}$	[8]	0.87	**Not Rejected**	None
$\frac{\partial f^r}{\partial L_f^r} / \frac{\partial f^r}{\partial A^r} = \frac{\partial f^s}{\partial L_f^s} / \frac{\partial f^s}{\partial A^s}$	[9]	0.001	Rejected	Negative
$\frac{\partial f^r}{\partial F^r} / \frac{\partial f^r}{\partial P^r} = \frac{\partial f^s}{\partial F^s} / \frac{\partial f^s}{\partial P^s}$	[10]	0.02	Rejected	Negative
$\frac{\partial f^r}{\partial F^r} / \frac{\partial f^r}{\partial C^r} = \frac{\partial f^s}{\partial F^s} / \frac{\partial f^s}{\partial C^s}$	[11]	0.52	**Not rejected**	None
$\frac{\partial f^r}{\partial F^r} / \frac{\partial f^r}{\partial A^r} = \frac{\partial f^s}{\partial F^s} / \frac{\partial f^s}{\partial A^s}$	[12]	0.001	Rejected	Negative
$\frac{\partial f^r}{\partial P^r} / \frac{\partial f^r}{\partial C^r} = \frac{\partial f^s}{\partial P^s} / \frac{\partial f^s}{\partial C^s}$	[13]	0.06	Rejected	Negative
$\frac{\partial f^r}{\partial P^r} / \frac{\partial f^r}{\partial A^r} = \frac{\partial f^s}{\partial P^s} / \frac{\partial f^s}{\partial A^s}$	[14]	0.001	Rejected	Negative
$\frac{\partial f^r}{\partial C^r} / \frac{\partial f^r}{\partial A^r} = \frac{\partial f^s}{\partial C^s} / \frac{\partial f^s}{\partial A^s}$	[15]	0.001	Rejected	Negative

There is a consistent pattern regarding the sign of the difference Φ, while the pattern is more or less consistent with regard to the resource allocation problem. Given declining marginal returns for all male and female labour, fertilisers and land, these tests point to one and the same conclusion; that households could increase efficiency by reallocating labour categories and fertilisers from rice to sugar cane. For land, it seems that the area devoted to sugar cane is a slight overrepresentation of what is efficient. These statements are interpretations of the results in [3], [5], [7], [9], [10], and [12], from Table 5. When it comes to pesticides and capital inputs, the two results are contradictory, see [13], and [15]. Test [13] states that capital to rice should increase to drive down the return and thereby increase the TRS. In contrast the test [15] tells us that capital input in the rice production should decrease in order to increase the return. This in turn would lead to an increase in the TRS and improve the possibility to that TRS quotients are equal.

As implied above, these tests are relatively crude since they consider only the overall effect and are not considering that each TRS represents a complex function including estimated parameters with accompanying standard deviations. We are therefore reluctant to firmly support the rejection of efficiency without further inquiry. It is in fact possible to test a set of non-linear restrictions on our parameter estimates. These restrictions can be calculated using (5) inserted in (2) above. As seen in (5), there are a number of parameters involved for each marginal value and in testing (2) there are four marginal values to consider. We can then solve for each of the involved parameter as a function of inputs and other parameters.

An example might clarify. If we take male and female labour to rice production, their respective marginal products are given by equation (4):

$$\frac{\partial f^r(\boldsymbol{X})}{\partial L_m} = [\beta_m + 2\beta_{mm} + \quad \beta_{mj} lnX_j] \frac{\hat{f}^r(\boldsymbol{X})}{L_m}$$

and

$$\frac{\partial f^r(\boldsymbol{X})}{\partial L_f} = [\beta_f + 2\beta_{ff} + \quad \beta_{fj} lnX_j] \frac{\hat{f}^r(\boldsymbol{X})}{L_f}$$

where subscript *f*, *m* depicts female and male, while *j* is other inputs than *f*, *m*.

Then, TRS^r_{mf} :

$$\frac{[\beta^r_m + 2\beta^r_{mm} + \quad \beta^r_{mj} lnX^r_j]\dfrac{\hat{f}^r(\boldsymbol{X}^r)}{L^r_m}}{[\beta^r_f + 2\beta^r_{ff} + \quad \beta^r_{fj} lnX^r_j]\dfrac{\hat{f}^r(\boldsymbol{X}^r)}{L^r_f}} \quad \frac{[\beta^r_m + 2\beta^r_{mm} + \quad \beta^r_{mj} lnX^r_j]L^r_f}{[\beta^r_f + 2\beta^r_{ff} + \quad \beta^r_{fj} lnX^r_j]L^r_m}$$

Depending on the final specification, some estimates will be zero due to the reduction strategy. Likewise, the TRS^t_{ij} between male and female labour to sugar cane is similar except for the suffix, which now becomes *s* instead of *r*. Then (2) becomes:

$$\frac{[\beta^r_m + 2\beta^r_{mm} + \quad \beta^r_{mj} lnX^r_j]L^r_f}{[\beta^r_f + 2\beta^r_{ff} + \quad \beta^r_{fj} lnX^r_j]L^r_m} = \frac{[\beta^s_m + 2\beta^s_{mm} + \quad \beta^s_{mj} lnX^s_j]L^s_f}{[\beta^s_f + 2\beta^s_{ff} + \quad \beta^s_{fj} lnX^s_j]L^s_m}$$

Now, we solve for each of the included parameters under the assumption that $\Phi = 0$. For example, let us solve for β^r_f, then we have:

$$\beta^r_f = \frac{[\beta^r_m + 2\beta^r_{mm} + \quad \beta^r_{mj} lnX^r_j][\beta^s_f + 2\beta^s_{ff} + \quad \beta^s_{ff} lnX^s_j]L^s_m L^r_f}{[\beta^s_m + 2\beta^s_{mm} + \quad \beta^s_{mj} lnX^s_j]L^r_m L^s_f} - 2\beta^r_{ff} -$$

$$\beta^r_{fj} lnX^r_j$$

(7)

This is non-linear in its nature and shows β^r_f as a function of the other estimates, and inputs. These functions, such as equation (7) label them $\beta^{t^*}_i$, can then be tested as non-linear restrictions on our estimates as given in our regressions with inputs evaluated at sample means. In short, the optimal value is a function of the other estimates and the factor inputs, and the predicted outputs and the H0 becomes:

$$\beta^{t^*}_i = \Gamma(X^t_i, \beta) \tag{8}$$

The test involves the variance of the non-linear function Γ, which under the assumption of consistency, can be based on the estimated variance-covariance matrix of the estimates, Greene (2000). The tests we perform are independent in the sense that it is sufficient to find one parameter that cannot be rejected to be equal to $\beta_i^{t^*}$ in order to not reject efficiency. To perform this test, it is required that we estimate the production functions in system. The SUR and the subsequent tests have been bootstrapped 20 times; the low number of runs is due to the extremely time-consuming calculation of Γ.

We assumed that passing the *t*-tests of equal TRS quotients' in Table 5 indicated that we cannot reject efficient allocation for these particular allocation problems, and we continue therefore with those that failed the test. In Table 5, we saw that nine TRS ratios were significantly different from zero, consequently these ratios will be further investigated.

Table 6 Testing Parameter Restrictions

Parameter tested	Test [3]	Test [5]	Test [7]	Test [9]	Test [10]	Test [12]	Test [13]	Test [14]	Test [15]
$\beta^s_{L_m}$	(1.1) Not rejected	(0.3) **Not rejected**							
$\beta^s_{L_m \times L_f}$	(1.1) Not rejected	(0.3) **Not rejected**	(0.1) **Not rejected**	(0.2) **Not rejected**					
β^s_{P}	(8.0) Rejected		(6.2) Rejected		(3.6) Rejected		(0.05) **Not rejected**	(0.2) **Not rejected**	
$\beta^s_{P \times P}$	(8.0) Rejected		(6.2) Rejected				(0.01) **Not rejected**	(0.06) **Not rejected**	
$\beta^s_{F \times P}$	(2.1) Not rejected		(6.2) Rejected		(1.5) **Not rejected**	(3.5) Rejected		(0.1) **Not rejected**	
$\beta^s_{C \times P}$	(8.0) Rejected		(6.2) Rejected		(0.8) **Not rejected**		(0.04) **Not rejected**		(0.02) **Not rejected**
β^s_{L}		(0.1) Not rejected		(0.1) **Not rejected**		(1.4) **Not rejected**		(0.1) **Not rejected**	(69.3) Rejected
$\beta^s_{A \times F}$		(6.2) Rejected		(0.2) **Not rejected**	(3.6) Rejected	(7.8) Rejected		(0.3) **Not rejected**	(69.3) Rejected
$\beta^s_{L_f}$			(0.1) **Not rejected**	(0.2) **Not rejected**					
$\beta^s_{L_f \times C}$			(0.09) **Not rejected**	(0.2) **Not rejected**					(0.02) **Not rejected**
β^s_{F}					(3.6) Rejected	(7.9) Rejected			
$\beta^s_{F \times F}$					(3.6) Rejected	(5.5) Rejected			
β^s_{C}							(0.1) **Not rejected**		(0.02) **Not rejected**

Chi2 values within parentheses

In the left column of Table 6 we show the particular parameter that we are testing. For instance, on the top line of the left column in Table 6 we see that the parameter of interest is $\beta^{s}_{L_m}$ which is the parameter associated with male labour to sugar cane production. Thereafter at the top of each of the subsequent columns, it is given which test (from Table 5) we are analysing. The non-linear test statistic is distributed chi^2 and the critical value is given in each cell with the label "**Not rejected"** (in bold) or "Rejected" stated within the cell. This reveals whether or not the test has been passed. We have only reported the estimates involved in the sugar cane production for reasons of brevity[14]. As can be seen in the table, we have found at least one estimate in each of the seven tests to be statistically equal to the calculated value from equation (7) and (8), (shown in bold). This means in short that we cannot reject allocative efficiency in factor inputs between sugar cane and rice production. As mentioned above we attempted a small number of bootstrap runs, a mere 20 runs or so, and found that in all cases there was at least one restriction in each of the equality tests that revealed that we could not reject equality. The reporting of these chi^2 values is exempted, but files are available upon request.

Previously we raised the issue of endogenous inputs but argued that we captured ability or experience and soil quality by the inclusion of household and village characteristics. We have in fact attempted an IV estimation and found even more non rejected tests. This result is expected since we lose precision when we use the IV technique.

Our results differ with the findings of Udry (1996) who claimed that there are efficiency gains from reallocating factors between production alternatives. We cannot argue that households would gain from reallocating their productive inputs and the discussion whether there are differences between factors' returns is subsequently defective if we are to rely on our results. But it is far-fetched to state that households indeed are efficient. Hence, we need to be cautious and call for more research. As implied above, it is plausible that a more complete data set, preferably a panel, would lead to more precision.

[14] We did not need to solve for rice estimates since at least one estimate passed the test in each test.

6 Conclusion

We have been able to analyse the household's problem of allocating production inputs efficiently and have found that we cannot reject efficiency in their factor allocation between the two dominating production activities, rice and sugar cane production. We estimated the production functions and tested the hypothesis of efficient allocated factor inputs using bootstrapped returns and non-linear tests of parameters. The two methods yielded contradictory results but in the paper we have argued that the latter testing (the non-linear restrictions) might be more accurate. Contrary to earlier literature, this test could not reject the efficiency.

We need to remember that household survey data suffers from noisiness and due to this inaccuracy, inefficiencies are difficult to verify statistically. Hence, the almost consistent markup of sugar cane returns convey a potential need for policy makers to reduce the difference. There are several possible sources for these differences, some of which are more compliant to effective policy measures. One example might be the credit market.

In our view, our findings imply that we do not directly have to substitute theoretical models that assume efficiency for more complex non-cooperative game theory. This is, in our view, a comforting result since the cooperative setting has an empirical tractability relative to non-cooperative models; capturing the essence of intrahousehold interactions with an explicit form of non-cooperative game might become exceedingly difficult, Lundberg and Pollak (1993). Reverting to an efficiency assumption therefore, makes the analysis easier to accomplish.

Naturally, more research is needed to verify our results, and two important improvements are readily apparent. First, one can compare activities where the risk profiles are known, and secondly, data accuracy can be greatly enhanced including the option for more efficient IV estimations.

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Appendix A

Table A, Probit estimation for two stage Heckit estimation

Variable	*Estimate*
Household size	0.02
	(0.04)
Ethnicity	-0.56*
	(0.33)
Head's education	0.005
	(0.02)
Spouse's education	0.07*
	(0.04)
Wealthy	0.5
	(0.4)
Village population density	0.001
	(0.001)
Head's age	-0.17**
	(0.07)
Head's age squared	.002**
	(.0008)
Total agricultural land	0.00002
	(0.00002)
Total agricultural land squared	-4.0e-10
	(3.7e-10)
Constant	3.1*
	(1.8)
Pseudo R-sq	0.09

Std deviations within parathesis. *, ** represents significance at 5 and 10 percent respectively.

Appendix B

Table B Village dummies for SUR estimation of rice and sugar cane

Variable	*Rice*	*Sugar Cane*
Village 1	0.56	-0.87*
	(0.36)	(0.5)
Village 2	-0.15	0.35
	(0.18)	(0.23)
Village 3	0.19	0.02
	(0.24)	(0.19)
Village 4	0.14	0.14
	(0.13)	(0.18)
Village 5	0.42**	-0.01
	(0.11)	(0.15)
Village 6	0.6**	0.14
	(0.14)	(0.19)
Village 7	.64**	Dropped
	(0.27)	
Village 8	-0.02	-0.20
	(0.13)	(.18)
Village 9	Dropped	0.68**
		(0.3)
Village 10	0.21	.35
	(0.21)	(0.2)

CHAPTER 4

Property Rights and Deforestation: The Choice of Fuelwood Source in Rural Viet Nam under Ethnic Heterogeneity

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Abstract

This paper analyses the choice of fuelwood supply sources in rural Viet Nam. In total, four distinct sources are available of which one is a newly constructed institution - user rights for natural forestland. The three remaining sources are user right plantations, a market alternative, and open access areas. The latter source suffers from unwanted deforestation. The analysis of choice is conducted using a logit model with randomly distributed parameters across households. This econometric technique allows us to calculate varying cross elasticity between the open access area and the other sources, enabling policy makers to design effective policy remedies for combating deforestation. Due to market imperfections, we cannot use market prices in the choice analysis and have therefore calculated shadow prices (and profits) for fuelwood from each source based on separate production functions. This gives us a set of prices used in a random parameter logit estimation of. We find in particular that households optimise in their choice of fuelwood source and a relatively stronger substitution effect emerges between plantation and open access areas. This implies that a policy change that affects the production of fuel from plantations might be an efficient option. Further analysis of producer surplus measures explains why some forest land, *i.e.* the *OA* was difficult to allocate to households. We suggest that poor households are more prone to accept some managerial responsibility of *OA* forest resources.

JEL Classification: D13, D23, Q23

Key Words***:*** **Property Rights, Deforestation, Energy Demand, Random Parameter Logit, LDC's**

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1 Introduction

Forest cover in Viet Nam decreased by more than 35 percent over a period of less than fifty years. In some northern parts, the situation is even worse where as much as 75 percent of the forest-cover has disappeared since 1950. The government introduced an ambitious reforestation programme some years ago but the deforestation continues, especially in poorer areas and where the forest resources are *de facto* open access in character. We see in Chapter 5 that poorer households utilise forest resources to a great extent, and consequently, the poorer strata bear the greatest burden of the continuing deforestation. The prime cause of deforestation is fuelwood collection, which accounts for more than 60 percent of the total Vietnamese deforestation (World Bank 1995). It is therefore interesting to analyse in some detail how households produce and consume fuelwood. This paper explores the fuelwood linkages between open access areas and other forest plots with usufruct rights using a Random Parameter Logit (RPL) model with the aim of exploring potential substitution patterns between collection sites and the market alternative. These substitution patterns can be used by policy makers in their quest to halt the deforestation of open access areas by encouraging the substitution of open access fuel with energy from other forest types. To this end, a change in property right regime might be necessary and this paper will gain insights that can be important for this process.

Historically, the state was the holder of property rights but due to difficulties in monitoring and enforcing the rights, households looked upon the forests as *de facto* open access resources. Recently, the Forest Inspectorate (FI) has allocated user rights together with managerial responsibilities to households. The reallocated lands show signs of forest recovery. The forest authority has however, not been able to allocate all forest lands and the remaining unallocated areas are ridden with deforestation problems much like those associated with open access resources.

The transfer of rights for state-managed public forests is a key feature of the forest policy dialogue in many developing countries[16]. Successful examples are infrequent, however, and the economics literature discussing them is sparse. Kant (1996), with examples from India identifies the combined conditions of large and

[16] Forest policy makers talk of panchayet forestry in Nepal, Joint Forest Management in India, ”household responsibility” for forests in China, and community-based forest management in the Philippines, Indonesia, Colombia, and Zambia, for just a few examples

homogeneous demands on the forest as necessary for successful joint community/state forest management. Johnson (1988), reminds us with an example from Honduras that the residual claimant (usually the state's interest in final timber harvest values) generally suffers as local communities responsible for forest management extract their preferred forest products first. Hyde & Amacher (1998), with a Philippine example, concludes that when forest ministry requirements are too stringent, no community will be interested in a shared arrangement for management of the resource. The problem in Viet Nam is slightly different. The Viet Nam arrangements are household contracts with the state, not community contracts with the state, and they exist in the same communities where we also observe problems of forest depletion of *de facto* open access forests for which no household is willing to enter an agreement. Amacher, Hyde, and Kanel (AHL, 1998), with examples from Nepal hypothesise that this situation occurs when fuelwood (or resource) prices are high enough to justify private forest management on nearby lands, while the entire resource value on the more distant open access lands is dissipated in the collection activity. Insufficient resource value remains to justify management and protection of the household's (or community's) own investment in these lands and this is probably why households in our sample are reluctant to agree on supplying labour for resource protection (they must for example protect the area from unlawful use) and other managerial responsibilities. The contract offers compensation, but the level of this reward is too small to make up an effective economic incentive for engaging in forestry.

Our interest in open access areas is based on two concerns. First, there are external benefits from the protection of these areas such as erosion control and improvements in water quality. Second, if poorer households are more reliant on open access areas, there are distributional aspects that might be important to consider in policy making.

This paper uses household data from northern Viet Nam to assess preferences between fuelwood sources. Households have in total four fuelwood sources: i) market purchase, M, and collection from, ii) the natural forest lands with newly established user rights NF, iii) user-right plantations P, or iv) the *de facto* open access state forest estate OA. All households do not have access to all sites since user rights are exclusive. Hence, a household without a user right plantation is excluded from collecting plantation fuel.

This implies that labour inputs are not substitutes across collection sites, and therefore we cannot aggregate the production.

A logit choice model is instead used to describe the choice of fuelwood mix of the household. In particular, we use an extension of a multinomial logit model, or Random Parameter Logit (RPL), which allows for household specific heterogeneity and avoids the IIA property of ordinary logit models. Early contributions using the RPL were notably in the economics of transportation see Louviere et al (1999), but also Revelt and Train (1997). Recently, Train (1998), and Carlsson (1999), have used the framework for analysing preferences for fishing sites and environmental considerations in the choice of transportation modes.

As explanatory variables in the choice probability model, we use the calculated shadow prices from a series of production function estimations, one for each fuelwood source. Using this insight together with the predicted values of each production function, we subtract labour's share to obtain the producer's share. In the absence of other factors, the producer's share is a measure of forest resource value and we adhere to what AHL (1998) hypothesised, that differences in this value can reveal why households refuse to accept the terms in the contract for certain areas and not for others. We will estimate cross price effects of demand for fuelwood from each of the three forest sources. Our final observations provide evidence for AHL's hypotheses. That is, households have preferences among fuelwood sources depending on the relative shadow price. The lowest income and lowest wage households are the groups most reliant on the distant forests and even they find these forests too low-valued to justify protection and management. They cannot justify even a limited management cost. This implies that the pressure on the remaining un-allocated forest will continue and might even increase as population pressure elevates. We anticipate therefore a continuing decline in *OA* stocks. There are however cross-effects between collection sites that can be utilised by authorities in order to change open access use. There are also collection patterns, which are consistent with the view that poorer households are more dependent on open access resources. This fact can be used in the attempt to allocate remaining forest land.

The rest of the paper is organised as follows. The next section briefly outlines the underlying economic theory. This is followed by a description of the data. Section 4 gives the empirical results. The paper ends by summing up the conclusions.

2 Model Specification

Underlying the choice of fuelwood source is the random utility model; see Ben-Akiva and Lehrman (1985), Long (1997), or Louviere *et al* (1999). The random utility model (RUM) assumes that a household chooses the alternative that maximises the utility gained from the choice made. The alternative is described by a set of characteristics $\boldsymbol{X}$. We have chosen to carry out an empirical strategy with the aim of achieving a parsimonious set of parameters that captures the most essential economic aspects of the choice decision. In our case, $\boldsymbol{X} = \{ P^s | z\}$, where P^s are the various fuelwood shadow prices for fuel produced from source $s = \{P, NF, OA, M\}$. The vector z represents a set of control variables, including for example village or household characteristics such as ethnicity. These variables might also be a source of heterogeneity between households.

The fuelwood price for each source is derived from a series of production functions: $FW^s = \Im^s(L, A | z)$, where L is the time devoted to collection, A is the land utilised, and z, is a set of household characteristics. The empirical strategy is therefore to start with estimations of these production functions. Then we predict the producer's surplus from each source and discuss these in the context of contractual arrangements.

3 Description of the Data

The data is from a survey conducted during the third quarter of 1998[17]. The data set contains 300 households in three communes, Man Duc, Than Hoi and Tu Ne, and ten hamlets. The area under study is found in the predominantly hilly district of Tan Lac, Hoa Binh province roughly thirty kilometres southwest of Hanoi. Seasonal patterns consist of two separate seasons; a rainy season between April and October and a dry season between November and March. The most frequent period used for fuelwood collection is during the third quarter though large variations exist.

In total, there are about 12,500 households in the district of which roughly 11,700 have their primary income from agriculture. Two ethnic groups are represented, Kinh and Moung, of which the Moung are in the overwhelming majority. Fuelwood prices refer to a volume measure, Gahn, which is a locally used. Though price is

[17][17] The writer is indebted to Dr Tran Thi Que of the Centre for Gender and Sustainable Development in Hanoi for supervising the data collection.

observed in most cases, we lack fuelwood price information for 97 observations. For these, we have imputed the village average means as the relevant market price faced by the household.

The most frequently used source of energy supply is the private user right plantations (*P*) which are also closest in distance to household premises. These plantations are usually made up of fast growing species such as eucalyptus and acacia and not primarily designated for energy production. There are 229 households with access to plantation areas of which 145 have been collecting fuelwood.

Second in order of importance for fuelwood collection is the natural forest with user rights (*NF*). Of 149 households with contracts on natural forestland, almost all have been collecting fuelwood. From these areas, households are allowed to take dry wood, and presumably, twigs from thinning. With the user right for natural forest, households agreed to protect the area.

Less frequently utilised for energy purposes are the deforestation stricken state forests, which are *de facto* open access areas (*OA*). It was not possible to allocate these areas as households refused to obtain the user rights under the contractual regulations. Households do nevertheless collect fuelwood and other non-timber-forest-products from *OA* areas. These areas are the primary targets for deforestation activities.

The data on fuelwood collection includes male and female hours spent per trip, number of trips per month, forest area utilised, together with a variety of household and village characteristics. The conditional statistics of various variables from the three sources are given in Table 1[18]. We see for example that the level of wealth differs substantially among the sub samples. This wealth is measured by the value of durables within the households and valued by the respondent. If we in addition consider the value of forestland (which must be regarded as essential), the picture becomes even more dramatic. Besides being low in wealth, the average household that collects from open access areas has roughly one third less forestland. Obviously, this is a main reason for these households using *OA* as a source of fuelwood.

[18] For more descriptive statistics see appendix A.

Table 1 Descriptive Statistics Conditional on sub sample household

Variables	*OA*. (obs=78)			Natural forest (obs=145)			Plantations (obs=229)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Household collection (Gahn/month)	12.0	4	50	15.1	2	50	11.0	2	30
Male Labour (hours /month)	22	0	90	16	0	64	4.6	0	60
Male collection quantity	6.1	1	25	7.4	1	30	1.4	0	25
Female Labour (hours/month)	30	0	200	36	0	200	14.5	0	66
Female Labour collection quantity	7.2	1	50	9.7	1	40	6.7	1	30
Plantation Area (m^s)	3641	0	59875	900	0	10	6634	0	162750
Natural forest Area (m^s)	2.2	0	19900	8100	0	59875	90	0	49000
Wealth (mill Dongs)	9.9	0.5	64	10.4	0.4	75	13.7	0.4	133
Household size	5.7	3	12	5.7	2	10	5.7	2	12
Ethnicity	0.98	0	1	0.97	0	1	0.95	0	1

Gender and age of the collectors differ slightly depending on which source we examine. For *OA* areas, it is primarily adults conducting the collection. The same pattern is evident for collection from natural forests as well. In the plantation the pattern is different however; here, young household members are relatively more involved in the collection. Both genders contribute to the collection of fuelwood. Two factors encourage males to engage in fuelwood production. First, there is a non-negligible risk of being robbed or attacked while walking to and from the forest area. This risk increases the further away from the village centre the area is located. Male participation is therefore needed to reduce the risk of being attacked. Second, we also know that households have an incentive for protecting their contracted forest and might in the case of interlopers, be liable to the Forest Inspectorate (FI) and or see their fuelwood collection diminish. The male labour participation in natural forest fuelwood production is not as frequent as in the case of open access case though. On average, males spend only half the time of female in the collection of fuelwood from natural forests.

4 Econometric Specification

There are some econometric issues to be dealt with. First, it is not possible to aggregate the output and estimate one production function since factor inputs are not substitutes. Consider a household with an *NF* plot but without a plantation area *P*, and assume that they collect from an *OA* source as well. If we were to aggregate these into one aggregated output and run the estimation for all households, it would potentially lead to a miss-specified econometric model. The labour input to production of fuelwood from *P* would most accurately be a missing value as the household is excluded from this production possibility. Transforming these from missing values to zero would also be inappropriate since we then would assume that the household chose not to invest in labour due to particular preferences when they in fact are prevented from doing it. Hence, aggregating all three production possibilities would result in a very small sample inadequate for making inference on.

On the other hand, we could strive to use a logit model for the choice of production of fuelwood. There are two obstacles to this approach: first, we will have no information on those households which conduct market purchases and will therefore not be able to estimate cross effects from collection sites on market behaviour. Second, considering the small sample and the relatively large number of exogenous variables in each production function, random parameter logit estimation might become exceedingly difficult. We opt instead for conducting the analysis in two steps, where in the first stage we estimate shadow prices that are used in the second step to analyse the choice of fuelwood mix. A drawback of this procedure is lack of precision in our parameter estimates since we are not able to correct for the standard errors that accompany our covariates in the choice estimation.

Another question is related to the relevant sample for each of our fuelwood sources and the subsequent econometric technique used. In the case of fuelwood production (*FW*) from plantation land (*P*), there are 229 households that have plantation land (of a total of 300) and obviously all 229 households are potential collectors from *P*. Only 145 have conducted any collection however. If there is a systematic and unobserved pattern among non-collectors, OLS estimates will be biased. We need then to correct for the selection effect. If furthermore selection occurs for households with plantation land, the estimation requires a double hurdle where the collecting household, has to pass two selection procedures before the final estimation (first it has to possess *P* and secondly, it has to collect *FW* from *P*). The path chosen here is a robust sample selection model since we could not find any significant double hurdle effect (first selection criterion was insignificant) that could explain the two-tier selection bias.

In the *NF* production, there are 149 households with *NF* areas and of these, 145 collect fuelwood. Hence, an econometric technique such as the Heckman is suitable if we are concerned to about correcting for sample bias. This is also the path chosen. The same bias is potentially valid for the case of *OA* production as well.

Hence, we need to correct for sample selection in all three estimations, see appendix B for the econometric specification. This means that we have to decide on what exogenous variables to use in the selection or decision equation. In general, it is likely that resource availability and substitutes affect the decisions. Likewise, factor input availability and composition are also two reasonable candidates for being important factors affecting the decision. This implies that labour availability and its composition should be included when we try to model the decision process. The composition is important if there are special requirements put on labour such as stamina needed for walking long distances.

There is furthermore a common view that poor households dominate the use of open access resources, thus, the wealth level could be significantly affect the decision to collect. Finally there might be cultural differences in preferences for forestry, and therefore we have included a dummy for ethnic background.

Some of the decision indicators differ between collection sources, since there are differences between the samples. In the collection from *P* and *NF* for example, the relevant indicators of labour availability are assumed to be the size of the household and the share of females, while in the case of production from open access, the availability is better explained by the number of adults since few young household members collect from these areas. Other differences are present, see further below.

5 Empirical Results

In the first part of this section, we use our data to estimate a series of fuelwood production functions from our three distinct sources. The objective is to calculate shadow prices for each source.

A. Production from Plantations

The econometric model used to fit the production from plantation land is the sample selection model, after Heckman (1976), see appendix B. In Table 2, we give the estimates for the production of fuelwood from private plantations. In the production from plantations, there is also the opportunity for combining the collection with grazing livestock and the size of the household's livestock can therefore help to explain the probability to collect from their plantation area[19]. Since we did not find any significant double hurdle effect, we have restricted the sample to include only those with plantation areas. This implies that we have two strong variables that describes the resource availability, namely the plantation area and the distance from the household.

Besides our labour availability indicators, we have included two dummies for the availability of substitutes, which describe whether the household has access to either an *NF* area or if there is an open access area within the village. The latter is a crude measure of the existence of an *OA* area that has been constructed from the survey data and hence not an exact indicator. As for the other exogenous variables in the selection equation we have followed the discussions above.

[19] The time reported is net of the time spent including grazing.

Table 2
Heckman Estimates of Private Plantation Production

Variable	*Cobb-Douglas*
Regression	
Labour	0.60**
	(0.04)
Plantation Area	0.028
	(0.04)
Distance to Plantation Area	-0.00010*
	(0.00003)
Household size	0.0067
	(0.015)
Share of Females	0.065*
	(0.03)
Dummy *NF* area	-0.14*
	(0.06)
Dummy *OA* area	0.18
	(0.14)
Constant	0.26
	(0.49)
Selection	
Livestock	0.27**
	(0.06)
Household size	0.015
	(0.03)
Household composition	0.039
	(0.05)
The Size of *P* area	0.42**
	(0.08)
The distance to forest plot	0.2*
	(0.06)
Substitute Dummy (*NF* area)	-0.15
	(0.10)
Substitute Dummy (*OA* area)	-1.4**
	(0.60)
Ethnicity	1.0*
	(0.53)
Head's education	-0.06**
	(0.02)
Wealth	-0.05
	(0.05)
Constant	-5.3**
	(1.0)
Rho	0.39**
	(0.14)

Observations 227, Censored 59, Log-Likelihood –181.2, Chi2: 318.2 The dependent variable is log of output per month.

Several of the estimates in the decision equation are significant and one is nearly significant: First, there is a slightly surprising effect from the distance as it indicates that households with a more distant plot are more prone to collect. The impact might seem odd but there is a positive relationship between the size of the plot and the distance meaning that the further away the plot is, the larger its size. Secondly, a household that has a larger size of its livestock is more inclined to collect fuelwood from *P*. Generally, households with larger numbers of grazing animals are forced to use plantation areas since close grazing grounds are not sufficient and open access areas are located out of economic reach. Also important is the size of the household's plantation area. It does not seem to matter, however, whether households are wealthier or not as indicated by the insignificant wealth variable. Both of the substitute indicators seem to be of the expected signs; that is they are both negative but only one is significant, the dummy for open access area.

We have tested for a translog specification but the C/D functional form was chosen since it did not perform less successful than the translog (we could not reject the squared and interaction terms to be simultaneously zero). In the regression equation we have aggregated labour inputs into one variable[20], and since the variable is in logs the estimate gives the elasticity of labour. Our measure of resource stock is not found to be significant. This indicates that there are neither economies of scale, nor any diseconomies when it comes to land. The distance to the forest is significant and negative as we would expect, implying that effects from deforestation are costly in terms of time spent. Household size, which is included as a measure of the possibility to specialise is not statistically verified while household composition seems to be significant instead indicating that relatively more females increases the collection of fuelwood from plantations.

B. Production from Natural Forests

Relatively closer to the villages, but still further away than private user plots lie the contracted natural forests plots, (*NF*). These areas have been allocated to households on two occasions, 1993 and 1996. We have tried a dummy variable indicating the allocation year but without discovering any significant impact in our estimations. Again, we correct for sample selection, see Table 3 for the results. This time, the decision is not only whether or not to collect but also whether the households decided to engage in managing a plot of natural forest. The sample selection indicator is however far from being significant, though the sample selection procedure is consistent even if the selection problem is negligible.

We have included resource availability (both human and natural resource inputs), and we have substituted the dummy for open access for a village indicator of forested area due to estimation problems with the OA variable. The size of the forested area is significantly different from zero and it simply shows that in villages with more natural forests, households engage naturally in collection and management of *NF*. The area of plantation within the village is significant and negative which suggests that there might be some substitutability between fuel from *NF* and *P*. Opposing this is the insignificant effect from the dummy indicating household ownership of some plantation area. As above, we find a statistically verified effect from the share of females within the household. The ethnicity indicator is positive which implies that the Moung people have shown a strong preference for signing the contract for the *NF* area. It is known that the other ethnic group, the Kinh are more entrepreneurial than the Moung. In addition, the Moung do not have the same political empowerment and could therefore be in a less advantageous situation regarding interactions with governmental authorities. Whether the Kinh reject forestry activities due to low profitability or for other reasons cannot be determined at this point, further research is necessary. The wealth indicator is significant and negative indicating that relatively poorer households have a higher probability of engaging in forestry activities.

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[20] Separated labour inputs across gender yielded significant estimates for both genders; this is true in all three estimations.

Table 3
Heckman Estimates of Natural Forest Production

Variable	*Cobb-Douglas*
Regression	
Male Labour	0.77**
	(0.03)
NF Area	0.042**
	(0.02)
Distance to *NF* Area	0.00005**
	(0.00003)
Household size	0.03
	(0.01)
Share of Females	0.049**
	(0.024)
Dummy *P* area	-0.04
	(0.02)
Constant	-0.60**
	(0.26)
Selection	
Ethnic Belonging	0.92**
	(.27)
Household size	0.036
	(0.033)
Household composition	0.27**
	(0.057)
Forest area	0.01**
	(0.0006)
Village plantation area	-0.0077**
	(0.001)
Substitute Dummy (own *P* area)	0.19
	(0.21)
Wealth	-0.11*
	(0.05)
Constant	-0.85
	(0.60)
Rho	0.04
	(0.18)

Observations 296, Censored 152, Log-Likelihood –148.2 Chi2: 545.9. The dependent variable is log of output per month.

In the regression equation our main factors of production are again labour input together with the availability of the resource, which is the amount of land contracted as forest user right. Besides the significant effects from labour inputs, forestland has the expected sign with elasticity well below one. In addition, the sign from our control variable measuring the distance to the plot is as expected. Household specific attributes such as household size and share of females have been included in the regression and only the gender composition turned out to be significant.

C. Production from Open Access Resources

Finally, we redo the production function estimation for the open access areas (*OA*) and in Table 4, our estimates for collection from *OA* areas are shown. We use a similar set of variables in the selection equation as we used had above in the estimation of fuelwood from *P* and *NF*. The dummy for *OA* used in the estimation of *P* again rendered difficulties in the estimation. We thus decided to use the average distance from the village to the forested area. This is also an imprecise measure, which perhaps explains why it is not statistically significant.

We see in particular that the wealth level has a negative bearing on the collection decision. Hence, if you belong to a household that is lower in wealth, the probability is higher that you will engage in the collection of fuelwood from open access areas. This finding is consistent with the literature on open access resource use which suggests that open access users are poorer in general, see Dasgupta (1993). Since the tree stock is lower in *OA* compared with other forest resources, the result implies that the poor stratum to a greater extent must endure lower resource availability in *OA* areas[21]. Two dummies for fuel substitute areas are included and both are shown to be significant but with different signs. The negative sign of access to natural forest fuel indicates that there might be substitution possibilities between the two types of fuel. The positive sign of access to plantation fuel implies that the two fuel types might be complementary.

[21] An indication that the stock is too low is given by the reluctance of the households to accept the stipulated terms in the contract for these areas

Table 4
Heckman Estimates of *OA* Production

Variable	*Cobb-Douglas*
Regression	
Male Labour	0.76**
	(0.08)
Distance to Natural forest	0.003
	(0.01)
No of adults	-0.002
	(0.02)
Share of Females	-0.089**
	(0.03)
Dummy *NF* area	0.14
	(0.26)
Dummy *P* area	0.058
	(0.1)
Constant	-0.40
	(0.31)
Selection	
Ethnicity	2.1**
	(0.4)
Household size	-0.03
	(0.05)
Household composition	0.11*
	(0.7)
Wealth	-0.36**
	(0.08)
Substitute Dummy (*NF* area)	-2.1**
	(0.26)
Substitute Dummy (*P* area)	0.55**
	(0.27)
The average village distance to forest plot	0.02
	(0.034)
Education	0.04
	(0.028)
Constant	0.58
	(0.96)
Rho	-0.034
	(0.53)

Observations 296, Censored 76, Log-Likelihood –105.5, Chi2: 209.37: *, **, depicts significance at 5, 10 per cent respectively. The dependent variable is log of output per month.

We will try to investigate this further below. The share of females is significant and positive, which is slightly surprising since respondents reported non-negligible risks connected to walking the distance to open access resources, therefore male companionship is necessary. Again, ethnic background (or ethnicity) is important for the probability of collecting, an effect of which we have touched upon earlier.

There are no surprises from the regression equation; the effect from labour input is significant to the production of fuel from *OA* areas. We do not find average distance to the natural forest from the village, which is chosen to proxy the distance to the open access source, to be significant. Labour availability (the number of adults within the household) is not statistically verified, nor are the dummies reflecting the availability of substitutes. The estimate on household composition, or share of females, is negative and significant, which is slightly surprising considering the risk factor we discussed above.

D. Producer Share

In this section we are interested in the distribution of producer surplus, or the producer share. There are two methods for calculating producer's share. We can use the inherent values derived from the production functions, meaning that we use the returns from labour in order to estimate fuelwood production costs and from these calculate the producer surplus. Alternatively, we can use the relevant opportunity costs, such as the labour costs involved in agricultural production. This is reasonable since much of the fuelwood the production we are estimating takes place during the peak agricultural season. Despite this, we regard fuelwood collection as a complementary activity that generates relatively lower returns than agriculture, thus using shadow prices derived from the agricultural sector might be an overestimation of their opportunity cost of time[22] and we decided to use the labour returns from each collection activity as the basis for shadow price calculations.

It is important to note than in calculating the surplus measure we assume that the reported market price of fuelwood p_j^m represents the relevant market opportunity faced by the household. The surplus is calculated using:

$$\pi = p_j^m F\hat{W}_j^s(L, A \mid z) - w_j L_j^s \tag{1}$$

where $F\hat{W}_j^s$ and $\hat{w}_j$ are the predicted values from each fuelwood production function estimated above, and the calculated labour returns respectively. The latter is calculated by taking the derivative of the fuelwood production function with respect to labour and multiplying this with the reported fuelwood price. The results are shown in Table 5

[22] Implicitly, we are saying that households are less likely to be able to adjust at the margin and equate labour returns between forestry and agriculture.

Table 5

Value of Producer Surplus sources.

Variable	*Value at sample means (thous. Dong)*
Plantation	10.0
Natural Forest	14.0
Open Access	6.7

The highest surplus comes from natural forest production, followed by the surplus from plantation followed by the producer's share from open access areas is smaller still. Despite a positive surplus from open access, it is still not sufficient to motivate households to engage in the protection of these areas. The benefits from *OA* collection are simply not sufficient to encourage any contract in which households must supply labour for forest protection. We need to remember, however, that there are other benefits that can be derived from *OA* areas, but these are typically small, see Linde-Rahr (2000b).

F. Choice of Source

In our choice model, the probability of choosing alternative s^i is equal to the probability that the corresponding utility derived from s^i is greater or equal to the utility of any other alternative in the choice set. The choice set consists of *S* alternatives. In our case the choice set is: $S = \{s^{oa}, s^{nf}, s^p, s^m\}$. Hence, the household chooses among a maximum of four sources for their fuelwood supply. In reality, the households seldom choose between more than two alternatives.

There is one obstacle in connection with the relevant choice set for each household. It can be argued that *OA* and *M* are indeed available to all households. It is likely that even households who have not collected from *OA* have access to these resources; in this case the nearest *OA* area is too far from the household premises to justify walking the distance. The problem then is that we do not have any shadow prices for non-collectors of *OA* areas. One way to solve the complication is to let the "missing" shadow price be equal to the highest shadow price of the collected fuel. This however imposes strict relationships between the different collection sites, and might severely obstruct the cross elasticities.

We do have market prices for most households and the prices of the collected fuelwood. The latter must theoretically be the lower bound of fuelwood prices from *OA*, otherwise households would prefer *OA* fuel under the assumption that they are being rational. It is slightly more difficult to find the upper bound since there is nothing that guides us to which exact upper bound to choose. The market price is one candidate, and a reasonable one since it is higher than shadow prices for all observations. But there is no theoretical guiding principle that states the correct choice. It might as well be slightly higher than the market price. Here, we opt for a five per cent increase of the market price as the upper bound of the "missing" fuelwood price of *OA* fuel.

Now that the interval is set we have only to decide what price each and every non-collector should "virtually" face as the relevant *OA* fuelwood price. With the interval being between the shadow price of collected fuel (lower bound) and a five per cent mark-up of the market price (upper bound), we have randomly picked a price using a uniform distribution between the lower and upper bound. This will hopefully limit the systematic impact on cross effects, which is not to say that they are unaffected.

In our attempts to analyse the choice of fuelwood sources, we are now ready to use the results from previous sections to fit a random parameter logit (RPL) model. The RPL is an extension of the multinomial logit model where limitations of the dependence of irrelevant alternatives property are circumvented. This implies that we can generate cross-effects that are allowed to differ over choices given a change in one choice's attributes. The technique also allows parameters to vary between observations.

Expanding an ordinary logit model into an RPL model we have the following probability that household *j* chooses alternative *s*:

$$P_j^s(S \mid \mu_j) = \frac{\exp(\alpha_j^i + \theta_j z_j + \beta_j^i x_j^i)}{\sum_{i=1}^{S} \exp(\alpha_j^i + \theta_j z_j + \beta_j^i x_j^i)} \tag{2}$$

Equation 2 describes the RPL model driven by the individual heterogeneity μ_j, see equation (3) below. S is the number of alternatives available to the household, which varies across households. The z_j are household specific data such as income or household size with their associated estimates, θ_j; the α_j^i and β_j^i are estimates on individual and choice specific constants and attributes respectively with either fixed or randomly distributed parameters. These parameters can be described by a function ρ_j^s containing choice invariant characteristics w_j^s, which produce individual heterogeneity in the mean of the randomly distributed α_j^s or β_j^s:

$$\rho_j^s = \gamma_j + \delta_j w_j + \sigma_j \mu_j^s \tag{3}$$

with γ_j being the constant, μ_j^s is a random term with mean zero and unity standard deviation. Another way of describing the model is to see that the overall estimate effect is the sum of two parts. Hence the effect becomes: $\beta_j X = \overline{\beta}_j X + \widetilde{\beta}_j X$, where the estimate β_j is the sum of a population mean $\overline{\beta}$, and a stochastic part $\widetilde{\beta}$, which differs between households and creates the heterogeneity. The latter part of this equation and the error term ε are potentially correlated across alternatives and households with a distribution $f(\beta \mid \Theta)$ where Θ represents parameters such as the mean and standard deviation of factors describing preferences over households. This implies a complex integration that cannot be solved analytically but needs a simulation method for getting the resulting probabilities, see Train (1998), and Louviere *et at* (2000).

Our covariate of interest is the shadow price of the collected fuelwood, P^s measured in thousand Dongs per unit of volume. We have tried to include measures of household characteristics, (those contained in z_j) but have not found that they had any significant impact on the choice estimation except as an explanatory variable in equation (3). The model was in general difficult to estimate especially when we included variables that were choice invariant. This made us estimate very simple specifications. We have also encountered very few indications of individual heterogeneity, which implies that much of the heterogeneity might in fact be confined to the attributes that we are using. This makes sense since our attribute is household specific derived shadow prices and they are likely to already embrace much of the potential individual heterogeneity. The empirical specifications are specified is as in (A) or (B), see below:

$$U(s) = \alpha^{p} + \alpha^{m} + \beta_j^{p} P^{p} + \beta_j^{nf,oa} P^{nf,oa} + \beta_j^{m} P^{m} + \varepsilon_j^{s} \tag{A}$$

In equation (A) there are three types of estimates. First, the intercepts are specified for *P*, and *OA* only. Second, β_j^{p} , and β_j^{m} are randomly distributed price estimates on *P* and *M*, respectively. Third, $\beta_j^{nf,oa}$ is the same[23] estimate on *NF* and *OA*. In the estimation we are assuming that the randomly distributed parameters, β_j^{p} , β_j^{m} , and $\beta_j^{nf,oa}$ are a function of ethnicity. Hence, δ_j in (3) is built around an ethnic dummy while σ_j is set to zero[24].

From this specification we have constructed (B) for comparison, where the shadow price *P* is forced to be equal in all choice equations though distributed across households according to equation (3), but where we allow the intercept to differ between *OA* and *NF*.

$$U(s) = \alpha^{oa} + \alpha^{nf} + \beta_j P_j + \varepsilon_{sj}^{s} \tag{B}$$

In Table 6, we present our results. There are no correlations between parameters in the models estimated since the diagonal values of the Cholesky matrix did not contain any significant correlation.

[23] We separated OA and NF but a likelihood test indicated that we could not reject equal estimates.

[24] σ was not verified in any of our attempts to estimate the model.

Table 6 Random Parameter Logit Estimates.
(Dep. Variable: Share of Total Fuelwood Demand)

Variable	*Model A*	*Model B*
Random Parameter in Utility Functions		
Shadow Price P		**-1.01*** (0.16)**
Shadow price of plantation fuel P^p	**-1.10*** (0.21)**	
Shadow price of natural forest fuel P^{nf}	**-1.45*** (0.18)**	
Shadow price of open access fuel P^{oa}	**-1.45*** (0.18)**	
Market price of fuel P^m	**-7.00*** (2.5)**	
Fixed Parameters in U		
α^p	**-1.5*** (0.37)**	
α^{oa}		**1.25*** (0.17)**
α^{nf}		**-0.24 (0.24)**
α^m	**-3.17 (10.4)**	
Heterogeneity in mean		
P^p: *Ethnicity*	**6.2*** (0.39)**	
P^{oa}/P^{nf} : *Ethnicity*	**-1.77*** (0.52)**	
P^m: *Ethnicity*	**6.88** (0.37)**	
Standard Deviation of Parameter Distribution		
Sd P		**0.34 (0.25)**
Log Likelihood	**LL=-211.57**	**LL=-211.55**

** and *** are giving the 5 and 1 % significance respectively. Std deviations within parentheses.

Model A is less constrained in its representation. All of our price parameters are significant and have the expected sign. It seems from the results that households use the shadow price to determine the site for collecting fuelwood. Given a change in the shadow price they adjust their collection mix accordingly. If for example, the household observes that the relative price of a fuel from a particular source increases, they substitute with fuel from another source within their reach.

We must recognise that there are also adjustment possibilities to make at the household level. If deforestation were to prevail with fuelwood becoming increasingly expensive, it is likely that households would adjust their choice accordingly, in addition to conserving wood, shifting burning technologies or indeed by inducing private investments in tree planting for energy purposes.

Heterogeneity in mean, visualised by $\bar{\beta}_{\cdot j}$ above, is found in all price parameters in model A. Generating this mean is the ethnicity of the household, and this implies that Moung and Kinh households have significantly different estimates.

From a policy perspective, it is interesting to analyse the cross price effects, that is, to see how a change in the price of one fuel type affects the collection of other fuels. This will enable us to detect potential entry points for policy interventions since our shadow prices are influenced by changes in the contractual agreement between households and governmental bodies.

Of the available sources, market transactions are most rare and at the other end, plantation fuel is most commonly used as a source of fuel. Not many households use both open access and natural forest simultaneously; much more frequent is the simultaneous use of plantation and open access. We would therefore expect that there is a strong opportunity to switch between open access sources and plantations while less of a possibility between natural forest and open access.

Table 7

Marginal Price effects from RPL models A and B.

	Least Constrained model, LCM£				*Constrained model, CM*			
Source	P_{LC}	OA_{LC}	NF_{LC}	M_{LC}	P_C	OA_C	NF_C	M_C
Plantation (P)	-0.39	0.37	0.13	0	-0.46	0.39	0.07	0.01
Open access (OA)	0.30	-0.48	0.16	0	0.38	-0.74	0.28	0.004
Natural Forest (NF)	0.09	0.11	-0.29	0	0.08	0.32	-0.37	0.002
Market	0	0	0	0	0	0.03	0.02	-0.007

£ For the LCM, the market alternative cross effects were essentially zero.

On the left hand-side in Table 7 we have the four choices and in the second to eighth columns we have the own and cross price effects. The table should be read "column-wise", with shaded cells showing own price effects while other cells give the cross effects. An example might clarify. If we look at the least constrained model, LCM, we see that a one unit change in the price of fuel from P decreases the share of collection from P with 0.39 units, while the cross effects are 0.30 increase in the share collected from OA and 0.09 unit increase from NF. Similarly, a one unit change in the price of fuel from OA, implies a decreasing share from OA equal to 0.48 unit, and an increase of the P share equal to 0.37 units.

In both specifications we find that a change of plantation fuel price leads to a relatively strong impact on OA collection. Hence, a decrease in P^p should lead to a reduction of fuel collected from OA. Similarly, an increase in the price from open access areas leads to a relatively strong impact on the collection of P, and if authorities can limit collection from these areas, households would substitute to plantation fuel instead. Overall, the relative strong cross-price effect between P and OA is comforting to policy makers who would like to switch the use of OA fuel to other types of fuelwood.

In effect, there are a number of potential avenues for Vietnamese policy makers. First, if FI would change the contracts on the management of P, it would have a relatively strong impact on OA collection. Second, authorities can decide to impose heavier enforcement on the protection of OA areas. Third, and perhaps the most tractable in the long term is to improve the productivity of P, thus increasing availability of fuel and making it cheaper to collect. This option requires, for example, targeted subsidies to households for increased planting of trees. The latter option also has a positive impact on sustainability. In the short term this option would have less of an impact of course, but already in the medium term households would be able to produce twigs from the newly planted stock. A combination of contractual relief and investment subsidies is obviously the most attractive alternative.

Given the budget constraint faced by relevant institutions, it is unlikely that any of the more effective policy suggestions will be implemented. Nevertheless, judging from Table 7, if authorities and international donors are anxious to save the remaining open access forest in Tan Lac, Hoa Binh, they should concentrate on policies that primarily affect fuel from *P* since the cross price effect is strongest between *P* and *OA* resources. Since supplying necessary funds can be difficult with Vietnamese budget constraints there is great scope for international assistance.

6 Conclusions.

In the past, households were left to use areas that in effect were open access despite the fact that they *de jure* belonged to state enterprises or other governmental entities. Thus, the introduction of user rights for natural forests and plantations has meant a substantial improvement for the households as a relatively large share of their energy demand is now under their control. Still, remaining open access areas are ridden with deforestation problems, implying that the present energy supply is not sustainable. Clearly, we have found that poorer households are utilising the open access areas more frequently relative to other household categories. Deforestation of these areas therefore implies a serious threat to the poorer strata.

The wealth impact must be regarded as expected. Hence, protecting these areas from deforestation would yield benefits to poverty reduction schemes and consequently increasing the attractiveness of reforestation schemes to international donors. We have also found evidence of differences in preferences between ethnic groups. The Moung are to a greater extent forced into long-term commitment of supplying labour to forestry activities that in turn might impede their future welfare levels by limiting available income generating activities.

We have found a significant impact of gender in the collection pattern and it seems as if the collection is slightly more geared towards being a female activity.

We have tried to describe rural Vietnamese household fuelwood consumption choices. Households respond to changes in the shadow price and seem to behave rationally to changes in prices, which means that policy interventions that induce virtual price changes will change household behaviour We have shown with our random parameter logit estimations that fuel types in this data set are gross substitutes. There is a relatively strong substitution effect between open access areas and plantations, consequently, we are likely to find effective policy options when utilising this fact.

There are some broad issues for the FI to consider. One potential avenue is for the FI to change the contractual regulations, thus changing household behaviour. We have seen that changing the institutional frame for *P* sources such as allowing for increased collection will induce positive effects on the consumption of *OA* fuel; this therefore, is potentially a fruitful way to proceed. A second suggestion is that *OA* areas might still be possible to allocate since they receive a positive surplus. These areas would then stand a better chance of being protected from deforestation. Households, which presently use *OA* areas for energy production should be targeted for any potential policy intervention. A radical option would be to allocate the remaining areas without any regulations on protection and management.

In principal then, the paper supports three policy interventions. Assuming that stricter enforcement of *OA* is too costly, policies should focus primarily on the rules that regulate collection of energy from plantations, for example by making it possible to increase the collection from these plots (remembering of course that the production should be sustainable). Second, *OA* forest plots could be allocated to present users with a minimum of managerial responsibilities thus benefiting those receiving user rights. Third, preferably this allocation could be accompanied by a cash and seedling compensation scheme to increase future productivity of the plantation (and perhaps *NF*) plots that serve as substitutes to the open access land.

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Appendix A. Descriptive statistics continued

Variable	*Mean*	*Std. Dev*	*Min*	*Max*
Share of females	1.3	0.95	0	6
Wealth (000 Dongs)	12830.9	15396.1	400	133150
Household size	5.6	1.8	2	12
Head's years of education	6.3	2.2	0	13
Spouse's years of education	4.8	2.8	0	13
Livestock (000 Dongs)	899	1160	0.36	7578
Dummy OA	0.90	0.31	0	1
Dummy NF	0.5	0.5	0	1
Ethnicity	0.88	0.32	0	1
Sex of household head	1.1	0.23	1	2
Population density	231.5	161	63	997
Communal forest land ha	247	133	11	456
Communal plantation land ha	89	63	5	172

Appendix B Sample Selection formulation

The Heckman technique is based on the following two econometric equations:

$$F\widetilde{W}^{s} = \alpha_1 + \beta_L L + \beta_A A + \xi z + u_1 \qquad \textit{Regression model}$$

where L and is the factor inputs, here measured as the input of labour and land, while *z* is a set of household characteristics, included to capture ability and to proxy for potential preference differences. The dependent variable $F\widetilde{W}^{s}$ is observed iff:

$$\alpha_2 + \gamma\eta_j + u_2 > 0 \qquad \textit{Selection model}$$

with

$u_1 \sim N(0, \sigma)$, $u_2 \sim N(0, 1)$, $corr(u_2 , u_2) = \rho$

where η represents the independent variables that describe the probability to engage in collection. The parameters depicted by the Greek letters α_i, β, γ, ξ, and ρ, are to be estimated. Error terms are corrected for heteroscedasticity by using White (1980) robust errors.

CHAPTER 5

Extractive Non-Timber Values, Cash and Poverty

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Abstract

Occasionally, households use open access forests as a source for collecting minor forest products, or environmental goods. These environmental goods can serve as an important additional source of income or nutrient supply especially if food or cash crops fail. Considering this link between forest production and the agricultural sector, we estimate the collection function of the environmental good in a sample selection framework in which the wealth status, the prime cash source and wage labour are assumed to influence the decision to collect the environmental good. The poverty link is strong and indicates that poorer household are more dependent on the environmental good. Furthermore, we find a weak and near significant impact of a cross-sectoral link. We calculate price and income elasticities for the environmental good's demand and find that the environmental good is a normal good with unity price elasticity.

JEL Classification: D13, Q23

Keywords: NTFP, Household, Demand, Poverty, Open access

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1 Introduction

The dependence of poor households on the natural environment is an issue of grave concern to policy makers in much of the developing world; a concern based on the state of local environments and the foreseen effects of households' use of natural resources. The perception that resources are dwindling is widespread and encompasses most natural resource types. One of the main concerns has been the alarm over the rapid depletion of tropical and sub-tropical forests. These forests can serve as important sources of cash, energy, and nutrient supply particularly to the poorer strata in periods of food shortages, Reddy & Chakravarty (1999), Byron & Arnold (1999). In Viet Nam, from where we have data, we find notably poorer households engaged in the marketing of non-timber forest products (NTFP) such as bamboo shoots. Thi Yen *et al* (1994) finds also that poorer households engage in bamboo collecting activities for cash income and food intake purposes. These cases hint to a link between forest production and the agricultural sector since substituting the failed harvest with forest produce can mitigate food or cash crop production deficiencies. Such a link becomes increasingly important the more that households are dispossessed in capabilities. The link requires any analysis of NTFP to be set within its appropriate framework, for example by investigating poverty and cash-crop production impacts on NTFP dependence, see also Pérez and Byron (1999).

The economic literature on household's use of forest resources in developing countries focuses on the production of fuelwood, see Köhlin (1998), and valuation of forest resources, see Pearce *et al* (1999), Kumari (1995), or Bann (1997). Economic Botany (1993) focused on the importance of NTFP to households and several contributions used an economic perspective, (Economic Botany: 47 (3), 1993). For example, Gunatilake *et al* (1993) analysed the relation between income and NTFPs and found a declining share of NTFPs contribution to total household income as total income increases.

In our study area, which is in northern Viet Nam, these values are important insofar as they are essential ingredients in the effort to design and allocate user rights for open access resources between households and the Vietnamese Forest Inspectorate. In this respect, households that are excluded from the allocation of open access user-rights are deprived of potential relief in cases of food or cash shortages. We note that this is largely a distributional issue and we need to remember that there are efficiency gains when changing open access resources to something more well defined. These efficiency gains can improve conservation-development opportunities; see Coomes *et al* (2001), but these are not considered here. Our focus is on poverty aspects on forestry use and potential effects from a change in property regime.

The existing body of economic literature on NTFP demand shows evidence of substantial resource-use differentiation, Cavendish (1998), and indicates a complex demand and supply pattern. Income and price elasticities differ between species and by implication; the supply and demand of environmental goods cannot be grouped together and analysed as a composite good without imposing restrictions.

This paper is an attempt to broaden the literature on the NTFP, exemplified by the collection and consumption of bamboo shoots[26]. Besides expanding the literature in general, our contributions are mainly of two sorts; first, we use an approach that enables us to draw conclusions using smaller data sets in our quest to calculate demand elasticities as opposed to using larger and more costly data sets. By the means of implicit shadow prices that vary across households, we are able to estimate demand elasticities for the environmental good. Secondly, we place the collection of the environmental good within its proper framework in an attempt to link poverty aspects and the agricultural sector to the forest sector.

We find that cash generating sources show a persistent and negative impact on the probability to collect. The relative poverty level of the household is negative and significant. Hence, it seems as if the environmental good collection is important to households low in wealth and cash generating sources. In the demand analysis, we find the environmental good to be a normal good with almost unity price elasticity. Further analysis of the importance of the environmental good to poor households reveals that on a wealth scale, the environmental good seems to increase in importance as households become relatively poorer.

Our paper is organised as follows. The next section outlines the agricultural household model we employ. This section is followed by our description of the data, Section 3. Thereafter, in Section 4, our empirical strategy and estimation results are given. We end by some concluding remarks in Section 5.

2 The Model

The aim with the model presented here is to show the necessity of using implicit shadow pricing due to existing market imperfections. Due to these imperfections, the model is non-separable where the household is treated as both a producer and a consumer. The standard agricultural household model is augmented with an environmental collection function, which depicts the relation between environmental collection inputs, consisting of labour, and the produce, which in our case is exemplified with bamboo shoots.

Let U represent a well-behaved quasi-concave household utility function which is maximised with respect to a total budget constraint, Y. Income equals the amount spent on a composite good X at price p_x and the amount of leisure enjoyed, L_l at price p_l. To pay for this consumption, households can sell a share of the environmental good's collection, equal to an amount of $p_E(Q_E - E)$, where Q_E is a well behaved and quasi concave collection function with a price p_E. E is the domestic consumption of the environmental good. Some households make an earning equal to the profits from a well-behaved cash crop production, Q_s, equal to p_sQ_s-p_vV, where p_s and p_v are prices of the cash crop output and the inputs V, respectively. Households occasionally sell labour L_w at price w, and finally they might cover cash expenses with an exogenous income stream, Ψ.

We have a time constraint T, which is the sum of leisure, wage labour, L_w; agricultural and environmental labour L_{Q_n} for $n = \{s, E\}$.

Thus, we have:

Utility $$U(X, E, L_l \mid z) \qquad (1)$$

Cash $$Y = p_x X = p_E(Q_E - E) + (p_s Q_s - p_v V) - p_l L_l + wL_w + \Psi \qquad (2)$$

Time $$T = L_w + L_{Q_n} + L_l \qquad (3)$$

Ag Production $$Q_S = (L_{Q_S}, V_s \mid z) \qquad (4)$$

Env. collection $$Q_E = (L_{Q_E} \mid z) \qquad (5)$$

[26] There are other NTFPs in the area such as mushrooms but observations are to few to make statistical analysis.

where z is a vector of household characteristics.

A separable or recursive model relies on the fact that all relevant markets clear, and that households are price takers. Then, it is possible to solve the utility maximisation problem in two sequential steps; first we maximise the full income and second, we maximise utility subject to this income constraint. If this would apply, the demand function for E becomes a function of prices $\boldsymbol{p}$, income Y conditional on z, see for example Strauss (1986):

$$E=E\,(\mathbf{p},\, Y\,|z\,) \tag{6}$$

We are however uncertain whether the market for the environmental good really is efficient or indeed exists at all. It is also questionable whether there is a labour market that does not restrain household members from supplying labour for wage compensations. Finally it is likely that the cash crop market is likewise operating at sub-optimal levels similar to the labour market; see also Chapter 2. Under these circumstances, we need to add three constraints to the model in order to capture the effects from imperfect markets. In general, these additional constraints would introduce a new set of prices into the model, called shadow prices. These prices are not market prices but instead endogenous to the household's choice in consumption and production. We subsequently add the following constraints:

$$L_w \leq M \tag{7}$$

$$Q_E - E \geq 0 \tag{8}$$

$$Q_S \leq \overline{Q}_S \tag{9}$$

Equation (7) implies that the household cannot supply more labour to the market than the upper limit M supports. Making equation (7) gender specific is straightforward but will not add any additional information. Constraint (8) refers to the fact that households might be self-sufficient of the environmental good. Equation (9) depicts as implied that households might be restricted in the production of the cash-crop. Q_S can take the value zero and is a simple way of capturing any market constraint in the production of the cash-crop. In the empirical section we will exemplify Q_S by sugar cane. If we add these constraints to the optimisation problem and substitute into the objective function the Lagrangean can be written:

$$\begin{aligned}\Gamma = \max_{X,E,Q_E,Q_s L_j,L_n} & U(X,E,L_l \mid z) + \lambda_1(p_x X - p_E(Q_E(\cdot) - E) - (p_s Q_s(\cdot) - p_v V) + \\ & p_l L_l + wL_w - \Psi) + \lambda_2(L_w - M) + \lambda_3(Q_E - E) + \lambda_4(Q_S - \overline{Q}_S)\end{aligned} \tag{10}$$

where λ_i represents the Lagrangean multipliers. From Strauss (1986), Jacoby(1993), and Skoufias(1994)[27], we know that market prices are not useful in demand equations when markets are missing or imperfect. In short, if market constraints are binding, the relevant prices that govern household's choices are as mentioned above labelled shadow prices. Shadow values often differ from market observations due to for example transaction costs. It is therefore clear that the model cannot be estimated using market prices of labour and goods since the relevant budget constraint contains elements that are virtual and effective to the household only. Under the assumption that market prices for wages and output are not optimal, we apply a method to linearise the budget constraint at the optimal values of the variables at hand. This solution was utilised by Jacoby (1993). The budget constraint will then include the relevant shadow prices, and hereafter, the procedure is similar to the separable household models where supply and demand is analysed sequentially.

The reduced form of the demand for the environmental good will take the general form:

$$D_E = D_E(p_E^*, W_E^*, Y \mid z) \tag{11}$$

where the P_E^* and W_j^* are shadow prices, both of which are unique across households[28].

[27] See further references in Linde-Rahr(2001a).

[28] Below, we are cautious not to create multicollinearity and instead use village averages for W_j^* for household specific values.

3 The Data

The data are from a household survey conducted in 1998[29]. It contains 300 households spread over three communes, in which 10 hamlets can be found. The area is located in the predominantly hilly district of Tan Lac in Hoa Binh province roughly thirty kilometres southwest of Hanoi, Viet Nam and covers about 6,200 hectares. We have sampled an area corresponding to 50 percent, or 3,140 hectares. Within the surveyed area, we find roughly 2,000 hectares that are defined as forestland. Some of this area does not relate directly to land with forest cover, merely that it is destined for forestry activities *de jure*. Of the two thousand hectares about 75 % are actually endowed with forest cover.

Roughly 94 % of the total population receive their primary income from agriculture. Rice paddy is the dominant agricultural activity. Sugar cane cultivation is however, the major cash crop. Those villages with any significant agricultural diversification normally diversify from rice production towards sugar cane.

The environmental good is exemplified by bamboo shoots. These are normally collected for nutritional purposes, however, in some cases households can utilise the environmental good for generating cash. There are two sources for collection of the environmental good; first, households can collect from Natural Forests (*NF*) with household-specific user rights. These areas are inherited with claims from the state mainly in connection with preserving the productivity of the forest plot. In return, households are allowed to collect dry wood for fuel (see Linde-Rahr (2001b) for details) and NTFPs according to demand. The second source is *de jure* owned by the state but where households *de facto* utilise the area without due concern of ownership. These areas correspond to open access resources. In order to avoid problems related to small samples we were forced to aggregate the two environmental collection sites into one, assuming that the inputs and outputs from the two sources are substitutes. There are 72 households that collect the environmental good but eight are unused in the collection estimation due to missing values. In Table 1, we have divided the descriptive statistics to show differences between collectors (*within*) and whole sample (*overall*).

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[29] The writer is indebted to Dr Tran Thi Que of the Centre for Gender and Sustainable Development in Hanoi for supervising the data collection.

The local ethnic majority (the Moung) dominates the collection of the environmental good. The overall mean of the ethnic dummy (which indicates Moung tribe) is 0.88 while the sample of environmental good collectors is close to 1. The gender balance between *within* and *overall* samples differ also and we see that bamboo-collecting households have fewer young males and more young females. The discrepancies are not huge however. The wealth is measured by the value of listed durable goods as specified by the respondent and includes items such as bicycles, furniture, radios, and blankets. From the table, we see that this value is significantly less for households that are engaged in collection. The wealth ranking, which shows the wealthiest households, supports that wealth is higher in non-collectors. The value of output from agriculture is, slightly higher for collectors. The difference is not significantly different from zero however.

The level of education is significantly lower in households that collect the environmental good since both genders have less years of schooling. Both wage labour and *NF* contracts are evenly spread across the two sub-samples. This is evident when we look at the dummy for wage labour and NF contractors respectively. The value of livestock is included since these can be a potential source for cash, no significant difference is found even though the spread is larger in the sample of collectors.

Table 1 Descriptive Statistics

Variable	Mean	Std Dev	Mean	Std Dev
	Overall		**within collectors**	
Household Size	5.6	1.8	5.9	1.8
Adult Males	1.8	0.9	1.9	0.94
Adult Females	2.0	1.1	2.1	1.0
Young males	0.71	0.78	0.68	0.78
Young Females	0.68	0.78	0.74	0.84
Head Education (Years)	6.4	3.3	6.1	1.8
Spouse Education (Years)	4.9	2.8	4.6	2.3
Wealth (thousand Dong)	12800	15400	10814	11980
Wealthy (Rank)	0.12	0.33	0.08	0.28
Value of agricultural output	9180	6718	9550	5730
Value of Livestock	2442	2875	2445	3246
Ethnicity 1=Moung	0.88	0.32	0.99	0.12
Dummy wage labour	0.38	0.48	0.37	0.49
Dummy forest contractor	0.5	0.5	0.5	0.5
Dummy Sugar cane	0.60	0.49	0.47	0.50
Labour input to Environmental Good (hours per month)			21.0	21.9
Bamboo collection			15.4	28.7
Open access users			0.52	0.50

We do not have any household specific observations regarding sale of the environmental goods, nor do we have any household specific observations on the market price except an average market price equal to 750 Vietnamese Dongs[30] per kilogram bamboo shoots.

Much collecting is performed during peak agricultural season, which is during late summer and fall. Both males and females are engaged in the collection process though females seem to spend more time collecting. The time devoted to collection is presumed to be free from joint products. We have asked respondents specifically to separate collection time from other activities.

4 Empirical Approach and Results

Many households do not engage in the collection of the environmental good and we are therefore confronted with a sample selection problem. Thus, we employ a sample selection model (the Heckman model), estimated using maximum likelihood. One of the virtues of the sample selection model is that we can explicitly check whether the poverty level and the cash crop have any bearing on the decision to collect the environmental good. The Heckman technique is based on the following two econometric equations:

$$\widetilde{Q}_E = \alpha_1 + \beta \mathbf{L}_{\mathbf{Q_E}} + \xi z + u_1 \qquad \textit{Regression model} \qquad (12)$$

where L_{Q_E} is the factor input, here measured as the input of labour, while z is a set of household characteristics, included to capture ability and to proxy for potential preference differences. $\widetilde{Q}_E$ is the empirical counterpart to Q_E, as described above. The dependent variable $\widetilde{Q}_E$ is observed iff:

$$\alpha_2 + \gamma \eta_j + u_2 > 0 \qquad \textit{Selection model} \qquad (13)$$

with

u_1~N(0, σ), u_2~N(0, 1), corr(u_2 , u_2) = ρ

where η represents the independent variables that describe the probability to engage in bamboo collection. The parameters depicted by the Greek letters $\alpha_i, \beta, \gamma, \xi$, and ρ, are to be estimated. Error terms are corrected for heteroscedasticity by using White

[30] One USD is about 15000 Dongs.

(1980) robust errors. This estimation technique is known to be sensitive to miss-specification in the selection equation and we have therefore evaluated the estimates using different specifications of the probit equation with no significant changes of the returns to labour.

Variables in the selection equation are based on a wealth proxy indicating a household possession of durables; a dummy for sugar cane land; a dummy if they supply wage labour[31]; labour availability (household size); whether or not the household possesses a forest contract; years of education of household's head. Our main variables of interest are the poverty proxy; the sugar cane dummy that would indicate if there is any statistical link between cash crop production and the collection of bamboo shoots; and the dummies for wage labour and other income.

A. Environmental Good Collection

We start our empirical investigation with the collection of the environmental good by estimating a generalised Cobb-Douglas equation. We have 297 observations in our sample as three were omitted due to missing values. Our only factor input is labour input. Land is obviously used but there is no information on the capital cost involved. Respondents reported no other capital inputs. We control for ability with a proxy describing the years of education of the household head. Finally, we incorporate a dummy for open access users to control for differences between collectors using different collection sites.

The results are given in Table 2. We cannot reject a homogenous production function of degree one, and we do not find any problems with omitted variables. Indeed, from looking at the results of the selection equation (lower part of Table 2), it seems as if our prior expectation regarding poverty are substantiated since the estimate of the wealth proxy is indeed negative and statistically significant, indicating that relatively wealthier households tend to be less prone to collect. We interpret this as forest resources are more important for households with less wealth.

On the other hand, our priors on the link between agricultural cash production and the environmental good has proven weaker, since we see that sugar cane production does not significantly reduce the probability to collect NTFP as the estimate on the

[31] We have tried to include the value of livestock but the estimation did not converge.

sugar cane dummy is negative, but only significant at 15 per cent. Hence, there is only a weak link between sugar cane production and the probability to collect the environmental good. The second source of cash is through wage labour, and from looking at the estimate on the wage labour dummy, this too seem to have only a weak impact on the decision to collect. Third, the exogenous income dummy is negative and significant at 5 per cent, implying that the collection is more important to households that are low in those income streams. The household size is significant, which implies that households with larger quantities of available labour have a higher probability to engage in collection activities.

Table 2 Environmental good's collection estimates

Variable (dependent is log of kg Bamboo/month)	*Estimates*
Regression	
Total Labour (log per month)	0.86***
	(0.14)
Open access dummy	-0.30
	(0.18)
Head's education	0.045
	(0.051)
Selection	
Wealth	-1.29**
	(0.58)
Household size	0.099**
	(0.033)
Dummy sugar cane land	-0.25£
	(0.17)
Dummy Wage labour	-0.16
	(0.16)
Dummy other income	-0.71**
	(0.28)
Dummy NF contract	-0.14
	(0.15)
Sex of household head	-0.046
	(0.25)
Age of household head	-0.017**
	(0.007)
Head's education	-0.023
	(0.017)
Rho	-0.37
	(0.51)
Statistics (Nobs=297, uncensored=64)	LL=217.8 Chi2=45.48

*, **, ***, and £ indicates significance at 1 , 5 10, and 15 per cent respectively.

In an early version of the regression equation, we separated male and female labour inputs and found significant estimates for both. However, wary of the small data set and frequent zero input, we used an aggregated labour variable. The elasticity to labour to the collection of the environmental good is 0.86 (we are using the log of the sum of total male and female labour). We cannot reject that the production exhibits returns to scale equal to one, implying constant returns.

In sum, being poor increases the probability of engaging in environmental collection. In the literature (see for example Dasgupta 1993), we often find poorer households to be highly dependent on these types of resources, and our data seems to further support this fact. Our results resemble that of Gunatilake *et al* (1993) who found a declining trend from NTFPs' contribution to total household income as total income increases, suggesting that conserving the forest productive capital is relatively more important to poorer households, see also Reddy & Chakravarty (1999).

We have reached the point where we are able to calculate household specific shadow prices of bamboo shoots, which we will subsequently use in our demand estimation. We saw in the theoretical model that we need shadow prices for labour and the environmental good in order to determine the demand for the environmental good. The shadow price is calculated by taking the derivative of the collection function with respect to labour and multiply this value with the reported market price of bamboo shoot. This gives the labour return, or shadow wage. Then, we multiply the shadow wage with the time it takes to collect one unit of bamboo shoot, which in turn leaves us with the shadow price of the environmental or extractive resource. At sample mean the calculated price is 0.74 thousand Dongs per kg, more or less exactly the same price as the reported market price.

In a two-sample *t*-test, we found significantly higher returns to labour for households collecting from the natural forests as compared to those utilising open access areas. Furthermore, wealth is considerable lower for open access users than the average wealth level of households that can utilise user right forest plots. We conclude that poorer households are not only more dependent on open access forests they also suffer relatively more from its lower productivity.

B. Demand for Environmental Good

Given the way we calculate shadow prices, it is implicitly argued that the relevant opportunity cost of time is not the value of labour derived from the agricultural sector but the time cost from the collection of the environmental good[32]. The empirical counterpart of Y in equation (11) is the sum of agricultural profits. We dummy the presence of labour and other income since the number of strictly positive observations are few and occasionally very high and thus can drive the results. We have 63 observations in our current sample. Considering the sample selection bias we faced above, we attempt the same estimation technique for the demand but this time with the price variable instrumented using LIMDEPs instrumental Heckit technique. No significant[33] sample selection is found and we reverted therefore to the IVOLS, using instruments for the shadow-price and the wages since they are endogenous to the dependent variable, see Table 3 for the results. We have also tried to separate the demand estimation over the two collection sources but the estimations suffered from small sample problems.

The own price effect has the expected sign and is significant at 5 % showing that households react to changes in the shadow price as we expected. We cannot reject that the estimate equals one and thus implying unity elasticity (since we have price in logarithmic values, the relevant elasticities are equal to the estimate.). We do not include the price of sugar cane since it does not vary between households.

Table 3 IV Estimates of Bamboo Demand (log of kg/ month)

Variable	*Estimate*
Bamboo Price IV (log)	-0.85**
	(0.17)
Household Income (log)	0.51**
	(0.19)
Dummy for labour income	0.24
	(0.18)
Dummy for other income	0.37
	(0.35)
Constant	2.65
	(1.75)

Rsq=0.63, Nobs=63 [The instrument used are: commune dummies, household size, ethnicity, education of household head and spouse, forest user right owners, a dummy for household with members with disability, and an intercept.]

[32] Consequently we are assuming that there is an alternative opportunity cost equal to the cost of producing the environmental good.

[33] The sample selection indicator was -0.61 with a std error equal to 2.5

Household income is also significant and positive at five per cent. Neither of the income related dummy variables are significant. The close to unity elasticity of demand for the environmental good reveals that a one percent change in shadow price induces a similar response change in the environmental good's consumption. This implies that changes in resource availability, or scarcity (which induces an increased shadow price) have roughly a proportional impact on the demand. A forest allocation scheme would inevitably reduce access to the forest for a subset of households and lead to an increase of the shadow price of the environmental good for such households. This would consequently impair supplementary income or nutrient supply to households with lowered access. It is plausible however, that efficiency gains will tend to be large and outweigh distributional concerns. These gains are likely to be of long-term character as improvements in management will follow, thus providing opportunities for sustainable use. But in the short term, households, which are prevented access to the environmental good, might suffer income and nutritional losses.

It is difficult to compare our results with other studies since only Cavendish (1998) calculates individual income and price elasticities and found that these varied greatly between species. Since no clear pattern emerges in the literature we are hesitant to jump to conclusions regarding the generality of our findings, which indicate that households in our sample respond rather modestly to an increase in shadow prices.

C. Income Perspectives

As bamboo shoots can also be a source of income, it is interesting to explore the relative importance of shadow bamboo profits compared to agricultural income. In Table 4, we give the mean values of the gross profit of various sources of income within the sample of bamboo collectors. As is readily seen, the gross profit from bamboo collection is indeed small and can hardly be considered worthwhile as it only amounts to about 1% of the agricultural income. If we look at the net profit levels, the relative importance increases slightly to about 2 % due to the assumed lower opportunity cost of collecting the environmental good.

However, compared to seasonal labour and the other income streams spread across seasons, the picture changes. Gross income from bamboo collection is around 15 per cent of these income sources. This must be viewed as a considerable share of the household budget. We need to remember that these values refer to only one type of environmental good, and that there are other similar goods, which are not dealt with here.

Table 4 Income Levels per season (within sample, n=63)

Source	*Amount, thousand Dongs (std dev)*
Gross Agricultural income	2390 (1430)
Labour Income	185 (500)
Other Income	207 (602)
Gross Environmental Shadow Income	28 (36)

The difference between shadow profits across collection sites is not statistically different from zero, which indicates similarities even though they differ in mean values. The fact that poorer households more frequently use open access areas, implies that these additional income streams are even more important to open access users. In fact, for households that collects from open access areas the shadow profit amounts to an average of 25 % of the labour income. The same pattern is seen when we compare the shadow profit to the agricultural income. Here, it is twice as important to households collecting from open access compared to those that collect from the natural forest. This reinforces the importance of NTFP from open access areas.

5 Conclusions

In this paper, we have investigated the production and consumption of an environmental good from a poverty perspective while controlling for cash substitutes. This inquiry was prompted by suggestions that these environmental goods play an important role especially in poor households' consumption baskets and as potential cash-sources.

The paper has also taken an interest in the characteristics of the demand for the environmental good. The demand's response to a change in price is proportional and the environmental good showed to be either a neutral good or a normal good.

We have found support for the view that relatively poorer households are more dependent on these kinds of forest resources. Therefore, it seems logical that for any poverty reduction strategy for rural Viet Nam should take this dependence into consideration, and authorities should ensure that environmental collection receives due attention.

We have found that the supplementary environmental income for households using open access areas takes up a higher share of their other income streams compared to households that collect from natural forest sites. Since open access users are poorer in general, this makes a strong case for considering poverty patterns in the design of forestry user rights. It gives us a hint of what could be lost if open access areas are transformed into private user regimes. If present open access users are deprived access to these areas they might become worse off, at least in the short run. There are considerable difficulties in switching from forest activities to agricultural cash crop production since there is a large initial investment needed to commence cash crop production, making this option unattainable to poorer households. Hence, the natural thing to do is to allocate remaining open access areas to the poorer strata while ensuring that these households are able to sustain the flow of forest resources.

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CHAPTER 6

Discussion and Conclusion

Almost throughout this thesis, we have found that poverty seem to be an important determinant when it comes to agricultural expansion and the use of open access resources. We have also seen a significant difference between the two ethnical groups. This is true for both agriculture and forestry sectors. In this brief chapter, we will try to extract what we have learnt regarding these two aspects of life in Tan Lac and attempt to draw some policy conclusions.

Agriculture

In agriculture, we have seen that King households which are on average wealthier, to a greater extent have been able to diversify by including sugar cane in their crop-mix, while Moung families have not reached the same level of diversification. The yield from the diversified farms seems to be higher than non-diversified farms. Consequently, Moung families suffer from lower returns than. Despite the difficulty to thoroughly test this statistically it is likely that there is a non-negligible difference potentially driven by a risk premium for diversification for compensation.

The root causes for lower diversification levels for Moung families can, I believe, be found in a couple interlinked areas. First, since an investment outlay is a major part of making leeway for diversification, credit availability and credit sizes becomes essential ingredients to boost diversification. The problem and importance of efficient rural credit markets in developing countries is widely discussed in the development literature and we do not need to further strengthen the arguments for increasing credit market efficiency here. It needs nonetheless to be pointed out that it is an issue to deal with also in Tan Lac.

Secondly, diversification probably requires a better infrastructure in terms of roads. This is a common problem in rural areas that necessitates huge public investment and careful planning to minimise impacts on productive land and unequal distributional aspects (a road will likely increase attractiveness of nearby land).

This brings us to the third issue, that of land availability. Obviously, in a region where agricultural land is scarce and fixed (at least in the short term), and where the land market is essentially non-existent, this is clearly a difficult challenge. But, there is land *de jure* classified as forestland some of which is presently under various agricultural use. These lands could more appropriately be classified as agricultural land. Thus enable farmers better managerial control, which in turn would improve yields.

All these three problems are potentially in the realm of international relief organisations' activities. Credit interventions have been a popular sector for relatively large-scale aid projects. In a similar vein, infrastructure and land classification projects are common undertakings of aid organisations.

From a more research perspectives the differences in returns, potentially stemming from market failures, indicate that aggregating agricultural production is not straightforward since labour inputs are not necessarily substitutes. Instead labour might have significantly different returns across activities or simply not defined at all and thus, using composite production estimation can seriously mislead labour return analysis. This finding has implications for a body of labour supply literature and casts doubts over recent estimates of labour supply functions using aggregated agricultural production.

The fact that we could not thoroughly reject efficiency lends some support to the recent literature on collective household modelling. This is comforting since non-cooperative models are less empirical tractable relative to cooperative models because capturing the essence of intrahousehold interactions with an explicit form of non-cooperative game might become exceedingly difficult. Further research should substantiate our results before we jump to conclusions and two important improvements are readily apparent. First, one can compare activities where the risk profiles are known, and secondly, data accuracy can be enhanced including the option for more efficient IV estimations.

Forestry

Recently, the Forest Inspectorate (FI) allocated user rights with managerial responsibilities to households. The reallocated lands show signs of recovery, and the introduction of user rights has meant a substantial improvement as relatively large shares of their energy supply and NTFP collection are under household control.

It seems as if the Moung households are focused more towards forestry activities since they are more active in both taking on managerial responsibility of forestland and utilising the forest for food and/or cash. Forest contracts are long-term commitments and Moung families might therefore become locked into low return forestry activities for a considerable period of time. This might seriously affect their future well being as other income generating alternatives become apparent but unavailable. If then, the productivity of the average forest plot deteriorates, the situation becomes even worse.

Some of the immediate remedies, indeed not easy to implement include improved markets for land, and alternative income sources to those households that are engaged in forestry.

Lower returns from open access areas indicate forest quality deterioration, implying that swift policy measures are needed if negative effects on the poorer strata are to be minimised. Poor households dependence on open access areas comes not as a surprise and the lower returns also partly explain why the Forest Inspectorate could not succeed in allocating the *OA* areas to households. On this respect, we can return to the issue of contractual arrangements by noting that the previous contracts, which included costly managerial responsibilities, should change in favour of lowering or completely redraw management costs. Then, as we mentioned, the target group for the allocation of the remaining areas should preferably be poor households presently using the *OA* resource.

When we consider the problem of open access deforestation, it seems as if fuelwood collection from plantation areas yields the strongest substitution possibilities and to reduce the pressure on remaining open access areas forest authorities should consequently concentrate on the links between plantation and the deforested areas. Again, there is a potential policy opening in the writing of the contracts between households and the Forest Inspectorate. If authorities would alleviate the restrictions on the use and the harvest from plantations and simultaneously help to improve its productivity, households could better manage their energy production and choose to collect an increased share from plantations instead of collecting from open access resources.

Household

We have already touched upon several aspects concerning the household and its members, of which poverty and ethnicity aspects have been the two most prominent issues. In this section we briefly relate our findings to household members. In the case of agricultural diversification, we have found that age of the household head seemed to be important in the decision to diversify. Older households (assuming age of household head is a good proxy for the average age of the household's member) tend to be less diversified. This probably suggests that older households are deprived from agricultural expansion also in the future since it is likely that they do not face the same opportunities to raise credits.

Second, the educational level of the household head or spouse has turned out to be significant in a number of cases. No clear patter can be seen however. Despite this, assuming that education and poverty are inversely correlated, a negative sign on the years of education on the decision to collect fuelwood corroborates with the fact that poorer households in general engage in activities where returns are low. The same but reversed pattern was found in the case of farm diversification. Here education was found to be positive indicating that higher educated household heads increase the probability to diversify.

There are some obvious gender aspects as well. The household composition effect in the decision to collect is interpreted as a pattern of relatively higher involvement of females in forestry activities. Since the returns from forestry are in general inferior to other activities' returns, females are trapped into duties with relatively lower yields. Despite the discussion of the risk of being attacked while walking to forest sites, the risk might not be perceived by the household (read male) to be significant as to ratify male companionship.

Policy

In brief, we suggest that the FI allocate remaining open access areas to relatively poor households with few alternatives to generate sufficient income. The accompanying contract should include less managerial responsibilities perhaps to the extent that they are exempted. Preferably, these contracts should be linked to productivity elevating support such as tree planting investments for plantations and *OA* areas.

We also suggest that credit programmes, land market interventions, or other suitable arrangements should be implemented to better facilitate the farm diversification for poor households. This is likely to improve the equalisation of returns (if divergence exists) between diversified and non-diversified households, thus generating higher returns to the poorer strata.

The End.

Appendix A

QUESTIONNAIRE

Tan Lac Distric - Hoa Binh Province

1. Commune : .... 1: Man Duc; 2: Tu Ne; 3: Thanh Hoi
2. Village: ....11= Bui; 12= Tan Phong; 13= Dinh
   21= Bin; 22= Buc; 23= Chua; 24= Cu
   31= Bao; 32= Tam; 33= Tan Tien

3. Head of Household ....
4. Sex: Male ☐ Female ☐ 1=male; 2=female

5. Ethnic........................ 1=muong; 2=kinh
6. Religion...
7. Stove ....1=fire-wood stove
8. Type of house:

Brick =1	Wood =2	Temporary=3
☐	☐	☐

9. Type of household:

Hungry=1	Poor=2	Average=3	Rich=4
☐	☐	☐	☐

Interviewee

10. Sex: Male=1 ☐ ☐ Female=2

11. Interviewer ....1= Tuan; 2= Binh; 3=Chau; 4=Thien
12. Date:..................................

Section 1 information on household

Q 1Please state the total number in you household [Household data][2] (individual worksheet)

No	Name	Relation	Sex 1=M 2=F	Age	Main occupation	Two major sources of wage earning		No: of days of paid work this season (*)	Average wage per day this season Th. Dong (*)	No: of days of paid work last season (*)	Average wage per day last season Th Dong (*)	Years of Education	Unearned inc. pension, social security family transfers etc per year	Normal physical ability 1=yes 2=no
NiH	Name	relation	Sex	Age	M.O	FSE	SSE	PDTS	PTS	PDLS	PLS	YoE	OI	NPA
1.														
2.														
3.														
4.														
5.														
6.														
7.														
8.														

relation : 1. Head, 2. Wife , 3. Son/daughter, 4. Parents, 5.Parent in law, 6.grand son/daughter 7.Brother/sister 8. Son/daughter in law 9. Other relative, 0. Not related **Main occupation :** 1= wage labour 2= agricultural work 3= student 4=unemployed 5= Communting wage labour, **major sources of wage earning:** 1= wage in state sector; 2= wage in private sector; 3= agriculture; 4=Other, (*) Cash income only.

Q 2 Wealth indicators [2]

Item	Quantity	Estimated value	Acquired year	Ownership? %Male
Land*				
House				
Tractor				
Motorcycle				
Bicycle				
Harrow/Plow				
Electric fan				
Radio TV etc				
Buffalo				
Horse				
Cow				
Pig				
Chicken/Duck etc				
Wooden Furniture				
Jewels				
Other items				

Q 3

Credits*	Amount	Interest	Expiring date

*: 1=bank; 2=relatives, neiboughrers and friends; 3=socio-organisations, 4=private lenders, 5=development programs

Q 4 Please state the amount paid for land tax last year.......................... th. vnd

Q 5 Please state the labor division in your household (1 = yes 2=no)

	Work	gra.f	gra.m	hus.	wife	son	Daughter	other
	Agriculture							
Q5.1	- Forest plantation	n	n	y	y	n	y	n
Q5.2	- planting							
	- Tending							
Q5.3	+ fertilization							
Q5.4	+ Weeding							
Q5.5	+ Insecticide spray							
Q5.6	- Harvest							
Q5.7	- Sale production							
	Forestry							
Q5.8	- Soil prepare							
Q5.9	- Forest plantation							
Q5.10	- Protecting the forest							
	- felling non-wood products							
Q5.11	+ Bamboo shoot, mushroom, vegetable							
Q5.12	+ Hunt							
Q5.13	+ Medicinal plants							
Q5.14	+ fire wood							
Q5.15	- Wood felling							
Q5.16	- Sale fire wood							
Q5.17	- Sale wood							
	Breeding							
Q5.18	- Buy breed							
Q5.19	- Feed							
Q5.20	- Treat animal							
Q5.21	- Sale product							
Q5.22	Handicraft							
Q5.23	Service (plough, drag, transport)							
Q5.24	Business							
	Housewife							
Q5.25	- Cook							
Q5.26	- Look after children							
Q5.27	- Shopping							
Q5.28	- Take care of children							

Q 6 Please state the decision making in your household. (1 = yes; 2=no)

	Work	Husband	Wife	Other
	Agriculture			
Q6.1	- species of tree	y	y	n
Q6.2	- Sale product	y	n	n
	Breeding			
Q6.3	- Species of animal			
Q6.4	- Sale product			
	Forestry			
Q6.5	- Forest plantation			
Q6.6	- Accept natural forest			
Q6.7	- Non-wood felling			
Q6.8	- Wood felling			
Q6.9	- Sale non-wood			
Q6.10	- Sale wood			
Q6.11	Investment to production			
Q6.12	Buy property			
Q6.13	Rite expenses			
Q6.14	Daily expenses			
Q6.15	Education of children			
Q6.16	Marriage of son/daughter			

Section 2 Land Holdings (LAND-POPULATION WORKSHEET)

Q 7 What is your total size of your land, including forest land, etc: ....ha.

Q 8 Present landholdings [2]

Land use	Area	Tenure		Ownership M/F or %M	Distance in meters
		Date of receive	Date of acquiring*		
Agricultural land: certificate					
Agricultural land: other					
Hill rice					
Aquaculture land					
Natural Forest NF, contract					
NF, other					
PAM, land certificate					
PAM, contract					
PAM, other					
Barren land contract					
Barren land, other					
Home garden					
Forest garden					
Residential land					
Rent land					
Other					

*: 99=for long time

Q 9 Please state the land use situation before the latest forest land-allocation [2]

Land use	Area	Tenure		Ownership	Distance in meters
		Date of receive	Date of acquiring	M/F or %M	
Agricultural land: certificate					
Agricultural land: other					
Hill rice					
Aquaculture land					
Natural Forest NF, contract					
NF, other					
PAM, land certificate					
PAM, contract					
PAM, other					
Barren land contract					
Barren land, other					
Home garden					
Forest garden					
Residential land					
Rent land					
Other					

Q 10 From the last change of tenure for forestland, did you acquire the area requested by you?

Yes=1 ☐ No ☐ (more)=2 ☐ No (less)=3

Q 11 Why did you not get the requested area?

Land is limited ☐ yes=1 (Q11.1)

Other, please specify

(Q11.2)...

....

Q 12 Are you satisfied with the process of the latest land-allocation for forestland?

yes=1 ☐ ☐ no=2

Q 13 If no, what would you change? [2]

	Item	More=1	Less=2	OK=3
Q13.1	Information			
Q13.2	Household participation			
Q13.3	Duration of process			
Q13.4	Include other types of land			
Q13.5	Security of property rights			
Q13.6	Other, please specify			

Q 14 Is there anything you would like to change in the present agreement on protection of natural forests (please exclude other natural forest than the one contracted)? If yes please state the proposed change. [2]

	Item	More=1	Less=2	OK=3	don't know =4
Q14.1	Payment for protection				
Q14.2	Natural Forest Area				
Q14.3	PAM area (not included in contract)				
Q14.4	Level of security in property rights.				
Q14.5	Benefits to the household when harvesting				

Q 15 Please state the lowest amount of compensation from the state if you would have to protect one hectare increased natural forest if the area is located close to your present NF?
Amount: ....th. vnd/ per year per hectare

Q 16, Please state the lowest amount of compensation from the state if you would have to protect one hectare increased natural forest if the area is located remote from your present NF contract?
Amount: ....th. vnd/ per year per hectare

Q17 Assuming that the state agrees with your statement in 14 How much larger area could your household consider to proct of the natural forest if it is located close?.................... ha

Q18 Assuming that the state agrees with your statement in 15 How much larger area could your household consider to protect of the natural forest if it is remote located?............... ha

Q 19 If you do not want to acquire more natural forest land no, please state if the present area is optimal or if your household want to decrease it, then please state the per cent change.

1. Area optimal ☐ yes=1 (Q19.1)
2. Per cent decrease ....(Q19.2)

Q 20 While going to your main productive fuelwood forest plot, do you have to pass other houses along the way?

yes=1 ☐ ☐ no=2

Q 21 Which household members graze livestock, if yes where do you graze them [1] (individual worksheet)

HH member	In combination with fuelwood collection	In combination with other activity (specify)*	Amount time spent only for grazing
	CFC	COW	Time

*: 1=study; 2= monitor forest; 3=collect food for animal (ex.pig, fish...); 4=collect non-wood products; 5=collect and produce organic fertilisers

Section 3 Questions on Population growth:

Q 22 Is this household expecting babies within 9 months?
yes=1 ☐ no=2 ☐ >> Q26

Q 23 If yes, when is the expected birth? Year ......Month.........

Q 24 Did you and your spouse take into consideration forest land (including barren land) availability when you decided to have more children?
yes=1 ☐ no=2 ☐

Q 25 If yes, is the availability of forestland including barren land refraining you and your household to have more children?
yes=1 ☐ >>Q27 ☐ no=2 >>Q27

Q 26 If no in 3, do you in general consider land availability to be important when making fertility decisions?
yes=1 ☐ no=2 ☐

Q 27 During the discussions pre land-allocation 1993 the issue was raised whether or not future offspring should be included in the basis for calculating the area allocated to the household ☐
yes=1 no=2 ☐

Q 28 In this process of forest land-allocation did you and your household anticipate that future offspring would be included in the basis for calculating the amount of hectares allocated to each household?

yes=1 ☐ no=2 ☐

.

Q 29 Beside possible present pregnancy, are you and your household planning to increase your family size within the foreseeable future?

yes=1 ☐ no=2 ☐

Q 30 If yes can you say more specific when you would like to have more children?

Year .... Month ....

Q 31 How many more offspring do you plan to have in total?

Amount : ....

Q 32 Which, do you believe, is the largest family size this hamlet can take in order for, the natural resources to be sustainable managed?: .... people

Q 33 Is there presently a problem with too large a population in this village?

yes=1 ☐ no=2 ☐

Section 4 Agriculture

This section deals with agricultural production and labour input to that work. This data is needed in order to understand your daily situation. We have for matter of convenience divided the calendar year into four pieces. Please consider this partition carefully. The first period to fourth period is as follows:

1. February to April	called spring	3. August to October	called autumn
2. May to July	called summer	4. November to January	called winter

Q 34 Table on Agricultural Production last year [2] (Q34 worksheet)

Crop	Area cultivated	Type of land used (1)	Quality of land	Irrigation *	Amount of fertilisers used *	Amount of pesticides used *	Oxen Capital used *	Other Capital used *	Total production last year	Home consumed	Total sales last year	Market price at time of harvest	Quantity lost to rotting or insects etc
Rice 1													
Hill rice													
Maize													
Sweet potato													
Cassava													
Vegetab. G1													
Fruits G1													
Fruits G2													
Sugar- cane													
Others													

G1: home garden
G2: forest garden
* : Cash only

(1) Code base on Q8

Q 35 Labour input to agriculture (Q35-Q46 worksheet)

Crop	Husband labour input average per month this season.	Wife labour input av. per month this season.	Total Son labour input average per month this season.		Total Daughter labour input av. per month this season.		Other family labour input av. Per month this season	
			<16	>16	<16	>16	<16	>16
Rice								
Hill rice								
Maize								
Sweet potato								
Cassava								
Vegetab. G1								
Vegetab. G2								
Fruits G1								
Sugar cane								
Other, please specify								

Q 36 Please state the contribution from household members to agricultural income

	Husband	Wife	Sons	Daughter	Others
% 1998					

Q 37 Please state how the labour input is distributed across seasons in per cent

Th¸ng	5 - 7		8 - 10	
	Agrlan	Barrlan	Agrlan	Barrlan
Husband labour				
Wife labour				
Sons' labour				
Daughters' labour				
Others' labour				

Q 38 Please state your costs of agricultural production last year

Input	Quantity	Price per unit (specify unit)	Agricultural land	Barren land
Wage labour				
Fertilisers : - chemical				
- organic				
Pesticides				
Seed/seedlings				
Tools/machinery/maintenance				
Interests				
Storage				
Other				

Q 39 Have your household ever practised shifting cultivation

yes =1 ☐ no=2 ☐

Q 40 If yes, please state the years practising it.

		Before land allocation	After the land allocation
Q 40.1	Common land area outside commune		
Q 40.2	Common land area inside commune		
Q 40.3	Own land		

example

Q 41 If you stopped during these years please tell us why

	Reason	Yes=1, No=2
Q41.1	Prohibited	
Q41.2	Acquired forest land	
Q41.3	Income raise	
Q41.4	Labour shortage	
Q41.5	Other, please state	

Q 42 Do you think that your use of barren land is sustainable in the long-term?

yes=1 ☐ no=2 ☐

Q 43 If yes, what do you do in order to make it sustainable?

Activity	Amount/ unit	Cost (in labour time or Th Dong)
Use fertilisers (kg/ha)		
Terracing (square meters)		
Plant trees (Number/ha)		
Construct wall to stop erosion (square m/ha)		
Other soil protection investment		

Q 44 If no, what is the reason (yes=1 no=2)

Slope of land	To little fertilisers	Wrong fertilisers	Wrong crop	Other	example

Q 45 With the present use, how many years do you think your barren land will be productive? .... years

Q 46 What would be necessary for you to undertake the required steps in order to make it sustainable

Need	Amount/ proposal/yes	Priority
Additional credits (Th. Dong)		
Higher protection payment (Th Dong/ ha)		
Subsidies on soil protection		
More secure in future benefits		
Other solution		

Section 5 Forest land

Q 47 Before the new land-allocation how much forestland did your household use?

	Area (ha)	Distance (km/min)
1 Natural forest, contract	Q47.A1	Q47.B1.................
2 Natural forest, remote	Q47.A2	Q47.B2.................
3 PAM forest private	Q47.A3	Q47.B3.................
4 PAM forest contract	Q47.A4	Q47.B4.................
5 Barren forest land	Q47.A5	Q47.B5.................
6 Forest Garden	Q47.A6	Q47.B6.................
7 Home Garden	Q47.A7	Q47.B7.................
8 Commons	Q47.A8	Q47.B8.................
9 Other	Q47.A9	Q47.B9.................

Q 48 Do your household monitor remote natural forest land?

yes=1 ☐ ☐ no=2

Q 49 If yes please explain (There is not any household monitor remote natural forest land)

Individual (see roster)	Number of hours this season	Number of hours last season	Distance to forest

Q 50 Do you pay anybody else to monitor remote forest?

yes ☐ no ☐

Q 51 Who do you pay? Organisation/Individual ....

Q 52 How much? .... Th Dong/ month

Q 53 In general is there a need to protect your Forestland, please exempt forest garden

yes =1 ☐ no=2 ☐

Q 54 If yes please state the amount of labour input to monitoring explicitly (try to separate this time from time devoted to combined activities. If this is not possible, please make a note)

Land	Husband labour input ave. per month this season.	Wife labour input av. Per month this season	Total Son labour input average per month, this season		Total Daughter labour input av. Per month this season.		Other total family labour input av. Per month this season		"Wage" rate for watch group/hired labour	
									WG	Hire
			>14	<15	>14	<15	>14	<15	>14	>14
Natural forest (contract)										
Natural Forest (remote)										
PAM(private)										
PAM contract										
Barren forest land										
Other										

Q 55 Please specify the total number of trees planted since 1993 by your household, quantity, planned end use of each tree species and type of land used

Species	Quantity	Price/unit	Year(s) of planting	Planned end-use	Type of land used (1)	Fin. source 1=own, 2=aid	Who decided to plant
Bamboo							
Cinnamomum							
Sa nhan							
Big Bamboo							
Fruit trees							
Eucalyptus							
Acacia							
Cassia							
Other							

(1)Code base on Q8

Q 56 Please rank the importance or values of the goods collected in the forests

Good	Rank 1 to 10
Bamboo shoots	
Mushrooms	
Resin	
Cinnamon	
Anise Star and Oil	
Cashew	
Castor	
Tung Oil	
Shellac	
Other	

Q 57-60 do not have answers because of policy

Q 57 Please state the expected income from the next harvest of timber from NF contract

Amount.............. Date of expected timber harvest ....

Q 58 Please state the expected income from the next harvest of timber from NF remote?

Amount.............. Date of expected timber harvest ....

Q 59 Please state the expected income from the next harvest of timber from PAM private?

Amount.............. Date of expected timber harvest ....

Q 60 Please state the expected income from the next harvest of timber from PAM contract ?

Amount.............. Date of expected timber harvest ....

Q 61, Please state your total collection of non-timber products from natural forest (contract) AM=adult male AFad female=YM=young male YF=young female

Good	Quantity collected per trip	Number of trips a month	Most freq. used quarter	Total time spent per trip				Bicycles used	Aver time to go to NF	
				AM	AF	YM	YF		Adults	Young
Bamboo shoots										
Mushrooms										
Resin										
Cinnamon										
Anise Star and Oil										
Cashew										
Castor										
Tung Oil										
Shellac										

Q 62 Please state your total collection of non-timber products from natural forest (remote)

Good	Quantity per trip	No:trips month	Most used quar	Total time spent per trip				Bicycles used	Aver time to go to NF	
				AM	AF	YM	YF		Adults	Young
Bamboo shoots										
Mushrooms										
Resin										
Cinnamon										
Anise Star and Oil										
Cashew										
Castor										
Tung Oil										
Shellac										

Q 63 Please state your total collection of non-timber products from plantation forest (private)

Good	Quantity collected per trip	Number of trips a month	Most freq. used quarter	Total time spent per trip				Bicycles used	Aver time to go to NF	
				AM	AF	YM	YF		Adults	Young
Bamboo shoots										
Mushrooms										
Resin										
Cinnamon										
Anise Star and Oil										
Cashew										
Castor										
Tung Oil										
Shellac										

Q 64 Please state your total collection of non-timber products from plantation forest (contract)

Good	Quantity collected per trip	Number of trips a month	Most freq. used quarter	Total time spent per trip				Bicycles used	Aver time to go to NF	
				AM	AF	YM	YF		Adults	Young
Bamboo shoots										
Mushrooms										
Resin										
Cinnamon										
Anise Star and Oil										
Cashew										
Castor										
Tung Oil										
Shellac										

Q 65 Please state your energy production from plantations, private, this season (3rd quarter)

Good collected	Average Ganh per trip				No of trip/month				Total time spent				Bicycles used			
	AM	AF	YM	YF	AM	AF	YM	YF	AM	AF	YM	YF	AM	AF	YM	YF
Fuel-wood																
Leaves																
Crop residues																
Other																

Q 66 Please state your energy production from plantations, contract

Good collected	Average Ganh per trip				No of trip/month				Total time spent				Bicycles used			
	AM	AF	YM	YF	AM	AF	YM	YF	AM	AF	YM	YF	AM	AF	YM	YF
Fuel-wood																
Leaves																
Crop residues																
Other																

Q 67 Please state the percentage change, if any, compared with the three previous seasons, in percentage change

good	Ganh per trip			No of trips/month			Total time spent			Bicycles used		
	1	2	4	1	2	4	1	2	4	1	2	4
Fuel-wood												
Leaves												
Crop residues												
Other												

Q 68 Please state your energy production from Natural forests, contract

Good collected	Average Ganh per trip				No of trip/month				Total time spent				Bicycles used			
	AM	AF	YM	YF	AM	AF	YM	YF	AM	AF	YM	YF	AM	AF	YM	YF
Fuel-wood																
Leaves																
Crop residues																
Other																

Q 69 Please state your energy production from Natural forests, remote

Good collected	Average Ganh per trip				No of trip/month				Total time spent				Bicycles used			
	AM	AF	YM	YF	AM	AF	YM	YF	AM	AF	YM	YF	AM	AF	YM	YF
Fuel-wood																
Leaves																
Crop residues																
Other																

Q 70 Please state the percentage change, if any, compared with the three previous seasons

good	Ganh per trip			No of trips/month			Total time spent			Bicycles used		
	1	2	4	1	2	4	1	2	4	1	2	4
Fuel-wood												
Leaves												
Crop residues												
Other												

Q 70a Please state your energy production from plantations, which belong other

Good collected	Average Ganh per trip				No of trip/month				Total time spent				Bicycles used			
	AM	AF	YM	YF	AM	AF	YM	YF	AM	AF	YM	YF	AM	AF	YM	YF
Fuel-wood																
Leaves																
Crop residues																
Other																

Q 70b Please state the percentage change, if any, compared with the three previous seasons

good	Ganh per trip			No of trips/month			Total time spent			Bicycles used		
	1	2	4	1	2	4	1	2	4	1	2	4
Fuel-wood												
Leaves												
Crop residues												
Other												

Q 71 Please state your energy use. Please remember that summer is during 2^{nd} and 3^{rd} period (roughly)

Energy	Quantity consumed per day		Price in terms of Ganh		Quantity sold		Quantity bought		Quantity consumed per day for heat	
	4^{th}&1^{st} quarter	2^{nd}&3^{rd} quarter	4^{th}&1^{st} quarter	2^{nd}&3^{rd} quarter	4^{th} - 1^{st} quarter	2^{nd} & 3^{rd} quarter	4^{th} - 1^{st} quarter	2^{nd} & 3^{rd} quarter	§«ng - Xu©n	HÌ -Thu
Fuel-wood										
Leaves										
kerosene										
Crop residues										
Other										

Section 6 Questions on income share distribution, demand and WTP.

1	Formal user-rights for Plantations and Natural Forests. These rights are the prevailing system in your district. Hence, under this system the household has an obligation to protect the NF and manage the plantation under the agreed contract and to receive a payment for protection and a share in future timber harvest besides the possibility to collect non-timber products.
2	Formal ownership for Plantation and Natural Forests. These rights come with no obligations what so ever. With this system there is no protection or management regulations. The households are free to use both the Plantation and the Natural Forest land, as they find beneficial.
3	No rights to the Plantation nor to the Natural Forest. The land is effectively owned and managed by the state. Hence, there is no formal and legal possibility for the household to have access and use of either of the two forestlands.

Suppose that the prevailing property right system is like in 1. [read alternative 1].
(WTP worksheet)

Q 72 What is the highest amount that you would be willing to pay for one additional hectare of Natural Forest close to your previous NF plot?

Amount:	Male .... Q 72.M	Female .... Q 72.F

Q 73 What is the highest amount that you would be willing to pay for one additional hectare of Natural Forest which is remote located?

Amount:	Male .... Q 73.M	Female .... Q 73.F

Q 74 What is the highest amount that you would be willing to pay for one additional hectare of Plantation on contract?

Amount:	Male .... Q 74.M	Female .... Q 74.F

instead that the prevailing property right system is like in 2. [read alternative 2].

Q 75 What is the highest amount that you would be willing to pay for one additional hectare of Natural Forest close to your previous NF plot?

Amount:	Male .... Q 7.M	Female .... Q 75.F

Q 76 What is the highest amount that you would be willing to pay for one additional hectare of Natural Forest which is remote located?

Amount:	Male .... Q 76.M	Female .... Q 76.F

Q 77 What is the highest amount that you would be willing to pay for one additional hectare of private Plantation?

Amount:	Male .... Q 77.M	Female .... Q 77.F

Q 78 What is the highest amount that you would be willing to pay for a total of one additional hectare of Natural Forest close to your previous NF plot and Plantation on contract, thus two additional hectares to your previous NF plot?

Amount:	Male .... Q 78.M	Female .... Q 78.F

Suppose that the prevailing property right system is like in 3

Q 79 What is the highest amount that you would be willing to accept for loosing one additional hectare of Natural Forest close to your previous NF plot

Amount:	Male .... Q 79.M	Female .... Q 79.F

Q 80 What is the highest amount that you would be willing to accept for loosing one additional hectare of Natural Forest which is remote located

Amount:	Male .... Q 80.M	Female .... Q 80.F

Q 81 What is the highest amount that you would be willing to accept for loosing one additional hectare of Plantation on contract?

Amount:	Male .... Q 81.M	Female .... Q 81.F

[The question below is to be asked only to those households that have at least one positive WTP.]

Q 82 Given that your household would be willing to pay a positive amount for get an additional hectare of Natural or Plantation forest, please state which of your current spending or savings you need to cut down in order to afford the extra cost of the forest or if you plan to take on additional wage labour.

	Male	Female
Expenditures cut		
additional labour		

If the respondent do not want to pay anything, that is, they value the item to zero Dong. Please ask the respondent to explain why he/she does not want to pay anything by picking one out of three alternatives:
Hence, ask them the following:

Which statement best express your reason for giving a zero response?

	Male	Female
I can't afford to pay for the good =1		
The good is not important to me =2		
I don't think that I should have to pay for the good = 3		

Answer for zero bids.

Q 83 Suppose your household receive a gift from the state or large organisation. What will you spend on

	priority	
	Male	Female
Environmental goods, such as tree seedlings, fertiliser and pesticides		
Public goods		
Leisure goods		
Other goods		

Appendix B

VILLAGE FACTS

Village :...............[X].

11= Bui; 12= Tan Phong; 13= Dinh
21= Bin; 22= Buc; 23= Chua; 24= Cu
31= Bao; 32= Tam; 33= Tan Tien

Commune: ....[T]

1: Man Duc; 2: Tu Ne; 3: Thanh Hoi

Total area (ha)			[1]
Density (per./km^2)			[2]
	Total	Male	Female
Population (per.)	[4A]	[4B]	[4C]
Labor (per.)	[5A]	[5B]	[5C]
Ethnic (per.)			
+ Kinh	[6A]	[6B]	[6C]
+ Muong	[7A]	[7B]	[7C]
+ Other	[8A]	[8B]	[8C]
Head of household	Total	Male	Female
Total of houshold (hh)	[9A]	[9B]	[9C]
Of which			
+ Rich	[10A]	[10B]	[10C]
+ Middle	[11A]	[11B]	[11C]
+ Poor	[12A]	[12B]	[12C]
+ Very poor	[13A]	[13B]	[13C]
Average distance from the houses to natural forest (km)			[14]
Average rain fall (mm)			[15]
Average slope of agricultural land (degrees)			[16]
Average slope of forestry land (degrees)			[17]
Average air temperatures (.^{0}C)			[18]
Date of last change in forest tenure (year)			[19]

LAND USE

Land	Land area (ha)
Total	[20]
Of which: 1. Agricultural land	[21]
Of which: + Rice 1 harvest + Rice 2 harvest + Rice seedling land + Other cereals land + Industrial tree land - Tea - Sugar cane	 [22] [23] [24] [25] [26] [27]
+ Aquaculture land	[28]
2. Forestry land	[29]
Of which: + Natural forest land	[30]
+ Planting forest land	[31]
+ Barren forest land	[32]
+ Non-forest land	[33]
3. Agro-forestry land	[34]
4. Special land	[35]
5. Homestead land	[36]
6. Waste land	[37]

bye-bye