ABSTRACT

Title of Document: FACTORS AFFECTING AGRICULTURAL EXPANSION IN FOREST RESERVES OF THAILAND: THE ROLE OF POPULATION AND ROADS

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In this dissertation, I examine the role of population and transportation costs in determining agricultural expansion in 670 villages located in Forest Reserves of Thailand, over the period 1986-1996. Specifically, I examine the role of population and transportation costs as drivers of agricultural decisions regarding crop adoption and area planted, and in determining the intensity of cultivation and agricultural expansion. I also contrast the impact of these variables on two groups of villages in Forest Reserves – villages whose residents 'have no secure property rights' and those whose 'land rights are ambiguous'. I examine Feder et al.'s (1988) conclusions about the importance of property rights in Thai forest reserves and find that there is some evidence supporting their conclusions in this study. Differences in property rights

account for some difference in the agricultural decisions of the two groups of villages, but that the nature of data does not allow a sharper distinction.

Results reported in the study are consistent with other studies of the area. The study suggests that decisions regarding crop adoption and crop area are sensitive to population but the magnitudes of impact are small. Lack of significance of transport costs in determining cropping decisions suggests that rural road building programs will not necessarily promote deforestation in the study area, contrary to evidence in other parts of the world. This is particularly important given the large number of Forest Reserve residents in Thailand, and the fact that, Forest Reserves are the last bastions of forests, and consequently of biodiversity, in Thailand. One policy implication of this is that investments in roads that help to increase access to markets and aid poverty alleviation may not have the deleterious effects on forests that would otherwise be expected.

FACTORS AFFECTING AGRICULTURAL EXPANSION IN FOREST RESERVES OF THAILAND: THE ROLE OF POPULATION AND ROADS

By

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To my teachers: Prof. D. R. Puri, Prof. Dharma Kumar, Prof. Nancy Bockstael and Prof. Maureen Cropper.

I doubt I'll ever scale the mountains of your minds…
but I'll keep trying.

Thank you for your patience, but above all, your passion.

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am a far cry from what they'd want to see ideally, but I hope I have imbibed a little of what they'd hoped to teach.

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To my family for being my safety net, my strength and my hope, this is our dissertation.

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1 Introduction

"*Protected areas are fast becoming islands of dying biodiversity because of the agricultural areas that surround them*"
Jeff McNeely (2001)[1]

1.1 Overview

Agricultural expansion is widely believed to be the main reason for deforestation in developing countries (Barbier et al., (1991); Barbier, (2001); Brown and Pearce, (1994); Lambin et al. (2003)). A study conducted by FAO (2001) of a stratified random sample of the world's tropical forests finds that 73% of the world's forests are being converted to non-forest land due to agriculture. 32% of the forest cover change can be attributed to large-scale agriculture and 26% to small-scale agriculture. Intensification of agriculture in shifting agriculture areas was the third largest cause and accounted for 10% of tropical deforestation. Expansion of shifting cultivation into undisturbed forest accounted for 5%. Barbier (2004) also reports that cultivated area in the developing world is expected to increase by more than 47% by 2050, with two-thirds of the new land coming from deforestation and wetland conversion (also see Fischer and Heilig, (1997)).

These figures underscore the importance of examining agricultural land, and factors affecting agricultural decisions, especially in forested areas, such as protected areas and forest reserves. An understanding of the direction and magnitude of effects can help to inform forestry policy and help alleviate pressures on the forest frontier.

[1] Jeff McNeely, Chief Scientist of IUCN, The World Conservation Union and co-author "*Common Ground, Common Future: How Ecoagriculture Can help feed the world and Save Wild Biodiversity*" 2001.

Thus the following questions become important: What are the agricultural practices pursued within forested areas? What are their main determinants? What is their net impact on the forest frontier? And finally, to what extent can this knowledge help inform forest policy? Using an unbalanced panel data set of 670 villages located within Forest Reserves of Chiang Mai, Thailand, I examine the first two questions. Specifically I estimate separate random effects crop equations for three main crops grown in the region – paddy rice, soybean and upland rice, using biennial panel data for the period 1986-1996. Using the same explanatory variables as in the crop equations, I also estimate random effects models for intensity of cultivation and agricultural land in a village. Results show that qualitative differences in agricultural decisions amongst Forest Reserve villages exist mainly because of differences in transport costs and differences in property rights. Population within Forest Reserves is also a significant determinant of agricultural behavior; qualitatively it has largely a 'subsistence' effect.

There are several reasons for examining reserved forest villages in Chiang Mai over the period 1986-96. Until 1985, North Thailand, where the province of Chiang Mai is located, had the country's lowest population density and largest forested area, including the largest and critical watersheds (Kirananda, (1985)). During 1985-1993, Thailand lost 11% of its forested area (Royal Forest Department, (1994)). During this period the province of Chiang Mai lost almost 2000 sq km of forest, which equals 10% of its provincial land area.[2] Forest loss in the province was attributed mainly to agricultural practices (Panayatou, (1991); Feeny, (1988)).

Forest loss in this area was particularly harmful because it resulted in large changes in local ecology and hydrology as well as in impacts nationwide. The period (1985-1993) witnessed reduced rainfall and dry-season water shortage caused by low infiltration rates (Walker, (2002); Supradit, (1997); Takahashi et al., (1983); Vincent et al. (1995)).[3] Floods in Central Thailand in 1987 were also widely blamed on deforestation in North Thailand. As a consequence the period witnessed frequent resource-related conflicts between ethnic Thais who live in the plains and the tribes that reside within Forest Reserves. The tribes are popularly perceived as apathetic to forest conservation efforts and their clearing activities are seen as being responsible for downstream water troubles (Wittayapak, (1996); Lohmann, (1999)). Examining the extent to which agricultural practices are leading to increased land clearing and unsustainable land use is therefore also relevant for regional and national policy.

1.2 Factors Affecting Agricultural Expansion in Forest Areas

In examining agricultural practices in forest villages in Chiang Mai I focus on three factors that have been found to be important drivers of agricultural expansion and deforestation: population, transportation costs and the absence of property rights.

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[2] North Thailand lost approximately the same percentage of forest area. Forest area fell from 84126 sqkm in 1985 to 75231 sq km in 1993.

[3] Walker (2002) notes that in North Thailand, “Forest cover and water supply have become inextricably linked in local and national debates.”

In this section I summarize the main conclusions from these studies. Details are presented in Appendix I.

Population and Transportation: A seminal study examining the effect of population on tropical agriculture is one by Esther Boserup in 1965. In the study, Boserup asserted that the main effect of a change in population was on the intensity of cultivation, defined as the frequency of cropping. Specifically she asserted that the distinction between intensive and extensive cultivation could be explained by the frequency of cropping. She also argued that population increases lead to a shift from extensive to more intensive systems of land use. The Boserup paradigm in which population is the main determinant of land use has been used subsequently by many studies, that assume population to be the main driver of agricultural production: many agricultural tropical communities are modeled as aiming to reach an exogenously determined consumption basket. In these subsistence communities, increases in population are the only reason for increases in agricultural production (see for example, Godoy (1997); Dvorak (1992); Angelsen (1996)).

The impact of transportation costs on agricultural decisions was first examined by Von Thunen in 1965. Von Thunen suggested that differences in crop choice could be attributed to transport costs alone (he assumed homogeneous soil fertility). He showed that farther farmers are more likely to shift from growing perishable cash crops such as vegetables, to growing crops that are more hardy and storable, such as staples and legumes.

Subsequently, both variables – population and transportation costs – have been cited in the literature examining agricultural expansion although few studies examine their impact in Thailand. Cropper, Griffiths and Mani (1999) and Panayatou (1991) are especially relevant since both examine the impacts of population and transportation costs in Thailand. Cropper et al. (1999) use province-level data to estimate an equilibrium model of land clearing between 1976 and 1989. They find that population density had a large impact on land clearing in North Thailand. The elasticity of land clearing with respect to agricultural household density is found to be 0.41 in North Thailand. Road density (measured as length of road network divided by provincial area) however had no statistically significant impact on cleared area. Panayatou (1991) and Panayatou and Sungsuwan (1989) support these conclusions in their study of population impact in Thailand. Panayatou and Sungsuwan highlight population growth as the most important driver of land use change, using state level panel data for the period 1962-1989.[4] Explanatory variables include agricultural prices, provincial income, population density and road density. For the study period, they estimated the elasticity of forest cover with respect to road density as -0.11. However, this estimate is probably biased, because the cost of access is also capitalized in land and timber prices, which are also found to be significant.

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[4] It is interesting that there are several studies – albeit not in the applied economics literature – that assert that roads have had *no* impacts or very little impact in Thailand. Jones (1973) while studying the impact of improved primary highways, finds little impact on agricultural area in Northern Thailand and concludes that "*most indicators continued much as they had earlier*". He also concludes the same in Southern Thailand "*a greatly improved primary highway appeared not to have altered a declining economy*". Howe and Richards (1984) confirm their support (pp 158) to say that there seems "…*no consistent pattern of response to the presence of new or significantly improved roads, either trunkline highways or feeder roads*…". They also comment on a baseline impact of roads, over and above which there seems little incremental impact "…*No doubt the efficacy of peasant farming is dominated by*

In the larger agricultural land use literature, there are broadly two types of studies that examine agricultural land use.

A Pixel as the unit of analysis: This group of studies follows Von Thunen (1965), and uses reduced form econometric models to explain and predict land use at the level of a pixel, assuming that land will be devoted to its most profitable use. These studies (see for example Chomitz and Gray, (1996); Nelson and Hellerstein (1996); Pfaff, (1997); Cropper, Puri and Griffiths (2001); Deininger and Minten (1996); and, Muller (2004)) customarily use physiographic information at the level of the pixel, such as soil type, elevation, slope to explain land use. Data are derived from a compendium of spatially explicit layers. Additional information such as population (usually measured at a much coarser level of aggregation, such as district or county or province) is used along with a complex measure of access to the market. The 'access' variable is weighted for road presence, road quality and location of population centers (a proxy for market locations). The results from such models are fairly straight forward and explicit: Steeper slopes, higher elevations and bad soil reduce the probability that land is converted to agriculture (from forest); Commercial crops are likely to be grown closer to markets, while subsistence crops are grown further away; and, higher population is correlated with a higher probability of the pixel of land being cultivated.

Most of these studies find that physiographic variables have stronger explanatory power than socio-economic variables in predicting land use although

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factors other than the economic cost of farm-to-market transport, provided there is some kind of road available at the time of year it is needed."

socio-economic variables such as population are measured at a much coarser level. The advantage of these studies is that all the explanatory variables are truly exogenous and study estimates are not biased by possible endogeneity. On the other hand, although these models are fairly rigorous, one disadvantage is that they are ill-suited to providing insights into how socio-economic factors can affect agricultural decisions.

An Agricultural household as the unit of Analysis: This limitation, that most studies using the pixel as the level of analysis are unable to explain the role of socio-economic characteristics in explaining deforestation, is alleviated, to some extent, by studies using the agricultural household as their main unit of analysis. These studies use socio-economic variables to analyze the role of main determinants with respect to the household. Households are modeled differently depending on how well they are integrated with input or output markets, and integration with markets is usually measured by transportation costs (Angelsen and Kaimowitz, (1996); Dvorak (1992); Godoy et al. (1997), Angelsen (1996); Dwayne (1992); Lopez (1984); Deininger and Minten (1996a); Sadoulet and Janvry (1995)). Effects of changes in population and transportation costs on agricultural decisions vary depending on whether households operate within perfects markets (transportation costs have most impact) if they operate in autarky (population changes have most impact), or if they operate somewhere in the middle of this continuum (the relative weights matter). Measuring magnitudes of impact of these two variables on agricultural decisions is thus important.

In more recent studies (Sadoulet and DeJanvry, (1995)) transportation costs have been studied more assiduously. Sadoulet and DeJanvry aver that all households are profit maximizers. But, one of the reasons that some households do not participate in markets (markets are thus 'missing'), is that difficult or non-existent physical access causes high transaction costs.[5] These transaction costs include not just search costs, bargaining costs and other costs that are not priced by the market but also the cost of transportation that exacerbate them. Thus most studies use transportation costs as a proxy for transaction costs. Subsequent studies have used this paradigm to model agricultural decisions of households (See for example, Minten and Kyle (1999); Jacoby (2000); and Puri (2001a, 2001b)). Transportation costs lower (raise) the effective price for the seller (buyer), compared to his shadow price, increasing the likelihood that households will choose not to participate in markets.

One implication of this is that households that are typically perceived by the outsider as being insensitive to market prices or uninterested in achieving higher levels of consumption/utility may not be so insensitive. In Africa for example, De Janvry, Fafchamps and Sadoulet (1991) find the elasticity of peasant supply response of cash crops is 0.18% (implying a very low response). Peasants treat food consumption as a necessity and subsistence production is undertaken to hedge against the possibility of income shocks. A positive income shock does not alleviate this (perceived) low response. This is explained by most economists as an increased desire for leisure and an inability to hire non-family labor. But once the authors

[5] Missing markets in labor (Fafchamps, (1993)), for food (De Janvry (1991); Onamo, (1998)), credit (Eswaran and Kotwal (1996)); Rosensweig and Wolpin (1993)) and insurance (Bromley and Chavas (1988)) have been explored variously.

account for shadow prices, the results are different: Increases in output response come mainly from an increased use of fertilizers. The study finds that shadow prices of food and labor increase by 8.8% and 9.3% respectively in response to cash crop price increases. These conclusions underscore the importance of locating households on the 'autarky-market continuum', which is a function of transportation costs and household attributes.

Other studies use transportation costs to explain decisions to participate in the market (see for example, Stifel, Minten and Dorosh (2003), Jacoby (2000); Minten and Kyle (1999); Fafchamps and Shilpi (2003); Puri (2001b)); and, the mix of crops they grow (Omamo, (1998); Goetz (1992); DeShazo and DeShazo (1995); Lendleton and Howe (2000), Vance and Geoghan (1997); and, Chomitz and Gray (1996)). The main thesis in these studies is that crop choices are dependent on subjective shadow values associated with these crops, transportation costs and market prices. One implication of these studies is that households *as a whole* cannot be characterized as subsistence oriented or operating in perfect markets. Rather goods produced and bought/sold are individually characterized as either 'for subsistence' or 'for the market' or indeed as both.

Property rights: The third important variable that I examine in this dissertation is property rights. The role of property rights in agriculture is summarized as follows: Firstly, farmers without secure land ownership will have fewer investment incentives than farmers with secure land ownership. Secondly, the absence of property rights has a negative effect on a farmer's ability to invest in land, since he cannot use land as loan collateral. Consequently, farmers with no secure titles are likely to have less productive land (see for example Feder et al. (1988)).

Inhabitants living within Forest Reserve Areas are not allowed to have secure land titles. Instead they are only permitted user rights. In a study of 230 farmers living in Forest Reserves in the North-eastern region of Thailand, in 1986, Feder et al. (1988) find four important things. First, despite the absence of secure land titles, there is an active land market. They find that the socio-political environment has so evolved in the country that farmers 'perceive' themselves as owners of their land. This perception is strengthened by the very low risk of eviction; only 1-4% farmers have ever been evicted from lands in Forest Reserves of Thailand. Second, although the Bank of Agriculture and Agricultural Credit (BAAC) does not require land as collateral for loans, the average loan amount provided to a farmer who offers land as collateral is different from the average loan amount provided to a farmer who does not. Third, farmers behave differently if they have secure rights. In the absence of these rights, they invest less in land and own less capital. Fourth, farmers with *no legal usufruct* rights behave no differently from farmers with *legal usufruct* rights. (Usufruct rights are rights to cultivate land.)

Farmers in the study sample used for this dissertation cannot use land as collateral. However they have different perceptions regarding their ownership status. The importance of these perceptions are tested using a dummy variable that distinguishes between villages that are ambiguous about their ownership status and villages that clearly have no legal ownership to land that they own. The study thus examines the role of perceptions of property rights on agricultural decisions.

1.3 Ex Ante Hypothesis and Contribution of the Dissertation

In this dissertation I examine the effects of population, transportation costs and property rights on agricultural decisions using panel data for the period 1986-1996 for 670 villages located in Forest Reserves of Chiang Mai, Thailand. Villages grow three main crops – paddy rice, upland rice and soybeans. Thailand is among the largest growers of paddy rice and its biggest exporter. But rice is also a staple. Most villages in the study sample grow paddy rice. On average upland rice and soybean are grown by 25% and 26% percentage of villages respectively. Using variables such as village population, travel time to market, water availability, soil quality, credit use, security of property rights, use of high yielding variety seeds and education level, I estimate three different random effects, reduced form equations for these crops. For soybean and upland rice, random effects Tobit models are used to estimate the probability that villages grow these crops, and conditional on adoption, the amount of area devoted to these two crops. I use the same variables to estimate random effects equations for total agricultural area and land use intensity. Since I do not have data on deforested area, I cannot examine the impact of various factors on deforestation; instead I examine their impact on agricultural expansion.[6]

More than one-fifth of Thailand's villages are located in Forest Reserves. Forest Reserves are the last bastions of forests in the country. Therefore examining and measuring the impacts of population and transportation costs, both of which can

[6] Barbier (2004) uses the same approach.

be influenced by the government, is important for policy. The dissertation makes several additional contributions to the literature.

Firstly, the dissertation estimates the impact of population and transportation costs on the agricultural frontier. Although the impact of roads and population may seem obvious, a closer examination reveals that this may not be so simple. Consider the scenario of an increase in population. This could lead to an increase in land clearing. But the impact could be small if agricultural wages are low and labor is mostly absorbed by the urban sector. Similarly, a reduction in travel costs could lead to an increased incentive to cultivate land but it could also aid labor mobility. Clearly measuring the magnitude of impact is important. Additionally, most studies use physiographic variables to explain agricultural decisions. Although these are critical, they do not help to explain the impact of tools that human beings do have some control over – policies affecting road building, population migration and credit availability for instance.

Secondly, the dissertation indirectly examines traditional assumptions about inhabitants living on the borders of, or within, legally designated Forest Reserve areas. Forest inhabitants are sometimes seen as detrimental to the forest and as non-participants in markets. Available policy options are thus assumed to be limited. Thus in countries such as India, Tanzania, Philippines and Thailand, meager state resources are used to resettle forest residents and devise compensation schemes that are often ineffective and are usually controversial (Albers and Muller, (2002); Wells, Brandon and Hannah, (1992), Cernea (1999), Cernea and Kanbur, (2002)).

As a response, Integrated Conservation and Development Programs (ICDPs) have become a favored policy tool in other parts of the world such as Indonesia, Bhutan, Madagascar and Papua New Guinea – schemes that potentially sustain forest growth and simultaneously, improve welfare of forest communities. These programs concentrate on providing alternative livelihoods to these farmers (See Paine, Byron, Poffenberger, (2004); Bruner, Gullison, Rice and Fonseca, (2001); Muller (2001)) However one of the main drawbacks of ICDPs is that they seek to provide livelihood alternatives that are not market-viable. ICDP ignores the role of access/isolation and transportation costs in farmer decisions and farm profitability (see for example, Rayamajhi et al. (2004); Jambiya et al. (2004)). Measuring the role of transportation costs on agricultural decisions within Forest Reserves can shed some light on the extent to which residents are integrated with markets.

Related to this, applied economic studies have frequently posited that farmers living at the forest frontier are not active market participants and their only goal is to cultivate their land for self-consumption. Irrational decisions deduced from low supply response to policy changes are explained using this logic. (This is the key reason for undertaking resettlement projects referred to above.) Although it is difficult to assess the validity of this conclusion with the data I have, the dissertation throws some light on factors that affect decisions to cultivate.

Thirdly, I examine the role that perceptions of security play in agricultural decisions. Most Protected area advocates create buffer zones around core protected areas that have looser administrative controls, and allow residents to own land. Residents who believe that they have property rights are likely to behave differently from residents who are poorer and have no rights on land that they cultivate. This presents a valuable opportunity to understand the importance of perceptions regarding land rights and the impacts that these have on crop choices and crop area.

Finally, the use of panel data containing socio-economic variables to examine agricultural practices is rare. Most studies examining deforestation in developing countries use cross-sectional data or a shallow panel spanning two years. Only one study to my knowledge (Almeida and Campari, (1995)) examines land area responses to policy changes using a panel dataset (2 points in time: 1981 and 1991). Others use cross-sectional datasets (Godoy et al. (1997) in Honduras; Godoy et al. (1996) in Bolivia; Jones et al. (1995) in Brazil; Munoz et al. (1992) in Mexico; and Pichon (1997) in Ecuador). As compared to studies using cross-sectional data, panel data models can help to alleviate biases due to omitted variables.

1.4 Conclusion: Assumptions in this Dissertation

In this dissertation I examine the role of several factors in determining area devoted to three main crops within Forest Reserves of Thailand. Determining the magnitudes of these variables on whether crops are grown, and on the area devoted to these crops can help one understand agricultural choices and decisions about acreage. I also use the same variables to examine total agricultural expansion and agricultural intensification. The maintained hypothesis is that agriculture is the main reason for forest clearing in Forest Villages of Chiang Mai.

The data used for the study has some features that recommend it for explaining land area decisions and crop choices in the survey area. The study panel has detailed information on total agricultural land and area devoted to various crop types (rice, short run crops and long run crops). Being a village-level dataset, it enables me to abstract from intra-village effects and household neighborhood effects, and concentrate on net changes in land area.[7] Another advantage of using village level data is that markets are rarely missing at the intra-village level, since reciprocal exchanges are common within villages located in remote parts of developing countries (Gilligan (2003)).

There are two main assumptions that I make in this study:

Firstly, that population within Forest Reserves is exogenous to crop choice. Populations within reserved areas of Thailand can be assumed to be controlled because administrative authorities do not allow mass migrations to occur in these areas; Villages are not allowed to exceed their sustainable carrying capacity.[8] This is supported by data: During 1986-1996, although the population of Chiang Mai province rose by more than 15%, population within study villages grew at less than 1% per year.

Secondly, I assume that access to markets is exogenously determined. Road construction and investments related to improvements in access are undertaken by three agencies in Thailand: The Department of Highways of the Ministry of Communications, the Office of Accelerated Rural Development of the Ministry of

[7] See for example Case (1991)

[8] Personal communication, Gershon Feder, The World Bank, 2004.

Interior (ARD) and the Department of Land Administration (DOLA).[9] I measure access to market using a composite variable – travel time to the market – which includes road presence, road quality and availability of transport, all three of which are usually highly correlated (Puri, (2002)). If road construction and road quality related investments within study Forest Reserves take place for reasons unrelated to agriculture, such as for security reasons or to provide access to parks, then this assumption is a plausible one. There is substantial evidence that road building before the study period took place to provide military access to remote areas. The assumption is also plausible for another reason: Unlike other forms of investment, roads investments occur in stages (Howe and Richards, (1984)). 'Stage construction' implies that early paths are often followed by animal trails, and these are gradually cleared to provide adequate width and ease difficult alignment. Road-related investments may thus consist of road construction, road maintenance or road rehabilitation (see e.g. Puri, (2002a)). This implies that road locations are determined almost at the same time as inhabitants start to settle in a location. Attributing road presence to increased agricultural activity may thus be erroneous. In addition, road-related investments are frequently assumed to be endogenous because the beneficiary communities can exert political pressure. To the extent that Forest Reserve villages are inhabited by minority communities, political pressure is not expected to have much sway on government investments.

In the next chapter I describe the creation of Forest Reserves in Thailand.

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[9] There are some other agencies of the government and state, that construct roads for special purposes, but their role is relatively minor.

2 Reserved Forests in Thailand

"*Uncertainty in forest boundaries is a major reason for not adjudicating parcels, as the DOL staff, to ensure that forest parcels are not adjudicated in forest land, have tended to leave a buffer in areas where a forest boundary is uncertain. In some regions of the country, particularly in the North, where land eligible for registration is often narrow valley floors, between forested mountains, the impost (sic) of a buffer can mean a significant proportion of parcels are not adjudicated.*"
(Rattanabirabongse, V. et al. "Thirteen Years of experience with Land Titling" *Land Use Policy*, 1998)

2.1 Introduction

This chapter analyzes the history of forest legislation in Thailand. This is important because all villages in the dataset used for this study are located within Forest Reserves. But it is also important because it highlights two important attributes of villages examined in this dissertation: The first is that inhabitants of Forest Reserve villages are likely to be hill tribe people who are poor, and who inhabit villages that are relatively remote and have poor infrastructure. The second is that the boundaries of Forest Reserves are not strictly defined: Impermanent Forest Reserve boundaries are a result of changing legislation and a myriad of legislative and enforcement agencies. Unclear and ever-changing boundaries of Forest Reserves have, in turn, implied ambiguous property rights within Forest Reserve villages. Both these attributes have important implications for crop choice and agricultural decisions.

2.2 The Creation of Forest Reserves - Forestry Legislation in Thailand

Two pieces of legislation provide the backbone of modern, conservation-related forest legislation in Thailand: The Forest Act of 1941 and the National Forest Reserve Act of 1964. The Forest Act of 1941 defined a forest as "*land without any private rights following land laws*". The Act made a break with the past, because it oriented forest legislation towards spatial conservation (Wataru, (2003)). The National Forest Reserve Act of 1964 converted forest area to National Forest Reserves (*pa sanguan heang chat)*. It also laid out restrictions of use within Forest Reserves[10]: Holding, possessing, clearing land, burning, collecting timber and gathering forest products were made illegal within Forest Reserve boundaries (Bugna and Rambaldi, (2001)).[11,12] Forestry legislation did not change significantly before 1989 when all commercial logging was banned and forest policy "*shifted to the protection of national environment*" (op. cit.). It is important to point out that although there were commercial logging interests in this region before 1989, Forest Reserves did not coincide with logging areas. A chronology of important events and legislation in Thailand's Forest sector is presented in Box 3.1 and more details are presented in Annex 7.2.

Since 1964, the official procedure for establishing/altering Forest Reserves has been as follows (National Forest Reserve Act, 1964): New areas, boundary revisions and other changes require a geographic survey and a subsequent Ministerial Order. After approval, Reserve boundaries are marked by poles and signs, and a public announcement is made, directed mainly at district offices, offices of sub-

[10] Literature differentiates between *National* Forest Reserves and Forest reserves, which were different before 1964. These are used interchangeably in the text since all Forest Reserves came under the RFD after this Act. Furthermore, although Forest Reserves had been in existence earlier, the Act of 1964 was the first to lay down procedures for preserving forest areas and designating them as 'Forests'.

[11] Simultaneously the first National Economic Development Plan of 1961 provided for 50% of the country to be kept forested.

[12] Forest land continued to be used. The 1964 Act did not recognize it.

district heads and all affected villages.[13] A National Forest Reserve Committee is established for each forest. The Committee consists of one member each from RFD, the Department of Local Administration (DOLA), the Department of Land (DOL) and two members chosen by the Minister of Agriculture.

Importantly, all appeals disputing Reserve boundaries are passed to the National Forest Reserve Committee. Villagers who claim usufruct rights to land within the reserved area can appeal only *after* an area is designated a Forest Reserve. This appeal is sent to the National Forest Reserve Committee and the Minister adjudicates.[14] Since an appeal contesting boundaries must be made within 90 days of the area being designated a Forest Reserve, people living within boundaries of Forest Reserves are frequently deemed 'illegal encroachers' if an application is not presented within the mandated 90 day period. No distinction is made between older residents and newer occupants.

The Royal Forest Department (RFD) is the main agency responsible for managing protected areas and Reserved Forests in Thailand.[15] (Protected areas are

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[13] The literature however contends that field level forest officers frequently do not recognize boundaries – which causes a lot of friction with local people. An interesting description of the process in North-east Thailand, is described as below: "…*When they measured a planned area, they surveyed only along the boundary with assistance from the village headmen and sub-district heads. Border areas that were dangerous and difficult of (sic) access might have been demarcated only on the map. Large and well-established villages and their paddy fields would be excluded if forest officers found them during their survey. But small hamlets of several households would not be excluded for the national forest reserves, even though forest officers found them, because according to the previous officer, exclusion of these hamlets from national forest reserves would mean approving earlier illegal encroachment into national forestlands.*" (Sato cited in Fujita, (2003)). Vague boundaries between forest and areas growing rain-fed paddy were called '*rice-producing forest*'.

[14] The National Forest Reserve Act, does not provide for a *prior* investigation of people usufruct rights.

[15] It was established in 1896 with a mandate to protect and manage all Forests and implement laws.

different from Forest Reserves in that the former are recognized by the IUCN (World Conservation Union) as important preserves, and enforcement is stricter within Protected areas.) The RFD facilitates protected area management via its Natural Resources Conservation Office, which has amongst its other divisions the Natural Park Division which regulates the use of parks. The RFD is in turn part of the Ministry of Agriculture and Cooperatives (MOAC).[16]

While RFD is the main actor, conservation related policies are developed and executed by several agencies in Thailand. These include MOAC, the Ministry of Science, Technology and Environment (MOSTE) and others outside these ministries, such as the National Resources and Biodiversity Institutes (NAREBI), the National Committee on the Conservation of Biological Diversity and the Office of Environmental Policy and Planning.

[16] Despite evidence of active policy making in this sector, many studies have decried the management of Protected and Reserved Forest Areas (see for example Augettante, (1996); Wataru, (2003)) and have commented on the difference between conserved forests and *actual* forest cover (See Table 3.1). Wataru (2003) contends that during the period of my study, the RFD lacked sufficient power to enact policies against local people who were traditional resource users as a result of which "*forest reserves are a failure*." Ganjanapan (2000), based on field research in North Thailand, concludes that the state, by enclosing the forest and not recognizing people's use of these forests, "*removed the villagers' incentive to protect the forests*." RFD's own figures point out the discrepancy between reserved forests and actual forest cover. Most of this is attributed to agriculture and shifting agriculture practiced by indigenous people, living within or close to forest reserve boundaries.

Box 2.1: Chronology of Important Events for Forest related Legislation in Thailand

(Note: Relevant important legislation are starred.)
1874: Local Governor's Act of 1874 and Royal Order on Taxation of Teak and other logs. Central government/King becomes involved in managing logging concessions.
1896: Royal Forest Department (RFD) founded.
1897: Forest Preservation Order of 1897 regulates size of Teak to be logged.
1901: Forest management completely under the control of the central government.
1913: Forest Preservation Act controls species of Teak and others. Act legally defines a 'forest'. Gives a minister the authority to designate non-logging areas and issue orders to prohibit land clearing.
1916: Draft of Forest Conservation Act. "First attempt" at introducing spatial conservation. Regional forest offices begin to select forests to conserve and designate as 'forest reserves'. Draft is not approved but temporary designations of 'forests' continue.
1938: Forest Preservation and Conservation Act of 1938. Divides forests into two categories - 'Preserved Forests' and 'Forest Reserves'
***1941**: Forest Act of 1941. Forest Reserves are promulgated.
1952: Forest Ranger service for control and policing forests. However Rangers only monitor commercial logging concessions and are not assigned to particular Forest Reserves or Preserves.
1953: Forest Preservation and Conservation Act is revised. Forest 'designating' committee must now contain a sub-district head as a member. Recognizing reality, temporary residence and use of forests start to be granted after investigation.
1954: Forest Preservation and Conservation Act is made a ministerial order. 240 Preserved Forests and 8 Reserved Forests are counted in the country.
1960: Forest Police founded as a department of the Police Department.
1961: National Park Act passed. First NESDP (1961-1965) provides for 50% of the country to be forested land. Forest rangers organized in 'forest protection units' are made responsible for forest protection.
1963: Department of Land Development (DLD) established.
***1964**: National Forest Reserve Act of 1964 passed. The Act recognizes that procedures for designating procedures are too time consuming. Therefore it omits the hitherto mandatory investigation of usufruct rights before designating an area a 'Reserve' or a 'Preserve'.
1965: Rural Forest development Units established, to provide services additional to protection units such as extension services, while protecting forests.
1966: Committee established to investigate local people's land use in National Forest Reserves.
1967: RFD starts to designate 'project forests' for logging.
1973: Ministry of Interior sponsors the 'Land distribution promotion project', conducted by RFD.
***1975**: Cabinet approves legislation for establishing 'Forest villages'.
1979: The 'Cultivation Rights Project' in forest villages commences.
1982: STKs start to be awarded.
1993: Cultivation Rights Project ends.
1989: All commercial logging is banned in Thailand.
1991: Zoning of National Forest reserves starts (Zone A: Land suitable for agriculture; Zone C: Protected forest zone; Zone E: Economic Forest).
1992: Forest Protection Units transferred to provincial forest offices.
1993: All degraded forest lands transferred to Agricultural Land Reform Office (ALRO), and excluded from National forest reserves. ALRO issues SPK4s to landless farmers.
Sources: Various. Mainly Bugna and Rambaldi (2001), Fujita (2003), Thailand (2003), Buergin (2000), RFD (Various years), Wataru (2003).

	All Thailand	North Thailand	Chiang Mai
Total Area	513,115	169,644	20,107
National Reserves (1993)	230,186	111,983	19,556
Forest			
1982	156,598	87,756	16,702
1985	150,889	84,126	16,210
1988	143,803	80,402	15,204
1991	136,698	77,143	14,741
1993	133,521	75,231	14,420

Source: Forestry Statistics of Thailand, Royal Forestry Department, 1994.

Table 2.1: Forest Area (square kilometers), Thailand, (1982-1993).

2.3 Property Rights within Forest Reserves

Before 1953, national forest policy in Thailand was exclusionary: legislation did not recognize *de facto* use of land within Forest Areas and recognized no rights of residents within its boundaries.[17] In 1953, authorities realized that such exclusion was not practical given the large population dependent on forest resources and their traditional uses. As forest authorities realized the needs of villagers, limited use of forest areas began to be permitted. RFD, along with the Ministry of Agriculture and relevant officers, began to provide limited sanctions for use of Forest Reserves. Applications to secure sanctions/rights to use land within Forest Reserves and extracting forest products were accepted at the District forest offices and sent to the headquarters via provincial forest offices. The Director General of the Forest office made these decisions. In 1975, official forest villages were created, via a cabinet

[17] Vandergeest (1996) calls this ingress of the state prohibiting traditional uses and imposing modern tenure systems, the "*territorialization of the forest*" by the state.

resolution. [18] Landless peasants were allotted land within these settlements, which could be used, but not sold or used for collateral.

A review of the literature reveals that although usufruct rights were granted, usufruct rights within Forest Reserves were being continuously investigated and re-defined at least until the 1990s (Table 2.2). This contributed to a great deal of uncertainty amongst Forest Reserve inhabitants. Thus for instance, in 1957, people occupying forest land at the time were given land titles called SK-1 (*So-Ko 1*) and NS-3 (*No-So 3)*. (SK-1s were claim certificates that were granted if residents successfully established possession before 1957. Land with an SK-1 certificate could not be used as collateral. NS-3s were granted for land that could be traded and used as collateral.) Then in 1976, the cabinet authorized the Department of Land and Ministry of Interior to issue NS-3K (*No-So-Ko-3*) land titles. (These were secure land titles but ownership could be challenged if land remained fallow for more than five years.) However since RFD opposed this strongly, titles were rescinded although the same freedoms remained in place (Roth, (2003); Wataru (2003)). In 1973 as part of a 'Land Distribution Promotion Project', the Ministry of Interior investigated land tenure and usage in National Forest Reserves. A sub-committee consisting of officials from the Ministry of Agriculture, Department of Agricultural Promotion, the Director-General of the Department of Public Welfare and RFD decided one of four actions after reviewing the results: i) Exclude the occupied area from the national forest reserve; ii) Temporarily allow residence and cultivation; iii) Remove the encroacher; iv) Abolish

[18] Forest villages were of three types: National Forest Reserve Improvement projects (carried out by RFD), royal projects and rural development projects. The last were expressly for national security.

the entire national forest reserve. In most cases temporary residence and cultivation were allowed.[19]

In 1990 according to TDRI, more than 20% of the country's 56,000 villages were located within Forest Reserves (cited in Gray, (1991)). An increased frequency of conflicts between encroaching villagers and forest authorities is an indicator of the tension between forest preservation and rural livelihoods (Lohman, (1999); Fujita, (2003)).

What this discussion brings out clearly is that user rights within Forest Reserves were in a state of continuous flux until the 1990s and depended on political will and on new programs adopted by different agencies engaged in protecting forests or developing land within them. In this context, the Department of Land Development (DLD) and RFD were particularly at odds with each other as each was keen to extend its domain but each had (and has) different mandates.

This ambiguity in user rights within Forest Reserves was also aggravated by the fact that boundaries of Forest villages changed frequently because of separate investigations, often conducted independently of each other. Thus we find several seeming contradictions. Table 2.2 (reproduced and adapted from Feder et al. (1988)), for example, contends that *No-So-3*s cannot be issued inside Forest Reserves.

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[19] This examination of usufruct rights continued till the 1990s although Annual Reports of the RFD indicate that the number of forests investigated each year varied from very few to 50-60. Simultaneously during the mid-1970s there were other investigations that aimed to do the same. But they were frequently conducted in vacuum and each investigation newly confirmed cultivation as legal or illegal.

However Wataru (2003) states that these were issued to people living *inside* Forest Reserves.

The following quotes (along with one at the beginning of the chapter) are eloquent:

"*Overlaps in jurisdiction are compromising key targets of the project by preventing the issue of titles for many parcels. This has been particularly been the case with forest boundaries and declared land reform areas…*"

"*Until phase III, field adjudication staff did not adjudicate near forests or in areas where forest boundaries were uncertain. This reduced the percentage of land adjudicated. Now, by mutual agreement, the RFD surveying resources are used to mark forest boundaries in adjudication areas, and to delineate forest boundaries in DOL maps.*"

(Rattanabirabongse, V. et al. (1998))

"*…some members of a given family could be squatters while other members are legal owners. In areas on the boundary of the forest reserve, an individual's landholdings could arbitrarily be split between land outside the reserve – for which he held a legal, secure land document – and land inside the forest reserve, for which he could be considered an illegal squatter."*

"*…In many instances it was several years before farmers learned that land they held or had acquired had been designated as forest reserves.*"

(Feder et al. (1988))

This discussion demonstrates two things: Firstly, that villages located on the boundaries of Forest Reserves were particularly likely to have ambiguous property rights, because of the ever changing boundaries of forest reserves and the buffer zone left around Forest Reserves that officials preferred to ignore while enforcing property rights. Secondly, villages located deep inside Forest Reserves were unlikely to have any secure property rights.

Title Type	Year Introduced	Rights	Limits (as described by Feder et al. 1988)*	Code within the study Dataset*
NS-4 (Chanod) Title Deed	1954	Most secure; full unrestricted ownership title. Can be used as collateral and is fully tradable.	Issued only outside forest reserves	1
NS-3 (No-So-Sarm) Certificate of Use	1954	Very secure. Can be converted into NS-4. Tradable under certain conditions. Can be used as collateral.	Issued only outside forest reserves, any transfer must be advertised for 30 days.	2
NS-3K (No-So-Sarm-Kor) Exploitation Testimonial	1972	Very secure. Can be converted to NS-4. Fully tradeable. Can be used as collateral.	Issued only outside forest reserves. Ownership may be challenged if land lies fallow for more than 5 years.	3
NS-2 (Bai-Chong) Pre-emptive certificate	1954	Authorizes temporary occupation of land. After a prescribed period may be converted to NS-3 or NS-4. Can be acquired only through inheritance. Cannot be used as collateral.	Issued only outside forest reserves; validity of rights conditional on use within 6 months of issuance.	4?
SK-1 (So-Ko-Neung) Claim Certificate	1954	Particular to the period during which Thailand was adopting the Land code. Claim to ownership is based on possession before the enactment of land code. Certificate tradeable only after transfer is advertised. Cannot be used as collateral.	Issued only outside forest reserves.	5
STK (So-Tho-Ko) 1 and STK 2 Temporary cultivation rights	1982	Certificate of use only. Can be acquired only through inheritance and cannot be used as collateral. Cannot be converted into NS-3 or NS-4.	Issued *inside* forest reserves; covers plots up to 15 rai. State reserves right to revoke usufruct rights if restrictions are violated.	6
NK-3 (Nor-Kor-Sarm) NK-2 (Nor-Kor-Som) NK-1 (Nor-Kor-Neung) SPK (Sor-Por-Kor)		These are issued in specific areas under small official programs. They can usually be acquired through inheritance and usually cannot be used as collateral. These are usually usufruct rights and cannot be sold until 5 years after issue date.		7

Source: Adapted from Feder et al. *Land Productivity and Farm Productivity in Thailand,* 1988.

Table 2.2: Land Title and Land Use Rights in Thailand (1954-1990).

2.4 Forest Reserves Villages – The Study Sample

There are seven different types of land titles that can be owned in this region (Table 2.2). Of these, three types of land titles allow land to be used as collateral. I use this definition to define secure and insecure ownership of land. Nineteen percent of the observations in the study sample claimed that their residents had *secure* property rights even though *de jure* residents can possess only usufruct rights. Perceptions about land ownership are thus important in this area.

As Feder et al. (1988) and Gine (2004) also document that residents of villages that have been in existence for a long period of time are likely to believe that they have secure property rights to the land that they cultivate, even if they do not possess land title papers. Feder et al. claim that despite the fact that land title documents are missing, there is an active land market in this part of the country, further underscoring this perception of secure land rights. Gine, when examining a sample of 191 villages in North East Thailand and Central Thailand, finds that 40% of the households located in villages in Forest Reserve and Land Reform areas had titled land and only 20% of the households were landless. Another factor that has contributed to this belief of secure ownership is that most residents pay property taxes. Finally, widespread acknowledgement amongst Thai authorities, that the absence of property rights within Forest Reserves and the ambiguous nature of land titles is not conducive to investments in land, has led to many land titling programs that have attempted to delineate boundaries and 'clarify' and 're-clarify' the status of property rights, often resulting in much confusion. Frequently these changes of legislations have only taken place at administrative centers.

Presence (no. of years) -> Land Title*	No. of villages	1 pt.	2 pts.	3 pts	4 pts	5 pts	6 pts
Never secure	413	89	29	60	78	23	134
Secure once	89	**35**	7	7	4	3	33
Secure twice	46		**20**	5	6	0	15
Secure three times	32			**13**	8	4	7
Secure four times	33				**21**	1	11
Secure five times	21					**2**	19
Secure six times	36						**36**
	670	**124**	**56**	**85**	**117**	**33**	**255**

* Secure title to land implies, land can be used as collateral. These are responses of Village Headmen.
Source: Data provided by Thammasat University.

Table 2.3: Security of land title cross-referenced with Frequency of Presence, Forest Reserve Villages, Chiang Mai, 1986-96

An important implication of ambiguous land rights is that the difference in perceptions regarding property rights may be a source of heterogeneity in agricultural decisions. As Table 2.3 shows 413 villages (62%) in the dataset never had secure rights to village land, irrespective of the number of years they are present in the data set. In contrast, of the 255 villages that are present in the data set for all years, only 36 claim to have secure rights through-out the study period. For the remaining villages, the status of their land titles "flips" from year to year.

One possible explanation for this flipping behavior is that these Forest villages are located in the buffer zones of Forest Reserves, where ambiguous legislation is likely to create confusion regarding boundaries and hence about land use rights. This group of 257 villages has **'ambiguous property rights'** and constitutes 38% of the study sample. On the other hand, Forest villages that claim to have no secure rights consistently are likely to be located deep inside Forest Reserves, where changing Forest boundaries create no ambiguity. I use this division of the sample to divide the sample into two parts – those that have '**no secure property rights**' **(NPR villages)**, and those that have '**ambiguous property rights**' **(APR villages)**. Because of what this implies for their locations, I expect – although I cannot verify –the first group of villages (NPR villages) to be located far inside Forest Reserves, and, compared to villages with “ambiguous” property rights (APR villages), to be more remote and poorer.

In the next chapter I describe the study dataset and attributes of study villages.

3 Description of Study Data Set

"*…agricultural expansion in Thailand has always been through a process of forest clearing and settlement…*" (Feder et al. (1988))

3.1 Introduction

This chapter describes characteristics of the 670 study villages used in this dissertation. The data for the study are provided by Thammasat University, which has been regularly collecting biennial data on rural villages in Thailand since 1986. The data are collected for the National Economic and Social Development Board (NESDB). Data for the study are present for the years 1986, 1988, 1990, 1992 and 1996, for the province of Chiang Mai.

The chapter begins with a description of the study area, Chiang Mai province. This is followed by explaining how I constructed the data set for 670 Reserved Forest villages from a data set consisting of all villages in the province. Section 3.4 describes characteristics of Forest Reserve Villages. This is followed in Section 3.5 by a detailed description of agricultural practices in study villages.

One feature of the survey is that village headmen provide responses to questions and the survey records modal values of variables. Data are collected via questions such as: "What is the mode of transport *most* (popularly) used by households in the village?" or, "What is the method of sale for *most* households?" The data also answers questions such as "Average selling price of crop in baht per kilogram?" The disadvantage of village-level data is that micro-relationships cannot be modeled and shadow prices cannot be estimated. (See Annex 7.2 for a complete list of the questions and variables collected in the survey.)

3.2 The Survey Area

The Chiang Mai valley is the largest valley in North Thailand and covers 160,000 hectares (20,000 square kilometers). The topography of the area consists of high mountain ranges running in the north-south direction. Between the mountain ranges are narrow valleys. In 1986 it supported 100,000 agricultural households (Fox et al. (1995)). It contains important watersheds: the Ping, Wang, Yom, Na, Yuam, Moey, Kok, Lao and Wing rivers all rise here and are critical to the rice economy of the central plains. The region has a typical monsoon climate. The rainy season is from June to October, followed by a long dry season. About 70% of the wet season rice crop is irrigated by the Ping River and dry season irrigation is available for about 60% of the land. Of the upland area, about 34.2% is agricultural land while the rest are rivers and forests (Deitrich, (1988)).

In the next section I describe the construction of the study dataset.

3.3 Construction of the Dataset

The study dataset is a subset of a larger dataset collected by Thammasat University for the province of Chiang Mai.[20] The villages included in the study dataset all responded that they lay within Forest Reserves at least once during the years 1986, 1988, 1990, 1992, 1994 and 1996.

All villages in the dataset are registered villages i.e. villages have to be registered with the Village Directory of the Department of Local Administration (DOLA). However all villages do not always respond that they lie within Forest

[20] The larger dataset consists of 784 villages.

Reserves for all the years that they are surveyed. Columns in Table 3.1 show the response pattern of villages in the study dataset. Thus out of 117 villages that were present in the dataset four times, 73 said they were in Forest Reserves all 4 years; however 24 said they were in Forest Reserves for only 3 out of the 4 years and 20 said that they were in Forest Reserves for at most 2 out of 4 years. This is consistent with the notion that Forest Reserve boundaries are ambiguous.

The resulting panel dataset is unbalanced. Of the 670 villages that appear at least once in the dataset, 255 (38%) are present for all 6 years; in contrast, 124 villages are present for only one year. (See table 3.1. Rows in the table show the number of times villages appear in the dataset.) Although attrition in panel data is common – villages may chose to not participate in certain years or may not be asked to participate in certain years for several reasons (e.g. lack of resources with the survey agency) – it is important to understand the cause of attrition or selection. Missing observations in a panel data may not be randomly missing and, if so, estimators may be inconsistent. Ignoring attrition and using a balanced dataset, as is common practice, may lead to inconsistent estimates (See Heckman, (1976); Nijman and Verbeek, 1992)).

Table 3.2 shows the pattern of presence for villages in this dataset. (A note on interpretation: 1xx1xx means that a village is present in the first and fourth year of the study period. Since data started to be collected in 1986, this means that a village was part of the dataset in 1986 – the first year, and 1992 – the fourth year.) Villages that are surveyed and respond in all six years are the single largest group in the complete dataset. They account for 38% of the villages surveyed. The second largest group is the villages that occur only once. These constitute 18.5% of the villages. It is interesting to see that there are very few villages that are missing from the panel for two or more *consecutive* waves. I thus assume that villages that fail to respond to the survey for two or more consecutive years are dropped in subsequent years by the survey agency. However it may also be possible that villages that do not respond for two consecutive years are not included in subsequent years, because the village has moved or disbanded. Additionally, the village could simply have been inaccessible, because of, for instance, high elevation or weather. Thus a variety of reasons could explain why almost 19% of the villages in the study panel appear only once.

		Number of times a village is classified within a Forest Reserve						
		Once	**Two Times**	**Three Times**	**Four times**	**Five Times**	**Six Times**	**Total**
Total Number of Times a Village is present in the dataset	**1**	124						124
	2	17	39					56
	3	8	16	61				85
	4	1	19	24	73			117
	5				4	29		33
	6					91	164	255
Total no. of villages in 'forest reserves'		**150**	**74**	**85**	**77**	**120**	**164**	**670**

Source: Data provided by Thammasat University, Chiang Mai, Thailand.

Table 3.1: Frequency of Occurrence of Forest Reserve Villages, (1986-96)

Pattern of Presence	No. of Villages	Percentage of 670 villages
111111	255	38.1
xx**1111**	57	8.5
1111xx	16	2.4
x**11111**	15	2.2
11x**111**	11	1.6
11111x	5	0.7
1x**1111**	1	0.1
111x**11**	1	0.1
xxxxx**1**	77	11.5
xxx**111**	50	7.5
xxxx**1**x	29	4.3
11xxxx	27	4.0
xx**1111**	25	3.7
111xxx	24	3.6
xxxx**11**	17	2.5
1111xx	14	2.1
x**1**xxxx	7	1.0
11xxx**1**	7	1.0
xxx**1**xx	5	0.7
xx**11**xx	5	0.7
xxx**11**x	4	0.6
1xxxxx	4	0.6
xx**1**xxx	2	0.3
x**11**xxx	2	0.3
x**111**xx	2	0.3
xx**1**xx**1**	1	0.1
xx**111**x	1	0.1
x**1**x**11**x	1	0.1
x**1**x**111**	1	0.1
x**11**x**11**	1	0.1
x**1111**x	1	0.1
11xx**11**	1	0.1
111x**1**x	1	0.1
111111 (all Villages)	**670**	**100**

Source: Dataset provided by Thammasat University; Note: 'x' denotes village is not present; '1' denotes village is present. So xx11xx means village is present only in the third and fourth year of the dataset. Since data is collected biennially starting in 1986, this means the village is present in 1990 and 1992. The above table shows there are 2 such villages.

Table 3.2: Pattern of Presence of Forest Villages, Chiang Mai, Thailand, (1986-1996).

There is another problem that requires mentioning: During the study period, several tambons changed boundaries (mostly in the early 90s). Since the unique 8 digit village level identifier contains within it a 2 digit tambon identifier, this implies that during the study period, the same village could have a different identifying number. This problem is not restricted to tambons. During the study period, the number of amphoes in the province increased from 22 to 24. This indicates that there was re-drawing of boundaries of amphoes and tambons. Maps for the province are further testimony to this but since the precise location of villages included in the dataset is not known, it is not possible to determine which villages changed their village identifiers.

In the next sub-section I discuss some other features of the dataset.

3.3.1 Crop Data

The NRD2C survey questionnaire (hereafter called the 'Thammasat dataset' since it was provided by the University) asks the village headman to respond to the question "*What is the most popularly grown short run (long run) crop this year?*" For crops other than paddy rice, crop area, the number of households growing the crop and other attributes are recorded only for the short-run or long-run crop that is 'most popular'. This means no crop is tracked for all years, other than paddy rice, unless it is 'popular' *every* year. [21] Furthermore, crops are tracked in groups i.e. 'short run crops' or 'long run crops'. Thus there are a large number of villages every year that do not have data for soybean and upland rice even though these are the single most frequently grown short run crops and long run crops respectively (Table 3.3). Although other short run crops such as Maize, Groundnuts, Tobacco and vegetables

[21] Village headmen are also asked questions about "the *second* most important short (long) run crop" and the "*third* most important short (long) run crop". Data on these is scarcer.

etc., are grown, soybean is the single most grown ‘short run’ crop. [22] Similarly upland rice – a ‘long run crop’, is the single most grown crop by most study villages in the region although on average it is only grown by one-fourth of the villages in the sample. (See Annex 7.1 for details of the survey.)

One way to deal with this problem of scarce crop specific data is to examine crop groups as a whole – short run crops (which include soybean, maize, peanuts, tobacco and vegetables) and long run crops (which include upland rice, tea and tree crops). Other than the obvious question about how similar these crops are, discrepancies in the way data are collected do not allow this. Aggregate data for area devoted to short run-crops or long run crops indicate that missing values and zeroes were confounded (Tale 3.4). For these two crop groups, there are no villages recording area as ‘zero’ in 1986, 1994 and 1996. In these years however the number of villages showing crop area as ‘missing’ is much larger than the other years. To do away with problems of comparability of crops and confounded data records, I examine only three specific crops – paddy rice, soybean and upland rice (Table 3.5).

Table 3.5 also shows one important characteristic of available data. For data on area devoted to soybean and upland rice there are a large number of zeros. Thus, as the last row of Table 3.5 shows, there are 1118+849 +15 = 1982 observations for which soybean area is zero, and 672 for which soybean area is positive. Similarly for upland rice, there are 1673 + 284 + 16 =1973 observations for which upland rice is

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[22] I estimated a multinomial logit model to explain whether a village reported zero, positive or missing area for short-run crops. The results showed that being closer to markets, having a higher population, being closer to Chiang Mai, and having adequate water increased the probability that data were recorded as positive for short run crops as a whole compared to data being missing.

zero, and 681 observations for which area devoted to upland rice is positive. This has important repercussions for estimation models, discussed later.

3.3.2 Data on Prices of Crops

Related to problems with the data described above are additional problems with the way crop prices are recorded. Since prices are an important determinant of agricultural decisions, these problems deserve a special note. The first problem with the way prices are recorded is that the price for a crop is recorded only if the crop is grown. This makes it difficult to use prices to explain *why* a crop is grown and also to explain area devoted to a crop since the prices of substitutes and lagged prices are often not available. Secondly it is not clear whether prices are farm gate prices or market prices from the question asked in the survey questionnaire. For both these reasons, I use travel time as a proxy for prices with the maintained hypothesis that it is the main cause of variation in prices that farmers see at the farm gate, and that prices otherwise equalize due to arbitrage.

In the next section I describe the main attributes of the study villages.

3.4 Characteristics of Study Villages

Villages covered by the survey are distributed over 21 amphoes (districts) and 147 tambons (sub-districts). Respondents to the questionnaire were village headmen. On average, more than 60% of the respondents answered that the main occupation of residents was agriculture. In 1996, 20% responded that factory work had become the main occupation in their villages. Characteristics of villages are presented in Tables

3.6 and 3.7. T-statistics for differences between mean values of most variables are significantly different at the 10% level for the two groups of villages – those with ambiguous property rights (APR villages), and those with no secure property titles (NPR villages). The exception is agricultural land. There is no significant difference between average agricultural land between the two groups of villages.

Village area and agricultural land: On average, villages are 4,350 rais in area (or 696.6 hectares).[23] NPR villages are almost 1.4 times the size of APR villages. This is consistent with the hypothesis that the first group of villages is located in forest interiors and the second group, on the boundaries of Forest Reserves, where property rights may appear more secure. NPR villages grew in area by 2% during the study period, while APR villages on average did not. Although village sizes are significantly different between the two groups, agricultural land within these villages is not. Average agricultural land is 918 rais (or 147 hectares). Agricultural land in NPR villages grew significantly by 1.5% over the study period, while APR villages did not witness any change. Intensity of cultivation is also much higher on average in APR villages compared to NPR villages. Area devoted to paddy rice accounted for the largest percentage of cultivated area.

Population size: The average density of population in Forest Reserve villages is approximately 0.6 persons/hectare. This is less than the average density of population for all Thailand in 1985: 1 person per hectare (UN, (2005))[24]. APR

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[23] 1 rai = 0.16 hectare.

[24] http://www.unhabitat.org/habrdd/conditions/soeastasia/thailand.htm

villages are more densely populated than NPR villages: The ratio of population to land area is 0.85 persons/hectare in the first group, compared to nearly 0.45 persons/ hectare in villages with no secure rights. Again, this is expected, if villages with no secure rights are relatively remote. On the whole, villages in this area do not show any significant changes in population or area over time. Population within these villages grew by 0.4%, starting from an average number of approximately 600 people per village. In this context it is interesting to note that these villages have high dependency ratios: On average, only 42% of the village population is a productive adult (i.e. ages 18-50 years). The average household size in these villages is 4.8 persons per household, which is equal to the national average.

Asset ownership: The data also show that households are not very rich – on average only 7% of the households own small tractors and less than 1% own motorized carts. Inhabitants are not very oriented towards cattle rearing – four households own three cows on average. A very small percentage of population works off farm – less than 4% on average – and although this increases during the study period, the percentages remain small.

Transportation costs: Transportation costs are measured using a variety of indicators: On average, villages are located a little more than an hour away from the nearest market but NPR villages are significantly further away from markets than APR villages. Travel time to market reduces slightly during the study period (1.7%

during the study period), but most of this decrease occurs in APR villages.[25] Similarly, villages are located almost an hour and a half away from administrative centers and this falls during 1986-96 (by 1.8%) and most of this decrease is seen in APR villages. I hypothesize that the decrease in travel time may be brought about by a change in mode of transport, or a change in road quality or a change in the number of roads going through the village. 89% of the villages in the dataset had a road going from the village to the district or to the market at the start of the study period (1986). 91% of the villages had a road going to a district center or a market at the end of the study period (1996). This implies that there was not much road building during this period.[26] (There could be maintenance or widening.)

To summarize, Tables 3.6 and 3.7 show that on average, compared to APR villages, NPR villages were larger, cultivated land less intensively, had less area devoted to paddy rice, had three times the area devoted to upland rice, had more cows per household, and were much more remote. Inhabitants were also poorer, much less literate and were much less likely to use credit from the BAAC or grow HYV rice.

[25] Adjusted R-square for fixed effects regression including village level village effects, time trend and time trend interacted with NPR dummy is 0.78. The regression is significant: F-statistic (2, 1740) = 5.97; Prob>F = 0.002.

[26] There are data on the kilometers of asphalted road (surfaced road) and kilometers of dirt road for every village. But these are aggregate numbers for *all* routes from that village and there is no way to verify what changes are occurring in the most commonly used route, or indeed, whether the same route is being compared year after year.

3.5 Agricultural Practices within Forest Reserve Villages

Table 3.8 shows the number of villages growing the three crops, viz., soybean, upland rice and paddy rice, and the average number of households per village that grew these crops. A few things of note are as follows:

The percentage of villages growing upland rice grew quite quickly from less than a percent of the villages at the start of the study period, to almost a third of the total villages in 1996. *Within* these villages, on average, more than half of the households grew upland rice; there is not much variance in this percentage. (The within-villages standard deviation for percentage of households growing upland rice is 14.5. This is less than one-fourth the average percentage of households growing upland rice for the pooled data.) However there is large variation in the area devoted to upland rice within villages, across years. (The within-village standard deviation for average area devoted to upland rice is 128.2 compared to the pooled average of 57 rais). The data also indicate that there is a significant increase in the average area devoted to upland rice, across villages. A village level fixed effects regression of the log of area devoted to upland rice on a time trend shows an increase of 14% in area during the ten year period (T-stat = 13.02).[27]

During the same period, on average, more than one-fourth of the villages in the study sample grew soybeans. In contrast to upland rice, this figure remains fairly constant. A fixed effects regression with percentage of households growing soybean as the dependent variable and a time trend, shows that the percentage of households growing

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[27] The adjusted R-square for this regression with village level dummies is 0.38; F statistic, (degrees of freedom = 1, 1893) is 169.6, showing that the regression is significant.

soybean within villages decreased during the study period. Average soybean area per village however grew relatively modestly by 4.0% for all villages during the study period.

Paddy rice is grown by almost all villages in the study sample. In 1986, about three-fifths of the households *within* these villages grew paddy. By the end of the study period, this figure had reduced to half. The data also show that the area per village devoted to paddy rice decreased at the rate of 4% during the study period.[28]

Some other facts are important to note: First, villages do not specialize in just one crop. The data show that households in Reserved Forest double crop. Although the proportion of households in villages that grow upland rice remains almost constant over the 10 year period, more and more villages adopted upland rice after 1988, and, in the first half of the panel period, area devoted to upland rice per village has a significant upward trend. Table 3.9 shows the number of villages that multiple crop in the study sample. The table also shows that very few villages grow all three crops. Paddy rice and soybean are grown by almost one-fifth of villages, but this percentage falls.[29]

This discussion suggests that both upland rice and short run crops may be contributing to the expansion of agricultural land which occurred within study villages. More importantly, for this ecologically fragile and important part of the region, fallow land decreased significantly during this period as shown by the percentage of villages in

[28] Village level fixed effects regression with time trend; Adjusted R-square=0.74; Observations=2563; F-stat(1,1893)= 51.94, Prob>F=0.000)

[29] The statistic in Table 3.9 will change if "double crop" means growing *any* short run crop and paddy or *any* long run crop and paddy.

different fallow land categories. This shows that despite the reduction in area devoted to paddy rice, there was increased pressure on agricultural land during this decade. The extent to which this expansion was influenced by population changes and transport costs and other variables is thus important. This is the topic of the next chapter.

Year	Soy (%)	Corn (%)	Groundn ut (%)	Tobacco (%)	Other (%)	Total # of villages Responding*
1986	33.1	22.3	15.1	6.0	23.5	251 of 367
1988	43.0	17.8	15.5	3.1	20.5	258 of 392
1990	47.5	18.0	9.4	5.9	19.2	255 of 429
1992	47.6	9.6	5.9	9.2	27.7	271 of 469
1994	54.4	15.6	8.9	0.8	20.3	237 of 477
1996	43.2	12.1	6.1	1.1	37.5	264 of 520

Note: *These include villages that do not give any response for the area question but give a response to whether they grow the crop at all. Source: Dataset provided by Thammasat University

Table 3.3: Main Short Run Crops grown In Forest Villages, Chiang Mai, Thailand, 1986-1996. [30]

Year	Short Run crop Area (=0 & Missing)	Short run crop area is Positive	Total no. Of villages
1986	130 (130 & **0**)	237	367
1988	133 (28 & 105)	259	392
1990	175 (71 & 104)	254	429
1992	199 (116 & 83)	270	469
1994	246 (246 & **0**)	231	477
1996	250 (249 & **1**)	270	520
Total	1133 (840 & 293)	1521	2654

Note: Figures are for respondents who provide positive responses to the area question. Source: Data provided by Thammasat University.

Table 3.4: Patterns of data and Confounding of data in the Study Dataset

[30] An average of 110 villages per year respond that they grow another short run crop, with 'second most frequency'. But all villages that report a second most frequently grown crop, report a first most frequently grown crop. It is assumed thus that villages grow their second most popular short run crop on the same area as their most popular short run crop.

Year	No. of villages	No. of villages growing paddy			No. of villages growing Short Run Crops				No. of villages growing Long Run Crops			
Data Availability ->					Crop data missing	Growing something else	Growing soy		Crop data is missing	Growing something else	Growing upland rice	
		Missing	Zero	Positive			Zero	Positive			Zero	Positive
1986	367	28	0	339	116	168	6	77	313	53	0	1
1988	392	1	33	358	134	147	1	110	279	63	0	50
1990	429	1	37	391	174	134	1	120	261	44	3	121
1992	469	6	36	427	198	142	3	126	257	38	2	172
1994	477	40	6	431	240	108	3	126	260	41	2	174
1996	520	15	49	456	256	150	1	113	303	45	9	163
Total	*2654*	*91*	*161*	*2402*	*1118*	*849*	*15*	*672*	*1673*	*284*	*16*	*681*

Source: Data provided by Thammasat University, Thailand.

Table 3.5: Data Patterns for Forest Reserve Villages, Chiang Mai, 1986-96.

	All Sample			APR Villages			NPR Villages		
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev**
Population	2573	568.96	365.7	1067	597.8	354.7	1506	548.5	372
Village area (Rais)	2277	4354.2	6188.6	987	3561.5	5123.1	1290	4960.6	6833.6
Agricultural land (Rais)	2382	917.6	1085.4	999	945.15	917.1	1383	897.7	1192.2
Paddy rice area (Rais)	2563	279.6	292.4	1073	310.5	289.9	1490	257.2	292.3
Soybean area (Rais)	2654	41.9	143.8	1096	58.8	137.5	1558	29.9	147.1
Area devoted to upland rice (Rais)	2654	57.1	209.4	1096	23.3	98.7	1558	80.8	257.8
% villages with less than 10% fallow land	2614	17.8		1081	24.6		1533	13.1	
% villages with more than 50% fallow land	2614	27.1		1081	18.0		1533	33.6	
Assets									
Avg. no. of cows per household	2586	0.82	2.25	1073	0.46	1.53	1513	1.072	2.62
Avg. Proportion hhs owning small tractors	2586	0.07	0.10	1073	0.09	0.11	1513	0.054	0.095
Avg. Proportion hhs owning motor carts	2651	0.002	0.02	1095	0.003	0.02	1556	0.001	0.02
% of hhs working outside tambon	2037	3.6	6.2	994	4.54	7.6	1043	2.7	4.2
Access Variables									
Avg. One way travel time to mkt. (mins.)	2408	70.6	66.4	1075	42.52	39.53	1333	93.21	74.5
Avg. One way travel time to district (mins.)	2509	83.2	90.4	1091	45.47	34.67	1418	112.23	107.8
Avg. proportion. Hhs owning motor bikes	2466	0.26	0.23	1064	0.38	0.24	1402	0.16	0.18
Proportion of literate population	2487	0.41	0.28	1058	0.54	0.23	1429	0.32	0.28
Avg. proportion of hhs with electricity	2586	0.49	0.43	1073	0.72	0.34	1530	0.32	0.41
Inputs									
Proportion of Adults	2573	0.42	0.13	1067	0.45	0.12	1506	0.39	0.13
% villages using HYV rice	2654	71.6		1096	92.2		1558	57.1	
% villages w/ sufficient (SR) Water	2644	25.9	44	1094	32.5	47	1550	21.2	41
% villages w/ sufficient (LR) Water	2632	11.4	31.7	1087	9.6	29	1545	12.6	33
% villages that use BAAC credit	2650	43.7	49.6	1096	71	46	1554	25	43

Note: APR Villages: Villages with Ambiguous Property Rights; NPR: Villages with No secure Property Rights; Source: Data provided by Thammasat University, Thailand.

Table 3.6: Basic Characteristics of Villages located in Forest Reserves, Chiang Mai (1986-1996), Pooled Dataset.

All Sample				APR Villages			NPR Villages		
Year	Mean	S. Dev.	Obs.	Mean	S. Dev.	Obs.	Mean	S. Dev.	Obs.
Population									
1986	597.1	379.3	357	632.5	369.7	166	566.4	385.8	191
1996	544.4	338.7	501	583.8	335.0	193	519.7	339.1	308
Village Area (rais)									
1986	4736.7	7209.9	269	3825.4	5785.1	143	5770.9	8450.1	126
1996	4347.8	5726.7	462	3273.1	4478.4	181	5040.0	6314.5	281
Agricultural Land (Rais)									
1986	788.6	699.5	299	812.7	763.2	151	764.1	629.5	148
1996	1066.5	1803.9	473	963.5	1075.9	182	1130.9	2136.2	291
Paddy rice area per village (Rais)									
1986	340.2	328.4	339	361.8	339.9	164	319.9	316.8	175
1996	250.4	297.2	505	265.4	262.8	197	240.8	317.3	308
Area devoted to upland rice per village (Rais)									
1986	0.21	4.0	367	0	0	171	0.39	5.5	196
1996	51.8	192.0	520	20.7	76.9	199	71.1	234.9	321
Area devoted to soybean per village (Rais)									
1986	28.25	102.2	367	37.7	99.8	171	20.0	103.7	196
1996	33.9	113.0	520	57.7	135.3	199	19.1	93.9	321
Percentage village with less than 10% fallow land (of agricultural land)									
1986	17.8		359	25		168	11.5		191
1996	15.2		508	18.0		195	13.4		313
Percentage villages with more than 50% fallow land (of agr'l land)									
1986	32.3		359	14.9		168	47.6		191
1996	22.6		508	16.9		195	26.2		313
Number of cows per household									
1986	0.68	1.2	350	0.35	0.92	165	0.98	1.4	185
1996	0.96	2.3	506	0.64	2.7	197	1.2	2.1	309
Proportion of households owning small tractors									
1986	0.035	0.066	350	0.05	0.08	165	0.019	0.05	185
1996	0.09	0.13	506	0.12	0.14	197	0.07	0.11	309
Proportion of households that own Motorized Carts									

1986	0.002	0.03	367	0.004	0.04	171	0.000267	0.001952	196
1996	0.003	0.015	519	0.004	0.015	199	0.002026	0.015986	320
Proportion of people working outside the tambon									
1986	2.7	5.0	212	2.7	5.6	133	2.7	3.8	79
1996	4.8	7.0	388	6.0	8.5	182	3.8	5.1	206
One way time of travel to nearest market using fastest route possible by the most popular mode									
1986	71.4	62.7	321	45.5	41.1	166	99.2	69.7	155
1996	69.5	66.2	480	36.9	33.1	196	92.0	73.7	284
One way time of travel to nearest district administrative center using fastest route possible by the most popular mode									
1986	84.5	79.9	330	51.3	37.2	169	119.4	96.3	161
1996	83.3	97.5	497	37.7	28.3	198	113.6	114.0	299
Proportion of households that own motorcycles									
1986	0.19	0.16	284	0.25	0.16	159	0.11	0.11	125
1996	0.35	0.27	497	0.54	0.25	196	0.23	0.21	301
Proportion of population that is literate									
1986	0.45	0.28	315	0.55	0.23	163	0.34	0.28	152
1996	0.36	0.29	492	0.51	0.24	188	0.27	0.28	304
Proportion of households that have electricity									
1986	0.29	0.38	350	0.47	0.40	165	0.13	0.29	185
1996	0.59	0.44	506	0.88	0.24	197	0.41	0.44	309
Proportion of adults (aged 18-50) in the population									
1986	0.28	0.09	357	0.30	0.09	166	0.25	0.08	191
1996	0.46	0.11	501	0.51	0.07	193	0.44	0.11	308
Percentage of villages growing HYV rice									
1986	76.0		367	92.4		171	61.7		196
1996	65.4		520	89.9		199	50.2		321
Proportion of villages in the sample for which water is sufficient for short run crops									
1986	0.36	0.48	367	0.43	0.50	171	0.30	0.46	196
1996	0.26	0.44	513	0.35	0.48	197	0.20	0.40	316
Proportion of villages in the sample for which water is sufficient for long run crops									
1986	0.1	0.29	366	0.09	0.28	171	0.11	0.31	195
1996	0.17	0.37	509	0.14	0.35	194	0.18	0.38	315
Proportion of villages that have households that use credit from the BAAC									

1986	0.33	0.47	367	0.58	0.50	171	0.12	0.33	196
1996	0.57	0.49	517	0.84	0.37	199	0.41	0.49	318

Note: APR Villages: Villages with Ambiguous Property Rights; NPR: Villages with No secure Property Rights; Source: Data provided by Thammasat University, Thailand;

Table 3.7: Basic Characteristics of Villages located in Forest Reserves, Thammasat Dataset (1986 and 1996)

		1986	1988	1990	1992	1994	1996	Total
soybean	% villages growing	21	28.1	28	26.9	26.4	21.7	25.3
	Avg. % of hhs per village	44.7 (29.3)	40 (25.7)	44.1 (26.2)	41.8 (27.2)	42.5 (28.4)	43.1 (23.4)	42.6 (26.6)
						Std. Dev.	Between Within	(23.43) (13.7)
	Avg. area per village (rais)	28.3 (102.2)	46.7 (174.5)	51.3 (168.9)	46.3 (153.1)	44.2 (139.1)	33.9 (113.9)	41.9 (143.9)**
						Std. Dev.	Between Within	(100.2) (78.8)
upland rice	% villages growing	0.3	12.8	28.2	36.7	36.5	31.3	25.7
	Avg. % of hhs per village	94.4 (0)	56.6 (32.7)	62.8 (31.6)	57.3 (31.2)	59.7 (30.5)	55.8 (32.1)	58.5 (31.4)
						Std. Dev.	Between Within	(29.3) (14.5)
	Avg. area per village (rais)	0.21 (4)	22.5 (105)	69.9 (201.2)	83.3 (255)	97.5 (297.9)	51.9 (192.1)	57.1 (209.4)**
						Std. Dev.	Between Within	(149.3) (128.2)
paddy rice	% villages growing	92.4	91.3	91.1	91.0	90.4	87.7	90.5
	Avg. % of hhs per Village	61.4 (33.2)	54.9 (35.9)	52.1 (35.8)	52.7 (36)	57.3 (33.7)	51.5 (36.2)	54.6 (35.4)
						Std. Dev.	Between Within	(31.3) (18)
	Avg. area per village (rais)	340.2 (328.4)	292 (306.9)	279 (284.3)	259.8 (264.8)	276.7 (273.4)	250.4 (297.2)	279.6 (292.4)**
						Std. Dev.	Between Within	(308.7) (147.6)
	Total Villages	**367**	**392**	**429**	**469**	**477**	**520**	**2654**

**Standard deviations for pooled data in brackets; * Is for households in 83, 110, 120, 122, 127, 111 villages for the six points in time respectively.

Table 3.8: Percentage of Study Villages growing different crops, Thammasat Data, Chiang Mai province (1986-96)

Year	1986	1988	1990	1992	1994	1996
No crop at all	**0**	**6.6**	**6.8**	**5.1**	**0.8**	**6.7**
One crop	**78.8**	**57.1**	**45.2**	**41.6**	**44.4**	**48.1**
Only paddy	78.7	55.3	43.4	39.1	44.4	45.9
Only soybean	0	0.5	0.2	0.2	0.2	0
Only upland rice	0	1.3	1.6	2.3	0.2	2.1
Two crops only	**21.2**	**33.4**	**41.7**	**45.6**	**47.0**	**40**
Paddy rice & soy	21.0	24.7	21.4	19.0	18.5	16.0
Paddy rice and upland	0.3	8.6	20.3	26.6	28.5	23.5
Soy and upland rice	0	0	0	0	0	0.5
Three crops	**0**	**2.8**	**6.3**	**7.7**	**7.8**	**5.2**
Number of villages	367	392	429	469	477	520

Note: Figures are for respondents who provide positive responses to the area question. Source: Data provided by Thammasat University.

Table 3.9: Percentage of Villages growing different Crops, Forest Villages, Thailand, 1986-96.

4 Econometric Issues

4.1 Introduction

In this chapter I describe the econometric model that I use for estimating crop area equations. The first part of the chapter describes the reduced form model I estimate and the expected impacts of explanatory variables. The second part of the chapter describes some of the econometric problems that arise while estimating these reduced form models. The chapter concludes by describing the individual crop equation systems.

For modeling crop choice and crop area, I estimate the following reduced form equation for the three crops *i* =paddy rice, upland rice, soybean; for *j* = 1,…,n (villages); *t* = 1986, 1988, 1990, 1992, 1994, 1996.

Log (Land devoted to crop *i* by village *j* in year *t*)= f(P_{jt}, T_{jt} , W_{jit}, G_{it}, $N_{it,}$ $L_{it\,,}$ A_{it}, t)

Where

P_{jt} : Population of village *j* at time *t*

T_{jt} : Time taken to travel by most favored mode from village *j* to the market at time *t*

$A_{jt:}$ Proportion of adults in village *j* at time *t*

W_{jit} : Availability of water in village *j* at time *t* for crop *i*

G_{jt} : Use of credit in village *j* at time *t*

N_{jt} : Land productivity in village *j* at time *t*

L_{jt}: Status of property rights in village *j* at time *t*

t : time trend

The three dependent variables are logarithms of area devoted to paddy rice, area devoted to soybean and area devoted to upland rice. I estimate these using random effects models. In the case of soybean and upland rice, I estimate a random effects Tobit equation, since the data are truncated at zero, with a considerable mass (probability distribution not shown here). I also estimate reduced form equations for agricultural land in the village and intensity of cultivation, using the same variables.

A few things are of note here: Firstly, credit use, as it is measured is endogenous to agricultural decisions. I thus estimate the equations for crop area and credit use simultaneously. Secondly, I do not estimate share equations for crop area — although soybean, paddy rice and upland rice are the main crops, they are not the only crops grown in a village. Additionally, agricultural area is not fixed in a village. Village boundaries and areas are ill-defined and farmers routinely squat on land. Thirdly, I do not estimate crop areas for the three crops as a system of equations. Estimating these crop equations as a system of equations would mean efficiency gains since they would account for contemporaneous correlation between error terms across equations. However I use different modeling techniques for the three crop areas. For paddy rice, I estimate a Random Effects Instrumental variables specification. For soybean and upland rice, I estimate Random Effects Tobit equations. To account for credit use being endogenous, I use a two-step procedure for the latter: a reduced form credit equation is estimated in the first stage using a random effects probit model. Predicted values from this equation are used to instrument for credit use in the crop area equations (the second stage). To correct standard errors in the second stage equation, I bootstrap standard errors. Ignoring contemporaneous correlation between error terms across crop area equations reduces the efficiency of estimates but this does not bias results. [31]

Finally, to measure the impact of population and transport costs on agricultural decisions, I also estimate equations on Intensity of Cultivation and total agricultural land using the same explanatory variables.

4.2 Expected Impact and Explanation of Variables used in Reduced Model

This section discusses the expected impact of explanatory variables in the empirical model:

Village population: Village population is expected to have two effects. The first is a scale effect: A larger number of households is expected to increase the demand for agricultural land. The second effect is the 'food' (or subsistence) effect. Demand for agricultural land is a derived demand. A larger population also means larger subsistence requirements. The subsistence effect is likely to be stronger for food crops in villages located far from the market. Furthermore, if villages are remote, access to markets is

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[31] Note that in equations above, wage is not included. Data for wages are not collected for two of the six years. Further, like data for prices, it is not clear if these are market wages or if these are wages earned in the village. There is very little data on labor markets in the area. Although there does seem to be employment-related seasonal migration, the survey does not have data on it. Furthermore, in the absence of market prices, I assume that market prices are similar for villages in the sample (This is reasonable. Government support in the agricultural sector is extensive. See appendix 7.3.) The only source of variation in farmgate prices is assumed to emanate from differences in transportation costs. Thus transportation costs are used as a proxy for market prices and wages.

difficult and subsistence needs of the village population are expected to be met by village production of food crops. Both these effects are in the same direction.

Travel time to market: The variable used measures the "average time taken one way, in minutes, to reach the market, using the most popular mode of transport." It thus takes into consideration mode of transportation and road quality (see for example Dawson and Barwell (1993)). Travel time to the market is used as a measure of cost of transporting crops to the market and inputs from the market. Additionally, I expect that farmers that are located far from the market exercise less leverage in getting the best farmgate price for their produce; are unable to spend much time searching for best bargains; are less willing to carry their produce back if a transaction does not go through; and, are likely to have limited access to information about markets. When farmers sell their produce to market intermediaries, the latter are more likely to exploit the lack of leverage caused by high travel times (Minten and Kyle, (1999)). Thus travel time is also a proxy for search costs, bargaining costs and, generally, costs of not being located *in situ*. Thus, for crops that are produced for the market – such as soybean – travel time is likely to have a negative effect on the probability that they are produced and on the amount of land area devoted to them. To the extent that upland rice and paddy rice are grown for subsistence, this effect is expected to be insignificant. Moreover, if the only reason that the crop is grown is that it is a substitute for a staple that can be bought in the market, then the travel time coefficient is likely to be positive.

Proportion of Adult population: The proportion of adult population is used as a proxy for available labor in the village and for the opportunity cost of labor. The proportion of adults in the village is expected to positively affect land brought under cultivation and the intensity with which it is cultivated. Adult labor is required to grow crops on virgin land that requires preparation (See Godoy et al. (1997) for a similar argument).[32] The presence of more adults is likely to increase the amount of land cultivated and ameliorate labor scarcity. (I also considered using the proportion of population of the village that works outside the tambon to measure the proportion of village population not available to work as labor on-farm. However the variable is ambiguously defined in the dataset. It is also not clear if the labor migrates to work off-farm seasonally or for the year.)

Productivity of Land: There are two dummy variables I use to measure land productivity. These are water availability and a dummy for acidic soil. Another possible variable is yield per acre but there are problems with measuring the variable since it is measured only when crop data are available. It is also potentially endogenous. [33] To model the area devoted to paddy rice I also use a time invariant dummy – HYV rice dummy – to indicate whether the village grew HYV rice at any time during the study period. HYV rice dummy =1 if the village *ever* grew HYV rice during the study period, and =0 otherwise. I expect this variable to have two impacts. The first is on paddy rice area. HYV rice is more resilient than non-HYV rice. It can thus be grown on land

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[32] It would be useful to gauge the different impacts of adult males and adult females.

[33] For example for upland rice yield/hectare is available only for 541 observations, or 248 villages for at least one point in time. For the subset of variables for which data are available: For soybean, there is a positive time trend when the log of productivity is regressed on year, while controlling for other variables (~3%). when I regress this variable for soybean on time dummies, the time dummies are insignificant (and indeed in the first two years, negative, compared to 1986. They are positive in the next two years but insignificant. Only in 1996 is the time dummy significant and positive – when an average increase of almost 30% occurs). Similarly for upland rice, the time trend is not significant or large (although it is positive). This indicates that there were not very many productivity increases among farmers located in Forest Reserve villages of Chiang Mai, during 1986-1996, although some may have taken place in the last

otherwise unsuited to non-HYV rice. I expect it to have a positive effect on area devoted to paddy rice. The other effect I expect to capture is that of 'attention' from local authorities. To the extent that growing HYV rice requires additional knowledge and training provided by field officers and that the government has been encouraging the cultivation of HYV rice, mostly via the BAAC, the dummy is expected to be positively correlated with BAAC presence. Thus the variable is used as an instrument in the BAAC credit use equations.

Water presence: A measure of the availability of water is used as a proxy for productivity of land. In this analysis, presence of water is measured by the response to the question "*Did this village have sufficient water to grow short run (long run) crops?*" The dummy variable is equal to 1 if there is sufficient water and is zero otherwise. Irrigation is usually provided by rain and, to a lesser extent, by small man-made weirs and canals (ASB, (2004)). Scarcity of water is an important resource constraint in this region. Walker (2002), in a detailed study of the Mae Uam catchment area of the Mae Chaem district of Chiang Mai, finds that even cultivation of dry-season varieties of soybean, which requires relatively less water, has reached its hydrological limit. Dry season varieties of soybean (typically grown in the region) and upland rice are crops that require little water. Although upland rice requires rainfall, it does not require standing water like paddy rice does. Paddy rice requires a lot of water to grow. I thus expect a positive and significant sign for water in rice area equations.

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year of the study period, for soybean. Witnessing an increase in area despite there being an increase in productivity, further strengthen my results.

Acidic soil: The other variable used to measure the productivity of land is an indicator for acidity of soil. It is recorded as 1 if soil within a village suffers from high acidity, and 0 otherwise. Exogenous increases in productivity are measured via the time trend variable. Acidity of soil is an undesirable quality. I expect the variable to have a negative coefficient.

Perceptions of Land Ownership: I use a dummy variable, which is equal to 1 if the village headman responds that "secure land titles were held by *most* farmers in the village". Secure land titles are defined as titles that allow land to be used as collateral or sold. From table 2.2, villages that respond that the most common title held is No-So-4, No-So-3 or the No-So-3-Ko, have secure titles. I expect that farmers who have secure land titles will be more willing to invest in land and grow cash crops. This variable is a village level constant, un-varying over time.

Credit use: is expected to increase the intensity of cultivation. The variable used to indicate use of credit in this study is '*Do villagers use credit from the BAAC'*. This variable equals 1 if people in the village use credit from the Bank of Agriculture and Agricultural Credit, and 0 otherwise. The BAAC is the lender of first resort in most of these villages, since it provides relatively low interest credit. Credit obtained from the BAAC is mainly for agriculture, unlike credit provided by private money lenders. Clearly, credit use is endogenous. I discuss this problem in more detail in the next section.[34]

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[34] One reviewer suggests the use of a BAAC credit dummy which is =1 for the year that a village starts using BAAC credit and then, irrespective of response, is coded =1, for all years thereafter. The object here is to measure the use of credit and not so much the availability of credit.

4.3 Econometric Issues/Problems

4.3.1 Endogeniety of Credit Use

Credit use is measured by responses to the question "(In the village) *Do villagers use credit from BAAC*". The response is recorded as a yes (response =1) or no (response =0). This question is asked for a variety of other credit sources also – 'Farmers' Savings Group', Cooperatives, Commercial Banks, Private credit institutions, Revolving loan funds (instituted by the Government), Businessmen and merchants, and others. The percentage of villages that use these sources of credit are shown in Table 4.1.

Table 4.1 shows that within the group of study villages, loans are most commonly taken from either the BAAC or cooperatives (which are supported by the BAAC)[35]. I only study credit taken from the BAAC, because other sources of credit can also be used for non-agricultural purposes. Credit from the BAAC can only be used for agricultural purposes.[36]

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[35] There are two kinds of cooperatives in the region. The first are being phased out by the government because of lack of capacity and fraudulent activities. The second are actively promoted by the BAAC. Indeed use of cooperatives and BAAC, are highly correlated amongst the study villages. Only 11% of the observations have cooperative presence but not BAAC presence.

[36] There is very little 'leakage' in this, since i) the BAAC has a wide network of field offices; ii) Reputation matters. Field officers use previous action on a loan to give subsequent loans.

Year	1986	1988	1990	1992	1994	1996	Total
Farmers' Saving Group	7.6	7.2	7.0	6.4	7.8	10.2	7.8
Cooperatives	32.2	32.6	33.7	39.5	40.0	43.5	37.4
BAAC	33.5	39.0	38.7	41.0	47.4	57.5	43.7
Commercial Banks	9.0	10.8	10.8	18.3	18.7	21.7	15.5
Private credit institution	Na	Na	Na	0	0	0.9	0.4
Govt. Revolving Loan Fund	0	0	0	0.9	5.6	27.1	6.4
Businessmen/ merchants	19.6	19.2	15.4	15.1	21.8	25.9	19.7
Others	13.6	13.6	11.4	7.8	9.5	12.9	11.3
Total no. of villages	**367**	**392**	**429**	**469**	**477**	**520**	

Source: Data provided by Thammasat University; Na: Data was not collected for that year; *Data in percentages except where noted.

Table 4.1: Percentage of Forest Villages using Credit from different Sources, Chiang Mai, Thailand (1986-1996)

	Use credit from BAAC	Do not use credit from BAAC	Total
Use credit from BAAC	84.6%	15.4%	100%
Do not use credit from BAAC	7.6%	92.4%	100%
Average	54.1%	45.9%	100%

Source: Data provided by Thammasat University, Chiang Mai, Thailand.

Table 4.2: (Non-Markov) Transition Probabilities for Use of Credit from the BAAC in Forest Villages, Chiang Mai, (1986-96)

Table 4.2 shows that during the study period, villages that start to use BAAC as a credit supplier rarely stop using it in subsequent years. Furthermore 8% of the observations that do not use BAAC credit in a certain year, switch to using it, in a subsequent year, reflecting perhaps increased coverage by the BAAC field office network.

To borrow from the BAAC, farmers have to establish that the loaned amount will be used for agricultural purposes. Farmers must then present a loan application to the business development officer at their local BAAC district field office, who also assists farmers in preparing this document. The BAAC currently charges an average annual interest rate of 11%.[37] Farmers who rent land or own land but do not have ownership documents are eligible for borrowing from the BAAC but loans have to be secured by personal guarantee or a 'joint liability contract' (or 'group loans' – which have become very popular) with other borrowers.[38] BAAC documents reveal that most BAAC borrowers do not use land as loan security (Feder et al. (1988); Gine (2004); Bhisalbutra (1984)) [39]. This implies that for my dataset, villages that have ambiguous property rights (APR villages) and villages that have no secure property rights (NPR villages) should use the BAAC equally, and should have equal access to its services.

Inclusion of the BAAC dummy introduces problems in estimation. Ideally it is credit availability rather than credit use that one would want to include in the model. The BAAC variable signals whether inhabitants of a village used BAAC credit or not. This binary event will be affected by two things: whether BAAC credit is readily available in the village and whether farmers demand such credit. The first is likely to be exogenous in the sense that BAAC offices are located in district offices and field officer and offices are

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[37] Till 1986 the BAAC's interest rate structure was based on loan size. Using the principle of cross-subsidization, larger loans were charged higher interest rates than smaller loans. The rate of interest varied with the Bank's average cost of funds combined with its operation costs per year. However the BAAC was restructured in the 80s. Since then it charges a fixed minimum rate plus a risk premium not exceeding 3% based mainly on debtor quality classification. Present interest rates are as follows: 9% per year for clients with an excellent record of debt repayment and no overdue debts for 3 consecutive years; 10% for clients with a very good record and no overdue debts for 2 years; 11% per year for clients with a good record and no over due debts for 1 year; 12% for new or original clients with over due debts and late payment in full; 13% for clients with over due debts incurred from causes that qualify for a waiver of penalties; 15% per year for clients with over due debts incurred from causes that do not qualify for a waiver of penalties. (BAAC regulation documents, http://www.baac.or.th/eng_baac/about/porobor/baac_act.htm)

[38] Several studies have established that neighborhood or peer group effects can help farmers in the same village en masse to adopt innovations and new technology (See Case (1991); Southgate and Whitaker (1992), Moran (1993); Ledec and Goodland (1998); Southgate (1991)).

[39] Feder et al. (1988) present a disequilibrium model for institutional credit. In their model, credit demand and supply are modeled separately.

spread out according to BAAC policies. However, BAAC use is also affected by farmers' demand for credit, making the BAAC variable endogenous. To summarize, endogeniety of BAAC credit use occurs as follows: Firstly, factors affecting agricultural decisions are likely to influence the demand for credit. The error terms for both equations are likely to be correlated; Secondly: Credit use is likely to be correlated with the omitted variable in the cultivation equation namely productivity, since credit provided by the BAAC can be used to purchase fertilizers and machinery. To understand the use of credit, as provided by the BAAC, it is important to understand the factors that affect its supply and demand.

To understand the role of credit from BAAC, I estimate a reduced form equation for the BAAC credit use variable. Other than the variables that are included in the crop area equations, I use three identifying instruments in the equilibrium equation for BAAC credit use. The first variable that I include is '*the proportion of people in the village that have completed compulsory education*'. Compulsory education in Thailand is provided free by the Thai Government for the first nine years, of which the first six are considered primary, and the rest three are part of secondary level education.[40] There are other education related variables in the survey that could serve, potentially, as identifying instruments. These include 'proportion of the population in the village with high school

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[40] A compulsory education law was passed in Thailand in 1921. It is well documented that although the Government is well intentioned, compulsory education is not used by all. This is either because of relatively uneven coverage of government resources in "outlying provinces" of which Chiang Mai is one, or, because of low propensity of families to send their children to school after they complete their primary education. Primary level schools are especially affected by this uneveness while secondary level education has remained concentrated in major towns. A report on the state of education contends "In the mid-1970s Bangkok with 10 percent of the country's population, had 45% of the secondary school poulation, while the North and the Northeast combined, with 55% of the nation's population, had only 26% of these students...In the late 1980s, the underlying problem of inequitable distribution of funds between the Center and the outlying provinces remained."(http://countrystudies.us/thailand/59.htm). Other than coverage, related studies also report that most children do not attend school after finishing their primary school,

education' and, 'proportion of the population in the village with more than high school education'. The first variable is not measured for all years. The second variable suffers from the drawback that it is also likely to measure the non-agricultural propensity of the population and is a weak instrument.

Since BAAC district offices are located at district centers, the second identifying variable is travel time to the district center. I expect use of BAAC credit to be negatively correlated with this travel measure. Loans from the BAAC are processed at the district offices. In non-rice area equations the third identifying instrument is a dummy variable that measures whether the village population ever used HYV rice. This village level, time invariant dummy, is equal to 1 if the village ever grew HYV rice, and =0 otherwise. It measures whether the village was visited by field officers and administrative officers and measures if the village has the attention of local authorities. The variable is not available for 1986 but is measured every year after that. Creating a time invariant dummy that measures the attention of authorities prevents me from losing data but captures the effect. I expect the variable to be positively correlated with BAAC credit use dummy.

4.3.2 Selectivity of Response - Is it Non-Random?

The dataset used for this dissertation is unbalanced. Villages enter and leave the dataset and only 38% of the villages are present for all points in time. Data sets in which respondents do not respond for certain times or waves are said to contain 'wave non-

because of the high opportunity cost of time and the cost of school supplies and food that is not covered by the government's mandate. (http://www.d-pal.org/english/thailand.asp) response'.[41] Understanding whether wave non-response in the dataset is random or systematic is important because ignoring non-random or systematic selection of villages into the dataset can lead to biased and inconsistent estimates (Heckman (1976); Hausman and Wise (1979)).

One possible way in which to deal with this is to use only the balanced data set but the literature presents compelling arguments for using a *complete* unbalanced panel and not just the balanced sub-panel for estimation purposes (Nijman and Verbeek (1992); Verbeek and Nijman (1992)). Estimates from balanced models may be biased if non-response is endogenously determined.

In the study data set, villages may be missing at random. If a village is missing at random, the fact that the village is missing is unrelated to the attributes of the village. To test if this is so, Verbeek and Nijman (1992a, 1992b) use the fact that inconsistency of estimates in unbalanced and balanced datasets are unlikely to be identical. They compare estimates from the complete *un*balanced panel with those of a balanced *sub*-panel, using both fixed effects and random effects.[42] I use data on paddy rice to examine if villages are selected non-randomly into the dataset. I estimate area equations for two panels – the *complete un*balanced panel, and, the balanced sub-panel. These tests and results are

[41] 'Wave non-response' and 'item non-response' are terms used by Verbeek and Nijman ((1990), (1992)). Woodridge (2002) uses the terms 'attrition' and 'incidental truncation' respectively. However while defining 'attrition', Woolridge does not allow for subsequent appearance of the observed identity. He also assumes that incidental truncation occurs because of non-observation rather than simple non-response or non-reporting. Methodologically however, the appellations are treated similarly to those suggested by Verbeek and Nijman and Woolridge expands on some of Verbeek/Nijman's methods. Item non-response occurs if the village itself entered the dataset, but data on a variable were missing. I use the Verbeek/Nijman terminology.

[42] The power of the tests they suggest is low since all estimators are inconsistent under the alternative. However for my purposes, these tests are sufficient.

discussed in detail in Appendix 7.4. The tests show two things: First, using the unbalanced data or the balanced data set for estimating a fixed effects regression yields estimates that are not significantly different. There is no selectivity bias here. However for random effects models, there is a difference between the balanced panel and the unbalanced panel. The estimates from the balanced sub-panel are inconsistent, showing selectivity bias. Hence I use the unbalanced panel.

4.3.3 Absence of Crop data and Prices – Is it non-random?

There is another type of missing data problem that requires special mention. (In the terminology of the previous section, this is called 'item non-response'.) Data for area devoted to the two crop groups ('short-run' crops and 'long-run' crops) are recorded as positive, missing or zero. Because data are available for other variables for these villages, and data for paddy rice are recorded, it is unlikely that villages were not contacted for this part of the survey. To understand whether there is any systematic bias in recording these data, I estimate multinomial logit models to analyze the impact of village level attributes on data recording. These multinomial logit models are estimated for two crop groups – short run crops and long run crops. Results are presented in Appendix 7.5. The results show that villages that are located far from Chiang Mai are more likely to have missing values compared to zero values and villages located far from the market are also likely to have more missing values. This confounding of zeros and missing values can thus be explained in two ways: a) villages far from Chiang Mai are less likely to collect data rigorously or to record it carefully since they probably get less intensive training or oversight (data are recorded at the tambon office), or, b) crop acreage for villages with little or no land devoted to the crop may be recorded as either missing or zero.[43] Large magnitudes of land are unlikely to be recorded as zero but small ones may be. For want of a better solution, I replace missing values for crop areas with zeros. Because of the large number of zeros for areas devoted to soybean and upland rice, I estimate Tobit equations for these two crops (see table 3.5). The dependent variable is Log(area). In all crop area equations, log(0) is assumed to be zero.

4.3.4 Random effects or fixed effects?

Mundalk (1978) calls the distinction between fixed effects and random effects – ‘spurious’. He asserts that one should always treat individual effects as random – and that the “Fixed effects model is simply analyzed conditionally on the effects present in the observed sample”.

Fixed effects models have the advantage that they are robust to correlation between unobserved characteristics at the village level and explanatory variables. Fixed effects regressions may thus produce unbiased and consistent estimates. Generally fixed effects estimation procedures are not very efficient, since they account for unobserved characteristics by including village level dummy variables thus reducing the degrees of freedom (Greene (1997); Mundalk, (1976)). In the study dataset however, with 670 villages and 2654 observations, this disadvantage is not likely to be significant.

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[43] That crop group data is better available, suggests that one could potentially estimate an endogenous switching model to explain why villages move from one crop to the other. I do this using a multinomial logit model. Results are not presented here but easily available. This route was not taken because the data on non-soybean crops were too sparse to allow further analysis along those lines.

A greater drawback to using fixed effects models in that they tend to yield unstable parameters in Tobit and probit models. In contrast to linear models, in fixed effects Tobit models, village level effects cannot be swept away and hence the parameters cannot be estimated consistently for a finite time period (Hsiao, (1986)). Honore (1992) develops fixed effects Tobit estimates that are consistent and asymptotically normal. This approach requires trimming observations so that the symmetry lost by censoring is restored. Consistency and normality are established for sample sizes greater than N=200 but it requires differencing which, given the dataset I am working with, is not practical. This is critical for this study. To overcome this drawback, I estimate random effects models. Where possible I compare the random effects estimates with the fixed effects estimates and test the difference between them using the Hausman test.

Using random effects specifications also allows one to use village level time invariant regressors, which fixed effects do not. Moreover, random effects models usually perform better when there are measurement errors and allow one to make out-of-sample predictions which are not possible with fixed effects specifications (Nerlove, (2002); Hsiao, (1986)). For all these reasons, I estimate random effects specifications.

4.4 Variable for measuring Intensity of Cultivation

In the dataset the intensity of cultivation variable is measured as a categorical variable:

Intense(jt) =1 if village j's cultivated land is more than 90% of agricultural land in year t.
=2 if village j’s cultivated land is 75-90% of agricultural land in year t.
=3 if village j’s cultivated land is 50-75% of agricultural land in year t
=4 if village j’s cultivated land more than 50% of agricultural land in year t.

year	Cultivated >90% agricultural land	Cultivated 75-90% agricultural land	Cultivated 50-75% of agricultural land	Cultivated Less than 50% of agricultural land	Total
1986	17.83	32.31	17.55	32.31	100
1988	21.59	29.56	18.51	30.33	100
1990	20.84	31.15	18.74	29.27	100
1992	19.05	28.35	28.35	24.24	100
1994	13.65	29.00	31.13	26.23	100
1996	15.16	28.94	33.27	22.64	100
Total	17.83	29.76	25.29	27.12	100

Notes: Numbers show percentage of villages in the category, for that year; Source: Data provided by Thammasat University, Thailand.

Table 4.2: Percentage of Village Agricultural Land Cultivated, by Year, Forest Reserve Villages, Chiang Mai (1986-1996)

Table 4.2 shows that, on average, there was a decrease in the percentage of villages cultivating less than half the village area. Table 4.3 shows that half the villages cultivating more than 90% of their land in a certain year, continued to do so, in the subsequent year. Similarly, half the villages that cultivated only 50% of their agricultural land, continued to do so. The large off-diagonal percentages show that there was significant movement from year to year.

	Cultivated >90% agricultural land	Cultivated 75-90% agricultural land	Cultivated 50-75% of agricultural land	Cultivated Less than 50% of agricultural land	Total
Cultivated >90% agricultural land	50.6%	27.5%	11.1%	10.8%	100%
Cultivated 75-90% agricultural land	16.0%	56.8%	16.4%	10.7%	100%
Cultivated 50-75% of agricultural land	8.9%	17.8%	61.3%	12.0%	100%
Cultivated Less than 50% of agricultural land	11.1%	15.9%	18.9%	54.0%	100%
Average	20.1%	31.7%	26.6%	21.7%	100%

Notes: Numbers show percentage of villages; Source: Data provided by Thammasat University, Thailand.

Table 4.3: (Non-markov) Transition Probabilities for Intensity of Cultivation, Forest Villages, Chiang Mai, (1986-1996)

4.5 The Estimation Models

For purposes of estimation the simplest form of equation for the three crops *i* = paddy rice, soybean, upland rice for *j* = 1,…,n (villages); *t* = 1986, 1988, 1990, 1992, 1994, 1996, I estimate the following random effects equations separately:

$$
\begin{aligned}
&Log(\text{Crop area})_{ijt} = a_{i0} + a_{i1}Log(\text{Population})_{jt} + a_{i2}Log(\text{Travel time to market})_{jt} + \\
&a_{i3}(\text{Water availability dummy})_{jit} + a_{i4}(\text{Acid soil dummy})_{jit} + \\
&a_{i5}(P\text{roperty rights dummy})_{jt} + a_{i6}(\text{BAAC use dummy})_{jt} + a_{i7}(\text{Proportion of adult population})_{jt} \\
&a_{i7}\text{Time trend} + u^{*}_{ji} + \varepsilon_{jit}
\end{aligned}
$$

$$Log(\text{Agricultural Area})_{jit} = a_{i0} + a_{i1}Log(\text{Population})_{jt} + a_{i2}Log(\text{Travel time to market})_{jt} + a_{i3}(\text{Water availability dummy})_{jit} + a_{i4}(\text{Acid soil dummy})_{jit} + a_{i5}(\text{Property rights dummy})_{jt} + a_{i6}(\text{BAAC use dummy}) + a_{i7}(\text{Proportion of adult population})_{jt} \; a_{i7}\text{Time trend} + u^*_{ji} + \varepsilon_{jit}$$

$$\text{Intensity of cultivation}_{jit} = a_{i0} + a_{i1}Log(\text{Population})_{jt} + a_{i2}Log(\text{Travel time to market})_{jt} + a_{i3}(\text{Water availability dummy})_{jit} + a_{i4}(\text{Acid soil dummy})_{jit} + a_{i5}(\text{Property rights dummy})_{jt} + a_{i6}(\text{BAAC use dummy}) + a_{i7}(\text{Proportion of adult population})_{jt} \; a_{i7}\text{Time trend} + u^*_{ji} + \varepsilon_{jit}$$

Where u^*_{ji} is distributed normally and is the unobserved influence of the village on repeated observations. ε_{jit} is the unobserved error term also distributed normally with mean 0 and variance σ^2_ε. This yields five separate equations. For each of these equations, to account for BAAC credit use being endogenous, I estimate a first stage random effects equation to get the predicted value for BAAC credit use. To model BAAC credit use, for each of the equations above, I estimate the following random effects equation, which includes all exogenous variables in the system, including the three identifying instruments. For paddy rice, the area equation is estimated as a linear random effects model, because very few villages do not grow paddy rice. For the paddy rice equation, I also include the dummy for whether villages have ever grown HYV rice. For the other two crops, to account for the large number of zeros, I estimate a random effects Tobit model.

$$\text{BAAC credit dummy}_{jit} = b_0 + b_1 Log(\text{Population}_{jt}) + b_2 Log(\text{Travel time to market}_{jt}) +$$
$$b_3 Log(\text{Travel time to district})_{jt} + b_4(\text{Water availability dummy})_{jit} +$$
$$b_5(\text{Proportion with compulsory education})_{jit} + b_6(\text{Acid soil dummy})_{jit} +$$
$$b_7(\textit{P}\text{roperty rights dummy})_{jt} + b_8\text{HYV rice use dummy} + b_9(\text{Proportion of adult population})_{\text{jt}}$$
$$b_9\text{Time trend} + u^*_{ji} + \varepsilon_{jit}$$

The next chapter presents estimation results.

5 Results

5.1 Introduction

This chapter is divided into two parts. In the first part, I present results for area devoted to paddy rice, upland rice and soybeans while allowing for BAAC credit use to be endogenous. Areas devoted to the three crops are estimated using three different equations. Paddy rice area equations are estimated using Generalized two stage least squares (G2SLS) random effects. Area equations for upland rice and soybean are estimated using a two-step variant of a random effects Tobit model. To account for endogeniety of BAAC credit use, I estimate a random effects probit model in the first step. This provides predicted values of BAAC credit use. The predicted value is used to instrument for BAAC credit use in the second stage Tobit equations. Bootstrapping standard errors in the second stage Tobit equations provide corrected standard errors.

In the second part of the chapter I present reduced form equations for agricultural land and intensity of cultivation of land in the village, using the same explanatory variables as for the crop equations. These equations show the net effect that explanatory variables have on the extensive frontier of cultivation – for which village agricultural land is a proxy, and, the intensive frontier of cultivation – measured by the categorical variable intensity of cultivation.

To tie the two sets of models together, simple linear regressions of agricultural land and intensity of cultivation on a constant, a time trend variable, and area devoted to the three crops show that the latter are significant. These are shown in Tables 5.1 and 5.2.

Table 5.1 shows that an increase in village agricultural land is associated with an increase in area devoted to Paddy rice and Upland rice. On the other hand, an increase in area devoted to Soybean is not: Villages that grow Soybean are likely to be those that have little agricultural land, and can only cultivate intensively. This is expected since Soybean is an input intensive cash crop. Table 5.2 shows that an increase in intensity of cultivation is associated with an increase in area devoted to Soybean and Paddy rice. Upland rice area is not significant. This too is expected. Upland rice is usually grown on forest frontiers, on land with low fertility but that is vulnerable to erosion. Land devoted to upland rice does not require much preparation. Soybean and Paddy rice on the other hand, require large amount of inputs and preparation. They are usually grown on land that is agriculturally important. Usually cultivated on fertile and flat river beds, and in watershed areas, this land is much more likely to have other crops grown on it, once Soybean and Paddy rice have been harvested.

Given limited data it is not possible to estimate structural equations for village agricultural land and intensity of cultivation, since it is not possible to instrument for areas devoted to the three crops.

Dep. Variable: Village agricultural area	Coefficient	Std. Dev	Z	P>Z
Year	15.35**	3.15	4.87	0
Area devoted to Paddy Rice	0.46**	0.06	7.8	0
Area devoted to Upland Rice	0.21*	0.09	2.36	0.018
Area devoted to Soybean	-0.19+	0.11	-1.69	0.091
Constant	-641.17*	294.84	-2.17	0.03
Sigma-u	1054.16			
Sigma-e	375.89			
Rho	0.89			
Observations	1979			
R-square Within	0.042			
Groups	622			
R-square Between	0.054			
R-square Overall	0.056			
Gaussian Wald Statistic (chi2, 4df)	85.5			
Prob > Chi2	0			

Note: ** denotes significance at the 1% level; * at the 5% level, and + at the 10% level. Source: Data provided by Thammasat University, Thailand.

Table 5.1: Linear Random Effects regression results for Land devoted to Agriculture, Forest Reserve Villages, Chiang Mai (1986-1996)

Dep. Variable: Intensity of cultivation	Coefficient	Std. error	Z	P>z
Year	0.0379	0.125	0.3	0.762
Area devoted to Soybean	0.01399**	0.0037	3.76	0
Area devoted to Upland Rice	0.0011	0.0034	0.33	0.738
Area devoted to Paddy Rice	0.0037*	0.0019	1.95	0.051
Constant	63.314**	11.5450	5.48	0
Sigma-u	14.0611	0.6781	20.74	0
Sigma-e	16.392	0.3547	46.21	0
Rho	0.4239	0.0273	0.3712	0.478
Observations	2174			
Groups	629			
Gaussian Wald Statistic (chi2, 4 df)	20.03			
Prob > Chi2	0.0005			

Note: ** denotes significance at the 1% level; * at the 5% level, and + at the 10% level. Source: Data provided by Thammasat University, Thailand.

Table 5.2: Random Effects Interval Regression Results for Intensity of Cultivation, Forest Reserve Villages, Chiang Mai (1986-1996)

In the next section I present some common procedures followed for all five estimated equations – three equations for three different crops, one for the intensity of cultivation and one for agricultural land.

5.2 Method followed for all estimation equations

Three things should be kept in mind while examining the effects of explanatory variable in the five different estimation equations.

First: I contrast results for two groups of villages – APR villages and NPR villages. To do this all explanatory variables are interacted with the NPR dummy. The dummy for NPR villages is defined as follows: NPR dummy =1 if villages do not have secure property rights and is equal to zero otherwise. The net effect of explanatory variable in the NPR villages is calculated by adding the marginal effect of the level variable (i.e. the *non*-interacted variable), to the marginal effect of the interacted variable. The net effect of the explanatory variable on NPR villages is significant only if the t-statistic of the sum is significant.

Second: for all five equations a first stage equation for BAAC credit use is estimated. The first stage BAAC credit use equations are estimated separately for each crop and are shown separately. This is because there are a different number of observations for each equation since data for all dependent variables are not available consistently for all villages for all times. For two crops – soybean and upland rice – and the intensity of cultivation equation, I use a variant of the two step procedure: For the first stage I estimate a random effects probit equation to estimate the equation for BAAC credit use. I use the predicted value from this equation in the second stage random effects Tobit equation. Since I use the predicted value in the second stage, standard errors need to be corrected in the second stage. To correct the standard errors in the second stage, I bootstrap the standard errors using repeated sampling with replacement. Z-statistics in the second stage are based on these bootstrapped standard errors.

Thirdly, I do not estimate the equations together in a SUR (seemingly unrelated regression) system. This is because of the difficulty of estimating equations that require different estimation techniques. This is required because the dependent variables are defined differently from each other. The equations for paddy rice and village agricultural land are linear random effects equations; the equations for soybean and upland rice are random effects Tobit equations; and, the equation for intensity of cultivation is a random effects interval regression. To the extent that these equations are not estimated in a system, the estimated coefficients are unbiased and consistent but not efficient. Furthermore, according to a well known result established by Dwivedi and Srivastava (1978), if equations have identical explanatory variables, then there is no difference between the estimates from a system of equations and those from single equations.

In the next section I discuss results for the three main crops.

5.3 Results for area devoted to three main crops

5.3.1 Paddy rice

Paddy rice is grown in fields flooded with water throughout the growing season. On average rice needs abundant sunshine and 160-200 mm of water per month. The main crop of paddy rice is cultivated anytime between May and October and harvested between November and January. Paddy rice has various qualities but there are two main distinctions from the point of view of the consumer: Glutinous and non-glutinous rice.

Glutinous rice is also called sticky rice or sweet rice and is grown predominantly in the upper North and the North eastern part of Thailand. The market for glutinous rice is separate from that for non-glutinous rice and its demand is more elastic. It is usually grown for self-consumption and the price of glutinous rice is usually lower than that for non-glutinous rice. In Chiang Mai, in 1986, total area devoted to cultivating non-glutinous rice was 102,098 ha while that to glutinous rice was almost 10 times larger: 1,077,860 ha. Paddy rice, as defined in the survey, can be either glutinous rice, which is usually grown for subsistence or, non-glutinous rice, which is grown for the market. The data does not distinguish between the two.

Table 5.3 presents some characteristics of paddy-rice growing villages in the study sample. Area devoted to paddy rice is a variable not directly available in the dataset. Instead, the dataset includes information on the following variables: "*Number of households with less than 1 rai of rice paddy?*", "*Number of households with 1-5 rai of rice paddy?*" etc. To arrive at the area variable, I multiply the midpoint of the interval with the number of households growing it. For area greater than 50 rai, I use 50 rai as the assumed area. The table shows that on average area devoted to paddy rice has been falling over time, and that area devoted to paddy rice is not significantly different between the two sets of villages.

The table also highlights another characteristic of paddy rice. In 1986, the average amount of rice produced annually in a village was approximately 142,816 kgs. Divided by the number of people in an average village in that year, this figure implies an average of 650 grams per person per day. The National Food and Nutrition Survey in 1986 reported that the average Thai consumes less than half this amount – or an average of

302.7 grams of white rice (along with 34.2 grams of rice starch). Even after accounting for losses during milling and transportation and demand for seeds, the data suggests that at least some portion of the crop must be marketed. The other thing to note in Table 5.4 is that the reported price of paddy rice shows little variation, consistent with the fact that prices for paddy rice are controlled by the government.

Variable	Obs	Avg	SD	Obs	Avg	SD	Obs	Avg	SD	Obs	Avg	SD	Obs	Avg	SD	Obs	Avg	SD
All sample	**1986**			**1988**			**1990**			**1992**			**1994**			**1996**		
Area devoted to rice (rai)*	339	340	328	391	292	307	428	279	284	463	260	265	437	277	273	505	250	297
% hhs growing rice	340	57	36	373	55	36	409	52	36	443	52	36	451	52	36	474	50	38
Rice per rai (kg/rai)	330	420	151	390	377	193	428	381	195	464	372	214	401	398	176	466	347	212
Rice price (bahts/kg)	278	2	0.62	277	3	0.4	322	2.9	0.6	315	3.3	0.9	300	3.5	0.7	307	3.9	0.9
Propn HHs growing HYV	Na			344	0.4	0.4	377	0.4	0.4	403	0.5	0.4	322	0.6	0.5	343	0.6	0.5
APR Villages																		
Area devoted to rice (rai)*	164	362	340	176	349	342	177	312	273	182	297	265	177	287	241	197	265	263
% hhs growing rice	165	56	32	172	53	31	175	49	32	179	52	33	184	50	34	195	48	35
Rice per rai (kg/rai)	165	491	138	176	464	172	177	468	184	186	469	199	171	482	159	190	428	211
Rice price (baths/kg)	142	2	0.7	140	3	0.4	143	3.1	0.5	159	3.4	0.7	154	3.6	0.8	159	4.1	0.9
Propn HHs growing HYV	Na			166	0.6	0.4	166	0.7	0.4	175	0.7	0.4	156	0.8	0.4	155	0.8	0.4
NPR Villages																		
Area devoted to rice (rai)*	175	320	317	215	246	267	251	255	290	281	236	262	260	269	293	308	241	317
% hhs growing rice	175	58	39	201	56	40	234	54	39	264	52	39	267	53	37.9	279	52	40
Rice per rai (kg/rai)	165	348	129	214	305	180	251	320	179	278	306	198	230	335	162	276	291	194
Rice price (baths/kg)	136	2	0.5	137	2.7	0.5	179	2.9	0.6	156	3.2	1.0	146	3.3	0.7	148	3.8	0.8
Propn HHs growing HYV	Na			178	0.3	0.4	211	0.2	0.4	228	0.3	0.4	166	0.4	0.4	188	0.3	0.4

Rounded off figures, Notes: APR villages: Villages with Ambiguous Rights; NPR: Villages with no secure property rights; Na: Data not collected for that year. Area devoted to rice is a constructed variable. Source: Data provided by Thammasat University, Thailand.

Table 5.3: Characteristics of Villages growing paddy rice, Forest Reserve Villages, Chiang Mai, Thailand (1986-1996).

5.3.1.1 Results for paddy rice

Results for area devoted to paddy rice are presented in Table 5.4 where the dependent variable is measured in logs. All results are for random effects models.

The columns in Table 5.4 report results for the following five specifications:

- Column (1) is a random effects specification, and treats BAAC credit use as exogenous;

- Column (2) is a single equation random effects specification that includes the exogenous variable, ‘proportion of people with compulsory education in the village,’ in the list of right hand side variables. The ‘proportion of people with compulsory education in the village,’ is one of two identifying variables for the BAAC credit use equation.

- Column (3) is a single equation random effects specification that includes both variables used to identify the BAAC credit use equation on the right hand side; namely, proportion of people with compulsory education in the village, and, the log of travel time to the district center.

- Column (4) presents random effects results with instrumental variables that use only one identifying instrument in the first stage BAAC credit use equation; namely, the proportion of people with compulsory education in the village. Model is estimated using Generalized two stage least squares.

- Column (5) presents random effect results with instrumental variables that use both identifying exogenous variables in the first stage to estimate the BAAC credit use equation. These identifying variables are: the proportion of people with compulsory education, and, travel time to the district center. Model is estimated using Generalized two stage least squares.[44]

The first column of Table 5.4 shows single equation results for the random effects model that assumes BAAC credit use is exogenous. BAAC credit use is not significant in this equation but population is. This result does not change when BAAC credit use is endogenous, as in columns (4) and (5). In Table 5.4, moving from the left side to the right side increases the set of explanatory variables. However, the effect of population remains stable. The dummy for acidic soil is significant in the non-instrumented equations but not in the specifications with instrumented variables. This indicates that the presence of acidic soil is likely to affect the use of BAAC credit more than the area decision. Coefficients for all other explanatory variables remain similar and constant across specifications, indicating that the results are robust.

Column (5) of Table 5.4 is the column I discuss here. To recap, in this specification BAAC credit use is endogenous. The equation for paddy rice area is a random effects equation with two instruments for BAAC credit use. The estimation equation for BAAC credit use is presented in Table 5.5 and discussed subsequently.

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[44] The first stage equations for BAAC credit are estimated using linear regression for rice and total agricultural land. For Tobit equations for soybean and upland rice and intensity of cultivation first stage equations use a random effects probit model. To the extent that marginal effects for Tobit equations are estimated at the mean of the variables, this difference should not make a difference (except at extreme values).

For column (5) in Table 5.4, a test of differences between the constrained model (i.e. without interacting explanatory variables with the NPR village dummy) and the unconstrained model (allowing the NPR interactions variables to have a non-zero coefficient) shows a significant difference between the two groups (chi-square statistic, 9 degrees of freedom = 33.8; Prob> Chi2 = 0). This indicates that it is important to allow for the NPR interactions to have non-zero coefficients. The model in column (5) in which explanatory variables are interacted with the NPR dummy is thus the appropriate model.

A Hausman test of the null hypothesis that there is no systematic difference between a fixed effects specification and a random effects specification cannot be rejected (chi-square, 14 degrees of freedom = 7.36; Prob>chi2 = 0.92). The overall model is significant: Chi-square (17) = 162.3; Prob > Chi-square = 0.

The specification shows that almost 68% of the unexplained error in the model is accounted for by the time invariant error term (rho = 0.68). This means that most of the variation is explained by inter-village variation rather than variation over time within the village.

For all villages in the estimation sample, travel time is not a significant determinant of paddy rice area. This can be explained if the main motivation for growing paddy is subsistence and not the market. The significant and positive sign on Log(Village Population) provides further support. An increase in village population by 1% increases the area devoted to paddy rice in the village by 0.8%. The effect of HYV rice use is large and significant: Villages that start using HYV rice are likely to increase land devoted to paddy rice by 2.67%. As mentioned earlier, HYV rice is much more resilient to pests and requires very little water. Other variables such as acidic soil do not have significant effects on area devoted to paddy rice. The effects for NPR villages are not significantly different, except in the case of HYV rice.

For NPR villages the null hypothesis that after controlling for other covariates, paddy rice area in NPR villages is no different from paddy rice area in APR villages, cannot be rejected. Coefficients for population and travel time are not significantly different for this group of villages either. However, the effect of HYV rice use is significantly lower compared to APR villages. NPR villages that start using HYV rice are likely to devote 0.83% more area to paddy rice than those that do not (coefficient estimate for HYV dummy for NPR villages =0.834; z-statistic = 2.36; P>z = 0.018). Credit taken from the BAAC has a negative coefficient but is not significantly different for this group of villages (coefficient on BAAC credit use for NPR villages = -2.49; z statistic = -1.59; P>z = 0.112).

The effect of BAAC credit use in the first stage equation for BAAC credit use is discussed next.

5.3.1.2 BAAC credit use equation for paddy rice area

Table 5.5 provides an analysis of the endogenous variable BAAC credit use, using a random effects linear model. The variables are jointly significant in explaining the use of BAAC credit (chi-square, 19 degrees of freedom = 494; Prob > Chi2 =0).

The results show that, for villages in the paddy rice estimation sample, an increase of 1% in market travel time decreases the probability of BAAC credit use by 0.03%.

Factors that increase the propensity to cultivate land, such as soil fertility, sufficient water and presence of adult labor, are likely to increase the probability that credit from the BAAC is used: Availability of water increases the likelihood of using BAAC credit by 0.05%; Presence of acidic soil has no significant effect. Proportion of adults increases the likelihood of BAAC credit use by 0.16%.

All the identifying instruments for BAAC credit use are significant. HYV rice dummy has a large effect on the likelihood of BAAC credit use: A village that grows HYV rice is 0.29% more likely to use BAAC credit than a village that does not; An increase in the proportion of people who have compulsory education in the village by 1% increases the likelihood of BAAC credit use by 0.15%. Finally, an increase in travel time to the district by 1% reduces the likelihood of BAAC credit use by 0.07%.

Population effects on BAAC credit use are quite different, depending on whether the village is an APR village or an NPR village. An increase of 1% in population leads to an increase in the probability of using BAAC credit by 0.09 %. These already modest effects disappear completely for NPR villages. BAAC credit use in APR villages is estimated to be increasing over time at a rate of 0.02% per year and for NPR villages at 0.03%.

	RE Structural	RE Reduced w/ compulsory education.	RE Reduced w/ compulsory edn. And Log(Travel to district)	Instrumental RE w/ compulsory education.	Instrumental RE w/ compulsory edn & Log(Travel to district)
	(1)	(2)	(3)	(4)	(5)
NPR dummy=1	-0.04	0.381	0.879	14.722	-4.26
	(-0.03)	(0.24)	(0.55)	(0.58)	(-0.83)
Year	**-0.043**	**-0.041**	**-0.039**	-0.038	-0.013
	(-4.16)**	(-4.00)**	(-3.83)**	(-0.9)	(-0.54)
(NPR Dummy=1)*Year	0.021	0.017	0.015	-0.15	0.071
	(1.43)	(1.19)	(1.03)	(-0.51)	(1.25)
Log(Village population)	**0.656**	**0.669**	**0.692**	**0.673**	**0.812**
	(5.83)**	(5.97)**	(6.16)**	(2.70)**	(5.08)**
(NPR =1)*Log(Village popn)	-0.054	-0.071	-0.093	-0.1	0.172
	(-0.36)	(-0.48)	(-0.63)	(-0.34)	(0.88)
Log(One way travel time to market)	0.062	0.053	-0.017	0.044	-0.033
	(1.08)	(0.93)	(-0.26)	(0.3)	(-0.36)
(NPR =1)*L(Tr. Time to mkt.)	0.094	0.103	0.118	0.274	0.106
	(1.29)	(1.4)	(1.4)	(0.81)	(0.88)
SR Water dummy	0.013	0.019	0.032	0.026	0.088
	(0.18)	(0.25)	(0.42)	(0.18)	(0.85)
(NPR =1)*SR water dummy	0.02	0.013	-0.012	-0.171	0.035
	(0.19)	(0.12)	(-0.11)	(-0.46)	(0.24)
BAAC credit use dummy	0.118			-0.127	-1.31
	(1.16)			(-0.07)	(-1.42)
(NPR =1)*BAAC credit dummy	-0.161			5.107	-1.186
	(-1.19)			(0.56)	(-0.65)
Proportion of adults in village	0.235	0.26	0.288	0.289	0.499
	(0.75)	(0.83)	(0.91)	(0.5)	(1.19)
(NPR =1)*Propn of adults	-0.622	-0.613	-0.595	-1.815	-0.293
	(-1.43)	(-1.4)	(-1.35)	(-0.83)	(-0.43)
Acidic Soil dummy	**-0.183**	**-0.18**	**-**0.164	-0.173	-0.158
	(-1.68)	(-1.66)	(-1.51)	(-1)	(-1.19)
(NPR =1)*Acidic Soil dummy	0.208	0.214	0.203	0.624	-0.031
	(1.48)	(1.53)	(1.44)	(0.8)	(-0.14)
HYV rice use dummy	**2.244**	**2.28**	**2.27**	**2.31**	**2.674**
	(6.84)**	(6.98)**	(6.97)**	(3.14)**	(5.84)**
(NPR =1)*HYV rice use dummy	**-1.892**	**-1.928**	**-1.906**	**-**2.952	**-1.839**
	(-5.18)**	(5.31)**	(-5.26)**	(-1.54)	(3.18)**
Propn of villagers w compulsory edn.		-0.017	-0.003		
		(-0.1)	(-0.02)		
(NPR =1)*Propn w comp. edn.		-0.134	-0.144		
		(-0.58)	(-0.62)		
Log(Travel time to district)			**0.167**		
			(2.30)*		
(NPR =1)*Log(Tr. Time to distt.)			-0.073		
			(-0.83)		
Constant	**2.399**	**2.176**	1.518	1.963	-0.516

	(2.02)*	(1.85)+	(1.26)	-0.49	-0.23
Observations	2268	2268	2268	2268	2268
Number of Villages	631	631	631	631	631
R-square Within					0.0011
R-square Between					0.1081
R-square Overall					0.1359
Wald Chi2 (17)					162.3
Prob > chi2					0

Notes: NPR =1 if villages have no secure property rights; =0 otherwise. Z-statistics in brackets. ** significant at 1% level; * significant at 5% level; + significant at 10% level.

Table 5.4: Random Effects single equation structural and single equation Reduced form equations, and, IV equations, Dependent variable Log(rice area), Forest Villages, Chiang Mai, 1986-1996.

		Observations		2268
			chi(19)	549
Dependent variable ->	**BAAC use dummy**			
	Coeff.	Std. Dev	Z	P>Z
NPR dummy =1	**-0.9101**	**0.4937**	**-1.84**	**0.065**
Year	**0.0212**	**0.0032**	**6.66**	**0**
NPR dummy =1 X year	**0.0113**	**0.0045**	**2.53**	**0.011**
Log(Population)	**0.0891**	**0.0343**	**2.6**	**0.009**
NPR dummy=1 X Log(Population)	**-0.0800**	**0.0450**	**-1.78**	**0.076**
Log(Mkt Travel time)	**-0.0341**	**0.0201**	**-1.69**	**0.091**
NPR dummy=1 X Log(Mkt Travel time)	0.0199	0.0261	0.76	0.447
Short run crop Sufficient water dummy	**0.0521**	**0.0237**	**2.2**	**0.028**
NPR dummy=1 X Short run crop Sufficient water dummy	-0.0114	0.0338	-0.34	0.735
Proportion of adults	**0.1565**	**0.0985**	**1.59**	**0.112**
NPR dummy=1 X Proportion of adults	0.0815	0.1374	0.59	0.553
HYV rice use dummy	**0.2866**	**0.0960**	**2.98**	**0.003**
NPR dummy=1 X HYV rice use dummy	-0.0973	0.1069	-0.91	0.363
Acidic soil dummy	0.0175	0.0340	0.52	0.606
NPR dummy=1 X Acidic Soil dummy	**-0.1049**	**0.0439**	**-2.39**	**0.017**
Proportion with compulsory education	**0.1522**	**0.0535**	**2.84**	**0.004**
NPR dummy=1 X Propn. With compulsory education.	**-0.1612**	**0.0717**	**-2.25**	**0.025**
Log(Travel time to district)	**-0.0670**	**0.0226**	**-2.96**	**0.003**
NPR dummy=1 X Log(District travel time)	0.0294	0.0274	1.08	0.282
_Constant	**-1.8320**	**0.3743**	**-4.89**	**0**

Notes: NPR =1 if villages have no secure property rights; =0 otherwise.
Z-statistics in brackets. ** significant at 1% level; * significant at 5% level; + significant at 10% level.

Table 5.5: First stage equations for BAAC credit use, for Log(rice area), Generalized Two Stage Least Squares, Forest Reserve Villages, Chiang Mai, Thailand (1986-1996)

5.3.2 Upland rice

Upland rice is mainly grown on mountainous slopes in Thailand and is usually grown for subsistence. It does not require standing water like paddy does but it requires rainfall. The typical growing season lasts 5 months or more.

During the study period the number of villages growing upland rice is increasing, as is the area. Tables 5.6 and 5.7 show average area devoted to upland rice in forest reserve villages, and, the (non-markov) transition probabilities for villages growing upland rice, in the study panel. Table 5.7 shows that, on average, 16% of villages that do not grow upland rice in a particular year grow it in the subsequent year. Conversely, one-fourth of the villages that grew upland rice in the previous year do not grow it in the subsequent year. On average, three-fourths of the villages that grew upland rice in a year grew it again. In the study panel, 31% of the villages grew upland rice every year.

	Observations	**Mean Area (upland rice)**
1986	50	76.5 (.) for 1 village
1988	110	177 (245) for 50 villages
1990	165	248 (316) for 121 villages
1992	208	227 (381) for 172 villages
1994	214	267 (446) for 174 villages
1996	207	165 (315) for 163 villages

Source: Data provided by Thammasat University, Thailand.

Table 5.6: Average area devoted to upland rice, conditional on growing, by year, Forest Reserve Villages, Chiang Mai, Thailand, (1986-1996)

Upland rice growing dummy	Not grow	Grow	Total
Not grow	84.5%	15.5%	100%
Grow	25.34%	74.66%	100%
Average	69.2%	30.8%	100

Source: Data provided by Thammasat University, Thailand.

Table 5.7: (Non-markov) Transition Probabilities for Villages growing upland rice, Forest Villages, Chiang Mai, (1986-1996)

5.3.2.1 Results for upland rice

Area devoted to upland rice is different from area devoted to paddy rice. Paddy rice is grown in well-watered flat fields while upland rice is grown on mountainous slopes. A large number of villages in the data set show that they did not grow upland rice. It is thus important to model the adoption of upland rice and then analyze area devoted to the crop. Upland rice is not grown in the amphoes of Doi Saket, San Kamphaeng, San Sai, San Pa Tong and Chai Prakhan. Villages located in these amphoes are not included in the estimation sample.

To study the variables affecting area devoted to upland rice, I use a two-stage procedure. In the first stage I estimate a random effects probit model for BAAC credit use. I use the predicted values from this equation to instrument for BAAC credit use in the second stage equation. The second stage equation estimates a random effects Tobit model for Log(area devoted upland rice). A Tobit specification is used because there are a large number of villages that do not grow upland rice. A Tobit specification explains the probability of adoption of upland rice, and, the impact of variables, conditional on upland rice being grown. Second stage model results are presented in Table 5.8. Marginal effects for the Tobit equations are presented in Table 5.9. First stage results for BAAC credit use are presented in Table 5.10.

Similar to the results reported in Table 5.4 for paddy rice, in Table 5.8 I estimate five different specifications for upland rice acreage with an increasing number of variables, to show the stability of results. The dependent variable is measured in logs. The columns in Table 5.8 are described as follows:

- Column (1) show a single equation random effects Tobit model with BAAC credit use assumed to be exogenous.

- Column (2) assumes BAAC credit use to be endogenous and estimates a single reduced form random effects Tobit equation. It includes proportion of people with compulsory education in the village as an explanatory variable.

- Column (3) also estimates a single reduced form random effects Tobit equation for upland rice area. It includes two variables that are used as identifying instruments for BAAC credit use. These are: proportion of people with compulsory education in the village, and, the log of travel time to the district.

- Column (4) estimates a single equation random effects Tobit equation for upland rice. Additional to the two variables used as identifying instruments for BAAC credit use, it includes one more variable. This is the village level HYV rice dummy. The HYV rice dummy =1 if the village has ever used HYV rice, and =0 otherwise.

- Column (5) estimates a two-stage random effects Tobit equation. The first stage estimates the equation for BAAC credit use. (These results are shown in Table 5.10 and are discussed below.) In this equation system, BAAC credit use is instrumented for by using three identifying variables: proportion of people with compulsory education in the village, log of travel time to the market, and, village level HYV rice dummy. Z-statistics in column (5) are derived from bootstrapped standard errors.

As with paddy rice equations, going from the left side of the table to the right side, the coefficients remain relatively stable and robust to specifications. In column (1), where the BAAC use dummy is assumed to be exogenous, the variable is not significant in explaining area devoted to upland rice. This does not change in column (5), where it is endogenous.

Since area devoted to upland rice is estimated using a random effects Tobit specification, it is clearly important to discuss the marginal effects. Before doing that, it is important to note a few things about the specification in column (5). The model in column (5) is estimated using a two-stage random effects Tobit specification to account for endogenous BAAC credit use variable. The model is estimated using quadrature procedures to maximize the Tobit log-likelihood function. If model estimates are stable, changing the number of quadrature points in STATA to maximize the likelihood function should not change estimated coefficients by more than 1%. To gauge stability, I estimate the model for 26 quadrature points and then again for 30 quadrature points (the maximum number allowable in STATA). Results shown here are for the model using 30 quadrature points but it is important to point out that all coefficients change by less than 1%, indicating that the results are reliable and stable.

The results in column (5) of Table 5.8 show that the average amount of area devoted to upland rice is increasing over time. Increases in village population lead to increases in area devoted to upland rice in villages included in the estimation sample. This is expected. Upland rice is mainly a subsistence crop. The effect of travel time to market however is significantly different depending on whether the village is an NPR or an APR village.

Clearly, to understand the magnitudes of these effects on the probability of growing upland rice and the amount of area devoted to upland rice conditional on it being grown, one must look at the marginal effects of the model. Marginal effects of the specification in Column (5) are presented in Table 5.9.

Results on the Probability of Growing upland rice: In Table 5.9 the first set of results shows the impact of variables on the probability of growing upland rice. These show that the number of villages growing upland rice increases annually at a rate of 0.04% per year for the study sample, and that rates of adoption are not different for NPR villages. The unconditional increase in upland rice area is 0.19% per year. Population has a positive impact on the probability of adoption of upland rice. An increase in population of 1% leads to an increase in the probability of cultivation of upland rice by almost 0.1 % in the estimation sample.

The effect of travel cost is different from the case of paddy rice. An increase in travel time to the market increases the probability that upland rice will be cultivated. This is to be expected since upland rice is a subsistence crop. An increase in travel times means that forest village residents will want to ensure that their subsistence needs are met and they are not dependent on the vagaries of the market. However this effect is alleviated in NPR villages. In NPR villages, changes in travel time have almost no effect on the probability that upland rice is cultivated (For NPR villages, coefficient on Log of travel time= 0.22; z-statistic = 0.85; Prob>z-statistic = 0.39).

Water is a constraint in most villages growing upland rice. This is shown by the significant and positive coefficient associated with the water availability dummy. Credit use seems to have no impact on the probability of growing upland rice.

Results on area devoted to upland rice, conditional on adoption: The second group of results in Table 5.9 shows the elasticities of area devoted to upland rice, with respect to explanatory variables, conditional on upland rice being grown. It shows that area devoted to upland rice, conditional on it being grown, is growing at a rate of 0.18% per year in all forest villages. A 1% increase in population in forest villages leads to a less than 0.5% increase in area devoted to upland rice and a 1% increase in travel time increases the amount of area devoted to upland rice by less than 0.5% also. But this effect of travel time is mitigated in NPR villages, where area grows by less than 0.05% with a 1% increase in travel time.

5.3.2.2 BAAC credit use equation for upland rice area

Table 5.10 presents results for the first stage of the two-stage Tobit equation discussed above. The sample of observations is smaller than the sample used to estimate the equations for paddy rice. This is because data are absent for some variables.

Results here are similar to those for the BAAC credit use equation estimated for paddy rice area. Village population has a significant effect on BAAC credit use in APR villages. Increases in travel time to the district and to the market reduce the likelihood of BAAC credit use.

All the identifying instruments are significant in explaining the likelihood of BAAC credit use: An increase in the proportion of population that has compulsory education by 1% increases the likelihood of BAAC credit use by 1.3%; A village that has grown HYV rice is 1.8% more likely to use BAAC credit than a village that has not.

For NPR villages the effect of population on likelihood of BAAC credit use is not significantly different from APR villages (coefficient for population in NPR villages = 0.093; z = 0.55; P>z = 0.58). Similarly the net effect of travel time to the district on the likelihood of BAAC credit use is also not significantly different. However the HYV rice dummy is significantly different. Thus, if an NPR village grew HYV rice during the study period, it was much more likely to use BAAC credit. But compared to APR villages, HYV rice has only half the effect on the probability of BAAC credit use (coefficient of rice HYV dummy in NPR villages = 0.92; z=3.74; P>z= 0).

	RE Tobit w / BAAC credit dummy	RE Tobit reduced w/ compulsory education	RE Tobit reduced w/ compulsory education Tr. Time to district	RE Tobit red w/ compulsory education Tr. Time to district HYV rice dummy	IV Tobit RE Interacted w/ compulsory education Tr. Time to district HYV rice dummy
	(1)	(2)	(3)	(4)	(5)
NPR =1	-1.493	1.658	4.009	4.27	**-3.577**
	(-0.14)	(0.15)	(-0.37)	(0.39)	(-1.83)
Year	**0.373**	**0.347**	**0.353**	**0.355**	**0.383**
	(4.39)**	(4.15)**	(4.23)**	(4.25)**	(3.51)**
(NPR =1)*Year	0.125	0.1	0.09	0.094	**0.153**
	(1.17)	(0.96)	(0.86)	(0.9)	(1.96)*
Log(village population)	**1.723**	**1.598**	**1.65**	**1.615**	**1.77**
	(2.63)**	(2.50)*	(2.58)**	(2.50)*	(2.15)*
(NPR =1)*Log(village population)	-0.582	-0.583	-0.629	-0.71	-0.607
	(-0.74)	(-0.75)	(-0.81)	(-0.91)	(0.64)
Log(Travel time to market)	**1.79**	**1.895**	**1.402**	**1.406**	**1.823**
	(4.43)**	(4.82)**	(2.94)**	(2.95)**	(3.02)**
(NPR =1)*Log(Travel time to mkt.)	**-1.484**	**-1.589**	**-1.29**	**-1.309**	**-1.6**
	(-3.20)**	(-3.51)**	(-2.26)*	(-2.30)*	(-1.85)**
LR Water dummy	**1.457**	**1.443**	**1.506**	**1.504**	1.466
	(1.87)+	(1.85)+	(1.93)+	(1.93)+	(1.60)
(NPR =1)* LR Water dummy	-0.557	-0.707	-0.776	-0.711	-0.538
	(-0.56)	(-0.71)	(-0.78)	(-0.71)	(0.19)
BAAC use dummy	-1.065				-1.171
	(-1.52)				(-0.28)
(NPR =1)*BAAC use dummy	-0.438				-1.012
	(-0.5)				(-0.59)
Proportion of adults	2.258	1.859	2.069	2.024	2.386
	(0.84)	(0.69)	(0.77)	(0.75)	(-0.02)
(NPR =1)*Proportion of adults	3.274	4.117	4.097	4.143	**3.369**
	(0.99)	(1.24)	(1.23)	(1.24)	(1.79)+
Acid soil dummy	0.029	0.015	0.238	0.246	0.092
	(0.03)	(0.02)	(0.28)	(-0.29)	(-0.46)
(NPR =1)*Acid Soil Dummy	0.326	0.536	0.325	0.357	0.135
	(0.33)	(0.54)	(0.33)	(-0.36)	(0.42)
Propn with compulsory education		-0.812	-0.84	-0.898	
		(-0.64)	(-0.66)	(-0.7)	
(NPR =1)*(Prop'n w comp. education)		**-2.602**	**-2.546**	**-2.587**	
		(1.65)+	(-1.62)	(-1.64)	
HYV rice use dummy				0.6	
				(0.42)	
(NPR =1)*HYV rice use dummy				0.072	
				(0.05)	
Log(Travel time to district)			**0.902**	**0.902**	

			(1.73)+	(1.74)+	
(NPR =1)*L(Trav. Time to dist).			-0.63	-0.617	
			(-1.04)	(-1.02)	
Constant	**-57.033**	**-54.247**	**-56.784**	**-57.221**	**-58.193**
	(-6.41)**	(-6.16)**	(-6.36)**	(-6.36)**	(-5.83)**
Observations	1930	1930	1930	1930	1930
Number of ID	538	538	538	538	538

Notes: NPR =1 if villages have no secure property rights; =0 otherwise. Z-statistics in brackets.
** significant at 1% level; * significant at 5% level; + significant at 10% level. Bootstrapped T-statistics in column (5), using 100 replications. Source: Data provided by Thammasat University, Thailand.

Table 5.8: Random Effects Structural, Reduced Form and Two-step Tobit equation estimates for Log(upland rice Area), Forest Reserve Villages, Chiang Mai, Thailand (1986-1996).

	Pr(L(upland rice area)>0) (predict, pr(0,.))				E(L(upland rice area) | L(upland rice area) >0) (predict, e0(0,.))				E(L(upland rice area)*| L(upland rice area) >0) (predict, ys (0,.))				
Y	0.247391				3.380444				0.83629				
Variable	**dy/dx**	**std error**	**z**	**P>Z**	**Dy/dx**	**std error**	**Z**	**P>Z**	**dy/dx**	**std error**	**z**	**P>Z**	**x**
NPR dummy=1	-0.2022	0.7419	-0.27	0.785	-0.8870	3.3544	-0.26	0.791	-0.9436	3.6993	-0.26	0.799	**0.5647**
Year	**0.0213****	**0.0054**	**3.94**	**0**	**0.0920****	**0.0233**	**3.96**	**0**	**0.0946****	**0.0241**	**3.93**	**0**	**91.7005**
NPR =1*year	0.0085	0.00723	1.17	0.243	0.0367	0.0314	1.17	0.243	0.0377	0.0324	1.17	0.243	**51.915**
Log(village pop'n)	**0.0984***	**0.0391**	**2.52**	**0.012**	**0.4257****	**0.1684**	**2.53**	**0.011**	**0.4379***	**0.17374**	**2.52**	**0.012**	**6.2198**
NPR =1 x Log(popn)	-0.0337	0.0464	-0.73	0.467	-0.1459	0.2009	-0.73	0.467	-0.1501	0.2064	-0.73	0.467	**3.5040**
Log(Tr time to mkt.)	**0.1013****	**0.0238**	**4.26**	**0**	**0.4384****	**0.1032**	**4.25**	**0**	**0.4511****	**0.1066**	**4.23**	**0**	**3.8109**
NPR =1 x L(Tr. Time)	**-0.0889****	**0.0279**	**-3.19**	**0.001**	**-0.3848****	**0.1209**	**-3.18**	**0.001**	**-0.3959****	**0.1244**	**-3.18**	**0.001**	**2.3504**
LR water dummy	**0.0867+**	**0.0488**	**1.78**	**0.075**	**0.3753+**	**0.2126**	**1.77**	**0.077**	**0.4123+**	**0.2474**	**1.67**	**0.096**	**0.1041**
NPR =1 x LR water	-0.0291	0.0525	-0.55	0.58	-0.1262	0.2297	-0.55	0.583	-0.12621	0.2229	-0.57	0.571	**0.0606**
Propn of adults	0.1326	0.1602	0.83	0.408	0.5737	0.6938	0.83	0.408	0.5902	0.7136	0.83	0.408	**0.4178**
NPR=1 x Propn adult	0.1873	0.1981	0.95	0.344	0.8101	0.8569	0.95	0.344	0.8336	0.8829	0.94	0.345	**0.2235**
Acidic soil dummy	0.0051	0.0477	0.11	0.914	0.0222	0.2064	0.11	0.914	0.0229	0.2139	0.11	0.915	**0.1472**
NPR=1 x Acidic soil	0.0075	0.057	0.13	0.896	0.0327	0.2488	0.13	0.895	0.0338	0.2593	0.13	0.896	**0.0912**
BAAC credit use	-0.0650	0.0995	-0.65	0.513	-0.2816	0.4306	-0.65	0.513	-0.2896	0.4429	-0.65	0.513	**0.4610**
NPR=1 x BAAC credit	-0.0562	0.1359	-0.41	0.679	-0.2433	0.5879	-0.41	0.679	-0.2503	0.6049	-0.41	0.679	**0.118285**

Notes: NPR =1 if villages have no secure property rights; =0 otherwise; ** significant at 1% level; * significant at 5% level; + significant at 10% level. Source: Data provided by Thammasat University, Thailand.

Table 5.9: Marginal Effects for Random Effects Tobit Model, Dependent variable (Log(upland rice area)), BAAC use instrumented for, two-step procedure, Forest Reserve Villages, Chiang Mai, 1986-1996.

Dep. Variable: BAAC use=1 if used, 0 otherwise	Coefficient.	Std. Error	Z	P>z
NPR dummy =1	-1.535	3.589	-0.43	0.669
Year	0.145	0.026	5.53	0
(NPR dummy=1) x Year	0.032	0.035	0.92	0.357
Log(Village Population)	**0.609****	**0.188**	**3.24**	**0.001**
(NPR dummy=1) x Log(Popn)	**-0.529***	**0.256**	**-2.06**	**0.039**
Log(travel time to market)	**-0.286***	**0.137**	**-2.08**	**0.037**
(NPR dummy=1) x Log(Travel time)	0.079	0.182	0.43	0.665
LR water availability dummy	0.151	0.302	0.5	0.617
(NPR dummy=1) x LR water dummy	0.148	0.383	0.39	0.7
Proportion of adults	**1.961***	**0.769**	**2.55**	**0.011**
(NPR dummy=1) x Propn of adults	0.139	1.055	0.13	0.895
Acid soil dummy	0.085	0.254	0.33	0.739
(NPR dummy=1) x Acid soil dummy	**-0.735***	**0.337**	**-2.18**	**0.029**
Proportion with compulsory education	**1.295****	**0.408**	**3.17**	**0.002**
(NPR dummy=1) x Prop w compulsory education	-0.730	0.543	-1.34	0.179
Log(District Travel time)	**-0.454****	**0.149**	**-3.05**	**0.002**
(NPR dummy=1) x Log(Travel time to district)	**0.305+**	**0.187**	**1.64**	**0.102**
HYV rice dummy	**1.836****	**0.398**	**4.62**	**0**
(NPR dummy=1) x HYV rice dummy	**-0.781+**	**0.455**	**-1.72**	**0.086**
Constant	**-16.539****	**2.779**	**-5.95**	**0**
lnsig2u	1.084	0.1767	0.7377	1.431
Sigma-u	1.7196	0.152	1.446	2.045
Rho	0.747	0.033	0.676	0.807
Observations	1930			
Groups	538			
Log Likelihood	-785.68			

Notes: NPR =1 if villages have no secure property rights; =0 otherwise. ** significant at 1% level; * significant at 5% level; + significant at 10% level. Source: Data provided by Thammasat University, Thailand.

Table 5.10: (First Stage) Random Effects Probit Equation for Two-step Tobit, Dependent variable (BAAC credit use dummy), Forest Reserve Villages, Chiang Mai (1986-1996)

5.3.3 Soybean

Soybean cultivation became important in the region in 1984 because its dry variety requires little water and the government started to promote it as part of an import substitution initiative. Soybean is usually planted in May and harvested by the end of the year. It is a typical 'short run' or a 'short-duration' crop and can be harvested within three months from planting. In 2002 soybean constituted one of the main non-rice crops in the region. Soybean has remained attractive since because of relatively stable prices, low input costs and relatively modest labor requirements (TDRI, (1994)). Corn is a popular alternative although it is very water demanding.

In Thailand, most dry season soybean (95%) is grown in the Northern region. Chiang Mai produces 60% of the dry season soybeans (AIT, (1988)). Notwithstanding the higher yield and quality of dry season soybean, 70% of the country's production comes from the rainy season crop. Soybean produced during the rainy season is planted in ploughed fields at the beginning of May and harvested in August. Soybean crop can be planted in rice stubble fields without much land preparation.

Since soybean needs to be processed before it can be consumed, it is expected that growers of soybean will be located near processing plants and markets. Furthermore, the main demand for soybean emanates from the cattle rearing sector, even though soybean is consumed by humans in the form of soy milk, tofu and soy oil. Domestic demand for soybean may be divided into three categories: demand for seeds, demand in the animal feed industry and demand for direct consumption (Sopin (1987)). Demand for soy oil is a large part of direct consumption. To meet this demand, soybean has to be sent to crushers, which produces mostly soybean meal used in animal feed.[45]

These facts indicate that unlike paddy rice and upland rice, soybean is a cash crop, which must be sold either to a merchant or to a processing mill since it has very little use in its unprocessed form.

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[45] Soybean meal is mixed in feed at a percentage of 10-15% of the mixture, depending on livestock type and oil. Soybean sent off to the crushers, is mainly soy meant for feed – the crushing process yields 77% of soybean meal and only 14% of soy oil, which is in turn used for cooking or canning/printing ink/paint. Soybean oil is thus a very small percentage of total production and is often substituted for by palm oil. Thus most soy sent off to the crushers is meant for mixing with animal feed.

	Total no. of villages in sample	Total growing Soy villages**	Average area devoted to soybean in a village (In Rais)*	Average no. of HHs growing soybean in a village*	Average Percentage of Households growing soybean *	Average area devoted per HH to cultivating soybean in a village*	Average Kg/Rai of soybean produced*
1986	367	83 (22.6%)	125 (185)	65 (56)	45 (29)	2.1 (1.9)	212 (73)
1988	392	111 (28.3%)	165 (298)	57 (52)	40 (26)	2.3 (2)	215 (159)
1990	429	121 (28.2%)	182 (279)	60 (53)	44 (26)	2.6 (2)	223 (124)
1992	469	129 (27.5%)	169 (255)	55 (53)	42 (27)	2.7 (2.1)	241 (132)
1994	477	129 (27%)	163 (229)	57 (52)	43 (28)	2.5 (1.8)	255 (130)
1996	520	114 (22%)	155 (200)	56 (42)	43 (23)	2.5 (2)	323 (249)
Total	2654	687 (26%)	162 (246)	58 (51)	43 (27)	2.5 (2)	246 (159)

* Standard deviation in brackets ** Figures in brackets show percentage of villages growing soybean as a percentage of villages in the sample that year; Source: Data provided by Thammasat University.

Table 5.11: Characteristics of Villages growing soybean for the estimation sample, Forest Reserve Villages, Chiang Mai, 1986-1996.

	Not Grow	Grow	Total
Not Grow	92.1%	7.9%	100%
Grow	19.6%	80.4%	100%
Total	72.3%	27.7%	100%

Source: Data provided by Thammasat University, Thailand.

Table 5.12: (Non-markov) Transition Probabilities for Villages growing soybean, Forest Reserve Villages, Chiang Mai, (1986-1996)

Table 5.11 shows that on average a little more than one-fourth of the villages in the sample grew soybean and that on average, 43% of the households in a village grew soybean. Most households devoted a little more than two-fifths of a hectare to soybean cultivation.

Table 5.12 show non-markov transition probabilities for villages growing soybean. It shows that there is some crop switching. Almost 20% of the villages that grew soybean in a previous year did not grow it in the subsequent one. The reverse switch happens less frequently however. Only 8% of the villages that did not grow soybean in a past year grew it in the subsequent year.

In the next sub-section I present results for area devoted to soybean.

5.3.3.1 Results for soybean

Similar to upland rice, there are a large number of villages that do not grow soybean at all. Thus it is important to model the adoption of soybean and to analyze area devoted to soybean conditional on a village growing soybean. To do this I estimate a two-step variant of the Tobit for area devoted to soybean, similar to the one estimated for upland rice. Table 5.13 presents single equation random effects Tobit results for Log(area devoted to soybean). The columns are explained as follows:

- Column (1) shows the structural equation that assumes the BAAC credit use is exogenous.
- Column (2) shows a single equation random effects Tobit equation results that includes the proportion of population that has compulsory education in the village.
- Column (3) has the same specification as column (2) but with Log(Travel time to district) added as an explanatory variable.
- Column (4) has the same specification as column (3) but has the HYV rice dummy added as an explanatory variable.
- Column (5) presents results for a two-stage random effects Tobit model for area devoted to soybean. The first stage of the equation, for BAAC credit use, is estimated using a random effects probit equation, and three identifying

instruments. These are: proportion of population that has compulsory education in the village, travel time to district and the HYV rice dummy.

In column (1) where BAAC credit use is assumed to be exogenous, BAAC credit use is significant for NPR villages. However in column (5) where BAAC credit use treated as an endogenous variable, BAAC credit use is an important determinant of soybean area for all villages. Coefficient estimates in the table, going from left to right, are similar.

It is important to note that although the models for soybean area are also estimated using random effects Tobit, as they are for upland rice, the coefficient estimates are not as stable. Changing the number of quadrature points from 26 to 30 changes the magnitude of coefficients from 1% to 14%. The coefficients for the sufficient water dummy, proportion of adults and acidic soil dummy change by more than 10%. So I do not discuss them here. Further, three amphoes do not grow soybean. Villages in these amphoes have been dropped from this sample. Column (5) in Table 5.13 presents the model I discuss here. Clearly, differentiating between effects of variables on adoption and area is important. These results are presented in Table 5.14. First stage equation results for BAAC credit use are shown in Table 5.15.

Results on probability of growing soybean: The first set of columns in Table 5.14 shows that the number of villages growing soybean is falling over the study period but at a modest rate. An increase in village population by 1% reduces the likelihood that the village will grow soybean by 0.04%. Similarly an increase in travel time by 1%

reduces the likelihood that the village will grow soybean by 0.02%. Being able to use BAAC credit increases the probability of soybean adoption by 0.19%.

For NPR villages, these results are a little different. On average NPR villages are less likely to grow soybean by 0.9%. A 1% increase in population leads to a 0.05% increase in the likelihood that soybean will be cultivated in an NPR village. Travel time to the market, has no effect on the likelihood of growing soybean in NPR villages.

Results on area devoted to soybean conditional on it being grown: The second set of columns in Table 5.14 shows the area devoted soybean conditional on it being grown in a village.

Along with the number of villages growing soybean, the area devoted to soybean also falls during the study period at a rate of 0.03%. An increase in population by 1% leads to a 0.15% decrease in the area devoted to soybean conditional on it being grown. A decrease in travel time to market increases the area devoted to soybean by 0.08%. BAAC credit use leads to a 0.73% increase in area devoted to soybean, conditional on being grown.

The effects on area devoted to soybean are different for NPR villages. NPR villages that grow soybean are likely to devote almost 6% less area to soybean than APR villages. An increase in population and travel time to market leads to an increase in area devoted to soybean but these effects are quantitatively modest, albeit significant.

5.3.3.2 BAAC credit use equation for soybean area

Results for the first stage of the two-stage equation are presented in Table 5.15. BAAC credit use is estimated using a random effects probit equation. Results for BAAC credit use for the larger soybean sample are similar to the results for BAAC credit use for the upland rice estimation sample with a few differences in magnitudes.

BAAC credit use in the soybean estimation sample is growing over time at the rate of 0.28% per year. A 1% increase in village population increases the likelihood of BAAC credit use by 0.6% and a 1% increase in travel time reduces the likelihood of BAAC credit use by 0.4%. Similar to the upland rice sample, a 1% increase in the percentage of adults increases the likelihood of BAAC credit use by 1.7%. In the upland rice estimation sample, this percentage was 1.9%. The effects of identifying instruments on the likelihood of BAAC credit use are all significant.

In NPR villages the some effects change significantly. NPR villages are 5% less likely to use BAAC credit than APR villages, although the rate of BAAC credit use is growing at the rate of 0.4% per year. Population has an insignificantly different effect in NPR villages on the probability that BAAC credit will be used. The presence of acidic soil in NPR villages in the estimation sample reduces the likelihood that BAAC credit will be used by 0.7%.

	RE Tobit w/ BAAC dummy (1)	RE Tobit Reduced w/ compulsory education (2)	RE Tobit Reduced w/ compulsory education & Travel time to district (3)	RE Tobit Reduced w/ compulsory education & Travel time to district HYV rice dummy (4)	IV Tobit RE w/ compulsory education & travel time to district & HYV rice dummy (5)***
NPR dummy=1	**-15.535**	**-23.689**	**-24.008**	**-18.258**	-18.459
	(2.24)*	(3.49)**	(3.48)**	(2.70)**	(-1.41)
Year	-0.032	-0.013	-0.016	-0.016	-0.065
	(-0.84)	(-0.35)	(-0.43)	(-0.43)	(-1.44)
(NPR =1) X year	0.028	**0.112**	**0.124**	**0.146**	0.066
	(0.4)	(1.70)+	(1.88)+	(2.21)*	(0.61)
Log(population)	-0.317	-0.329	-0.353	**-**0.513	**-**0.597
	(-0.94)	(-0.93)	(-0.99)	(-1.47)	(-0.30)
(NPR =1) X Log(popn)	**1.071**	**1.198**	**1.199**	0.424	1.346
	(2.10)*	(2.35)*	(2.31)*	(0.85)	(1.29)
Log(Travel time to market)	**-0.571**	**-0.587**	**-0.442**	**-0.427**	**-0.333**
	(2.82)**	(2.89)**	(1.86)+	(1.73)+	(-1.99)*
(NPR =1) XL(Tr time to mkt.)	**0.799**	**0.756**	**1.158**	**1.019**	**0.588**
	(2.31)*	(2.19)*	(2.73)**	(2.44)*	(2.00)*
SR water dummy	-0.015	0.093	0.075	0.057	-0.103
	(-0.05)	(0.34)	(0.28)	(0.21)	(-0.24)
(NPR =1) X SR water dummy	0.55	0.586	0.719	0.716	0.641
	(1.11)	(1.22)	(1.49)	(1.52)	(0.42)
Propn of adults	**1.821**	1.773	1.725	1.673	0.78
	(1.63)	(1.58)	(1.54)	(1.49)	(0.59)
(NPR =1) X Propn of adults	-2.403	-2.146	-2.401	-2.645	-1.544
	(-1.19)	(-1.07)	(-1.2)	(-1.31)	(-0.50)
BAAC credit use dummy	0.651				**3.011**
	(1.58)				(3.08)**
(NPR =1) X BAAC credit	**1.097**				-1.078
	(1.76)+				(-1.04)
Acid soil dummy	0.356	0.369	0.367	0.339	0.372
	(0.94)	(0.99)	(0.99)	(0.91)	(0.61)
(NPR =1) X Acid soil dummy	-0.166	-0.428	-0.422	-0.277	-0.169
	(-0.28)	(-0.74)	(-0.73)	(-0.47)	(-0.16)
Propn w compulsory edn.		**1.352**	**1.315**	**1.236**	
		(2.16)*	(2.10)*	(1.94)+	
(NPR =1) X Propn w comp. edn.		0.121	0.164	-0.288	
		(0.13)	(0.17)	(-0.29)	
Log(Travel time to district)			-0.283	-0.283	
			(-1.05)	(-1.04)	
(NPR =1) X L(Tr. Time to distt.)			-0.547	-0.495	
			(-1.29)	(-1.19)	
HYV rice dummy				**5.423**	

				(3.98)**	
(NPR =1) X HYV rice dummy				-1.063	
				(-0.71)	
Constant	4.479	2.661	3.637	-0.531	**6.927**
	(1.17)	(0.66)	(0.88)	(-0.13)	(1.98)+
Observations	2086	2086	2086	2086	2086
Number of ID	561	561	561	561	561

Notes: NPR =1 if villages have no secure property rights; =0 otherwise. ** significant at 1% level; * significant at 5% level; + significant at 10% level. ***Bootstrapped t-statistics in column (5) using 200 replications. Source: Data provided by Thammasat University, Thailand.

Table 5.13: Showing Single equation structured (Columns 1), single equation reduced (Columns 2-4) and IV (Columns 5-6), Random Effects Tobit equations for Log(soybean area in rai), Forest Reserve Villages, Chiang Mai, 1986-1996.

	Pr(L(soybean area)>0) (predict, pr(0,.))				E(L(soybean area)| L(soybean area) >0) (predict, e0(0,.))				E(L(soybean area)*| L(soybean area)>0) (predict, ys (0,.))				
Y	0.25459				3.012101				0.76685				
Variable	dy/dx	Std.	Z	P>Z	dy/dx	Std.	Z	P>Z	dy/dx	Std.	Z	P>Z	x
NPR dummy =1	**-0.89507**	**0.18624**	**-4.81**	**0**	**-5.81344**	**3.9518**	**-1.47**	**0.141**	**-6.75657**	**4.49738**	**-1.5**	**0.133**	**0.534036**
Year	-0.00414	0.00264	-1.57	0.117	-0.01577	0.01001	-1.58	0.115	-0.01647	0.01046	-1.58	**0.115**	**91.4142**
(NPR =1) x year	0.00425	0.00604	0.7	0.482	0.016207	0.02309	0.7	0.483	0.016929	0.0241	0.7	0.482	48.9664
Log(Population)	**-0.03814**	**0.02335**	**-1.63**	**0.102**	**-0.14542**	**0.09007**	**-1.61**	**0.106**	**-0.1519**	**0.09459**	**-1.61**	**0.108**	**6.2044**
(NPR =1) x Log(Popn)	**0.08601**	**0.03417**	**2.52**	**0.012**	**0.327963**	**0.13248**	**2.48**	**0.013**	**0.342568**	**0.13895**	**2.47**	**0.014**	**3.29975**
Log(Tr time to mkt.)	**-0.0213**	**0.01367**	**-1.56**	**0.119**	**-0.08122**	**0.05163**	**-1.57**	**0.116**	**-0.08484**	**0.0539**	**-1.57**	**0.116**	**3.80416**
(NPR =1) x L(Tr. Time mkt.)	**0.037598**	**0.02327**	**1.62**	**0.106**	**0.143364**	**0.08849**	**1.62**	**0.105**	**0.149748**	**0.0927**	**1.62**	**0.106**	**2.22675**
SR water dummy	-0.00659	0.01708	-0.39	0.699	-0.02515	0.06518	-0.39	0.7	-0.02619	0.06768	-0.39	0.699	0.279482
(NPR =1) x SR water dummy	0.042246	0.03352	1.26	0.208	0.160938	0.12804	1.26	0.209	0.173403	0.14212	1.22	0.222	0.123202
Proportion of adults	0.049864	0.07618	0.65	0.513	0.190133	0.29005	0.66	0.512	0.198601	0.30308	0.66	0.512	0.418544
(NPR =1) x Prop of adults	-0.09871	0.14339	-0.69	0.491	-0.3764	0.54545	-0.69	0.49	-0.39317	0.5694	-0.69	0.49	0.21083
Acid Soil dummy	0.02417	0.02439	0.99	0.322	0.092072	0.09283	0.99	0.321	0.097857	0.10022	0.98	0.329	0.139981
(NPR =1) x Acid soil dummy	-0.01071	0.03807	-0.28	0.778	-0.0409	0.14554	-0.28	0.779	-0.04232	0.14923	-0.28	0.777	0.084851
BAAC credit use dummy	**0.192497**	**0.07486**	**2.57**	**0.01**	**0.734**	**0.28178**	**2.6**	**0.009**	**0.766688**	**0.29468**	**2.6**	**0.009**	**0.506512**
(NPR =1) x BAAC credit use	-0.0689	0.12227	-0.56	0.573	-0.26272	0.46686	-0.56	0.574	-0.27442	0.48746	-0.56	0.573	0.109848

Notes: NPR =1 if villages have no secure property rights; =0 otherwise. Notes: NPR =1 if villages have no secure property rights; =0 otherwise. ** significant at 1% level; * significant at 5% level; + significant at 10% level. ***Bootstrapped t-statistics in column (5) using 200 replications.Source: Data provided by Thammasat University, Thailand.

Table 5.14: Marginal Effects for Random Effects Tobit Model, Dependent variable (Log(soybean area)), BAAC use instrumented for, two-step procedure used, Forest Reserve Villages, Chiang Mai, 1986-1996.

Wald	chi2(19)	=	256.21		
Log	likelihood	=	-816.61501	Prob	
	Coef.	SD	Z	p>z	
NPR =1	**-5.6412**	**3.5553**	**-1.59**	**0.113**	
Year	**0.1373**	**0.0256**	**5.36**	**0**	
(NPR =1) X year	**0.0578**	**0.0342**	**1.69**	**0.091**	
Log(Population)	**0.5747**	**0.1769**	**3.25**	**0.001**	
(NPR =1) X Log(popn)	**-0.4205**	**0.2629**	**-1.6**	**0.11**	
Log(Travel time to mkt.)	**-0.3933**	**0.1411**	**-2.79**	**0.005**	
(NPR =1) X Log(Travel time mkt.)	0.2509	0.1859	1.35	0.177	
Short run water dummy	**0.4296**	**0.1804**	**2.38**	**0.017**	
(NPR =1) X Short run water	-0.1250	0.2548	-0.49	0.624	
Proportion of adults	**1.7117**	**0.7309**	**2.34**	**0.019**	
(NPR =1) X Prop'n of adults	0.5615	1.0323	0.54	0.587	
Acid soil dummy	0.1046	0.2498	0.42	0.676	
(NPR =1) X Acid soil dummy	**-0.7023**	**0.3382**	**-2.08**	**0.038**	
Propn of population with compulsory edn.	**1.4818**	**0.4058**	**3.65**	**0**	
(NPR =1) X Propn w comp. edn.	-0.7140	0.5412	-1.32	0.187	
Log(Travel time to district)	**-0.4060**	**0.1537**	**-2.64**	**0.008**	
(NPR =1) X Log(Travel to distt.)	0.1485	0.1915	0.78	0.438	
HYV rice Dummy	**0.8906**	**0.4628**	**1.92**	**0.054**	
(NPR =1) X HYV rice Dummy	-0.1723	0.5318	-0.32	0.746	
Constant	**-14.2557**	**2.6610**	**-5.36**	**0**	
Lnsig2u	1.1478	0.1941	0.7672	1.528	
Sigma_u	1.775	0.1722	1.4676	2.147	
Rho	0.759	0.0354	0.683	0.8217	
Likelihood-ratio	Test	Of	rho=0:	chibar2(01)	369.43
Obs	=	2086			
Groups	=	561			

Notes: NPR =1 if villages have no secure property rights; =0 otherwise. ** significant at 1% level; * significant at 5% level; + significant at 10% level. Source: Data provided by Thammasat University, Thailand.

Table 5.15: First stage Random Effects Probit equation for BAAC credit use, for Log(soybean area), Forest Reserve Villages, Chiang Mai, Thailand (1986-96)

5.4 The Intensive and Extensive Frontiers of Cultivation

The main aim of the dissertation is to examine factors affecting deforestation in Forest Reserve villages of Chiang Mai. In the sections above I explore factors that affect adoption and area decisions for three main crops grown in these villages. However these are not the only crops that are grown and there is also double cropping. This is especially true for paddy rice and soybean. Thus there is no unique mapping of the sum of paddy rice, upland rice and soybean into total agricultural land. Therefore it is useful to explore how the same factors that affect crop decisions affect intensity of cultivation and total agricultural land as a whole.

5.4.1 Intensity of cultivation

Boserup (1965) in her classic exposition of factors governing agricultural expansion in developing countries, especially in Asia, defined agricultural intensification as "*…the gradual change towards patterns of land use which make it possible to crop a given area of land more frequently than before*." (pp 43). In this definition she thus departed from the definition of intensification that measured increased use of inputs per hectare of cropped area. In this dissertation, the Boserup measure of intensity is used: Intensity of cultivation is measured by a variable that is the response to the question "*What percentage of agricultural land is being used (for cultivation) in the village, in this year?*" Implicit in this question is the understanding that the village has agricultural land that has been left fallow. Thus the percentage of land cultivated in time t, by village i, is assumed to be defined as:

% of land cultivated at time t in village i= [(Total land cleared and potentially fit for cultivation - Area left fallow at time t by village i)/Total land cleared and potentially fit for cultivation]X100

5.4.1.1 Results for Intensity of Cultivation

Since the intensity of cultivation is measured as a categorical variable, with each value representing an interval, I estimate the equations for intensity of cultivation using a random effects interval regression model. Similar to the procedure followed for the crop area equations, I estimate a reduced form equation where BAAC credit use is endogenous. The results I discuss here use a two-step variant of the interval regression model in which the first step estimates a reduced form model for BAAC credit use, using a random effects probit model. Results are presented in Table 5.16. The specifications in different columns are explained as follows:

- Column (1) presents a random effects interval regression which assumes BAAC credit use is exogenous.

- Column (2) presents a single equation random effects interval regression model which includes, along with the other explanatory variables, the proportion of population in the village that has compulsory education.

- Column (3) is the same as column (2) with an additional explanatory variable – dummy for HYV rice growing.

- Column (4) is the same as column (3) with an additional explanatory variable – Travel time to district.

- Column (5) is a two-step variant of the random effects interval regression, where the first stage uses a random effects probit equation to estimate the model for BAAC credit use. Results from the first stage are reported in Table 5.17.

The estimation procedure for a random effects interval regression uses maximum likelihood, which is implemented using quadrature methods in STATA. Increasing the number of quadrature point from 26 to 30–the maximum allowable in STATA – does not change the magnitude of coefficients by more than 1% for all specifications. All reported coefficient estimates are thus stable. Reading Table 5.16 from left to right shows that the estimates are similar. In Column (1) where BAAC credit is assumed to be exogenous, the variable is positive and significant. However the variable does not remain significant once it is instrumented for, in column (5). There are three instruments used to identify the BAAC credit use equation. These are proportion of population that has compulsory education, travel time to the district center and HYV rice use dummy. BAAC credit use is estimated using a random effects probit equation. Results are shown in Table 5.17 and are discussed below. The predicted value of BAAC credit use from this equation is used in the second stage equation to model the intensity of cultivation. Standard errors are bootstrapped over 200 replications. Rho, the proportion of total variance contributed by the panel level variance is 0.36 (standard error = 0.02) for this model. The panel level variance is significantly different from the pooled estimator.

Results in Table 5.16 show that a 1% decrease in travel time to market increases the percentage of agricultural land cultivated by 2.9% points. Population has no effect on the intensity of cultivation for either group of villages. Short run crop water availability increases the percentage of area cultivated by almost 6 percentage points. This may be occurring if short run crops such as soybean and mung bean are grown on intra-marginal lands.

Results show that the effects of explanatory variables are different for NPR villages. On average NPR villages cultivate land less intensively than APR villages. NPR intensity of cultivation is less on average by 71 percentage points. Secondly, for NPR villages, there is almost no effect of a change in travel time to market (travel time estimate for NPR villages = 0.343; z=0.42; Prob>Chi-square =0.67). Short run water availability also has no effect on intensity of cultivation in NPR villages (the short run water coefficient in NPR villages = 1.6; Z-statistic = 1.04; Prob>Z= 0.30).

5.4.1.2 BAAC credit use equation for intensity of cultivation

To estimate the first stage of the model in column (5) of Table 5.17, I estimate BAAC credit use using a random effects probit equation. Results are presented in Table 5.17. For the villages included in this estimation sample, an increase in travel time to market by 1%, increases the likelihood of BAAC credit use by 0.4%. Sufficient water availability for short run crops increases the likelihood of BAAC credit use by 0.4%. A 1% increase in the proportion of adults increases the likelihood of BAAC credit use by 1.6%. All the identifying instruments are significant. A 1% increase in travel time to the district center decreases the likelihood of BAAC credit use by 0.4%, and the use of HYV rice in a village during the study period increases probability of use of BAAC credit use by 2%. For NPR villages, the effects of growing HYV rice and proportion of population with compulsory education diminish significantly. Growing HYV rice during the study period leads to a significant but smaller increase in the probability of BAAC credit use (=1%).

	Random Effects singular w BAAC credit use	Reduced form Random Effects singular w Propn. With compulsory edn	Reduced form Random Effects singular w Propn. With compulsory edn and HYV use	Reduced form Random Effects singular w Propn. With compulsory edn and HYV use and Travel time to dist. Center	Random Effects Interval Regression Instrumental Variables
	(1)	(2)	(3)	(4)	(5)
NPR dummy =1					**-71.091**
					(2.15)*
Year	0.046	0.172	0.146	0.147	-0.269
	(0.29)	(1.1)	(0.93)	(0.94)	(-1.26)
(NPR =1)*year	-0.122	-0.123	-0.053	-0.063	0.485
	(-0.85)	(-0.86)	(-0.37)	(-0.43)	(-1.43)
Log(Village Population)	1.927	2.586	1.6	1.575	0.328
	(1.32)	(1.77)+	(1.08)	(1.07)	(0.2)
(NPR =1)*Log(Village Popn)	-2.476	-2.742	-2.21	-2.252	0.083
	(-1.37)	(-1.51)	(-1.19)	(-1.21)	(0.04)
Log(Travel time to market)	**-2.342**	**-2.595**	**-2.671**	**-1.878**	**-2.868**
	(2.57)*	(2.87)**	(2.96)**	(1.72)+	(2.91)**
(NPR =1)*Log(Tr time to mkt.)	**2.554**	**2.673**	**2.86**	**2.807**	**3.212**
	(2.21)*	(2.33)*	(2.51)*	(1.95)+	(2.52)*
Short run water dummy	**5.836**	**6.246**	**5.879**	**5.756**	**5.716**
	(4.01)**	(4.29)**	(4.04)**	(3.95)**	(3.87)**
(NPR =1)*SR water dummy	**-4.399**	**-4.608**	**-4.399**	**-4.16**	**-4.11**
	(-2.11)*	(2.21)*	(2.11)*	(1.99)*	(1.92)+
LR water dummy	-3.264	-3.436	-3.069	-3.126	-3.06
	(-1.46)	(-1.54)	(-1.38)	(-1.4)	(-1.37)
(NPR =1)*LR water dummy	3.474	3.799	3.843	3.856	3.343
	(1.14)	(-1.25)	(-1.26)	(-1.27)	(1.1)
Proportion of adults	**-9.643**	-9.151	-9.145	**-9.645**	-7.157
	(-1.65)+	(-1.56)	(-1.57)	(1.65)+	(-1.16)
(NPR =1)*Propn of adults	**32.385**	**31.478**	**31.273**	**31.152**	**28.112**
	(4.03)**	(3.92)**	(3.90)**	(3.87)**	(3.25)**
Acidic soil dummy	**-8.274**	**-8.235**	**-8.141**	**-8.24**	**-7.973**
	(-3.96)**	(3.94)**	(3.90)**	(3.95)**	(3.82)**
(NPR =1)*Acidic soil dummy	-0.377	-1.076	-0.939	-0.885	-0.85
	(-0.14)	(-0.4)	(-0.35)	(-0.33)	(-0.3)
Propn with compulsory edn.		3.821	3.39	3.369	
		(1.23)	(1.09)	(-1.08)	
(NPR =1)*Propn w comp. edn.		0.531	0.774	0.701	
		(0.13)	(0.19)	(-0.17)	
HYV rice dummy			**13.531**	**13.453**	
			(3.65)**	(3.63)**	
(NPR =1)*HYV rice dummy			**-10.329**	**-10.434**	

			(2.50)*	(2.53)*	
Log(Travel time to distt.)				-1.592	
				(-1.29)	
(NPR =1)* L(Travel time to dist)				0.467	
				(0.3)	
BAAC credit use dummy	**4.959**				4.93
	(2.80)**				(1.09)
(NPR =1)*BAAC credit dummy	-1.202				-1.904
	(-0.51)				(-0.28)
Constant	**65.433**	**51.902**	**48.576**	**51.837**	**104.437**
	(4.70)**	(3.73)**	(3.50)**	(3.69)**	(4.88)**
Observations	2204	2204	2204	2204	2204
Number of ID	628	628	628	628	628

Notes: NPR =1 if villages have no secure property rights; =0 otherwise. ** significant at 1% level; * significant at 5% level; + significant at 10% level. ***Bootstrapped t-statistics in column (5) using 200 replications. Source: Data provided by Thammasat University, Thailand.

Table 5.16: Random Effects Reduced form single equation and Interval regression for Intensity of Cultivation, Forest Reserve Villages, Chiang Mai, Thailand 1986-1996.

Dependent variable: BAAC credit use dummy	Coef.	Std. Err.	Z	P>|z|
NPR dummy =1	-3.723	3.504	-1.06	0.288
Year	**0.148****	**0.026**	**5.75**	**0**
(NPR dummy=1) x Year	0.048	0.034	1.39	0.165
Log(Village population)	0.581	0.179	3.26	0.001
(NPR dummy=1) X L(population)	-0.416	0.253	-1.65	0.1
Log(Travel time to market)	**-0.361***	**0.142**	**-2.54**	**0.011**
(NPR dummy=1) X Log(Travel time)	0.204	0.185	1.1	0.27
Short run water sufficiency	**0.455***	**0.184**	**2.47**	**0.013**
(NPR dummy=1) X short run water.	-0.151	0.262	-0.57	0.565
Long run water dummy	-0.132	0.286	-0.46	0.643
(NPR dummy=1) X long run water dummy	0.293	0.381	0.77	0.442
Proportion of adults	**1.573***	**0.722**	**2.18**	**0.029**
(NPR dummy=1) X proportion of adults	0.515	1.033	0.5	0.618
Acidic soil dummy	0.065	0.249	0.26	0.795
(NPR dummy=1) X acidic soil dummy	**-0.834***	**0.338**	**-2.47**	**0.014**
Proportion with Compulsory education	**1.398****	**0.402**	**3.48**	**0.001**
(NPR dummy=1) X Propn with compulsory education	**-1.047+**	**0.539**	**-1.94**	**0.052**
HYV rice dummy	**2.065****	**0.439**	**4.71**	**0**
(NPR dummy=1) X HYV rice dummy	**-1.021***	**0.482**	**-2.12**	**0.034**
Log(Travel time to district)	**-0.408***	**0.150**	**-2.71**	**0.007**
(NPR dummy=1) X Log(Travel time to District)	0.160	0.187	0.86	0.392
Constant	**-16.336****	**2.688**	**-6.08**	**0**
/lnsig2u	1.234	0.171		
sigma-u	1.854	0.158		
Rho	0.775	0.030		

Notes: NPR =1 if villages have no secure property rights; =0 otherwise. Source: Data provided by Thammasat University, Thailand.

Table 5.17: First-stage equation results for Interval regression, Dependent variable is BAAC credit use binary variable, Forest Villages, Chiang Mai 1986-1996.

5.4.2 Total Agricultural Land

I use village agricultural area to measure the extensive frontier of cultivation. This definition ignores de facto encroachment on surrounding forest land which may not have been measured if village headmen are trying to keep their responses consistent with data supplied on total (official) village area. In Forest Reserves where property rights are absent, encroachment is likely to be high. In this sense, estimation results represent a lower bound.

5.4.2.1 Results for Agricultural Land

To investigate land expansion as measured by village agricultural land, I use the same variables as above. Variables that affect intensity of cultivation should also affect land expansion. Results are presented in Table 5.18. I estimate a random effects equation via Generalized two stage least squares to estimate the model for agricultural land. The dependent variable is in logs. Columns in Table 5.18 are defined as follows.

- Column (1) presents the random effects equation for agricultural land, assuming BAAC credit use is exogenous.
- Column (2) presents a random effects equation for agricultural land that includes the proportion of population with compulsory education amongst the explanatory variables.
- Column (3) presents the same specification as in column (2) but adds the HYV rice to the list of explanatory variables.
- Column (4) presents the same specification as in column (2) but adds travel time to the district to the list of explanatory variables.
- Column (5) presents the same specification as in column (3) and adds the travel time to district to the list of explanatory variables.
- Column (6) is a random effects model with BAAC credit use instrumented for, by using three identifying instruments. These are proportion of population with compulsory education, travel time to the district and HYV rice dummy. The

results from the first stage random effects equation for BAAC credit use are shown in Table 5.19.

Results in column (6) show that a 1% increase in village population leads to a 0.4% increase in area devoted to agricultural land in the villages in the estimation sample. BAAC credit use increases agricultural land by 1.1% in the villages constituting this estimation sample. A 1% increase in travel time to the market increases the area under cultivation in APR villages by 0.16%. Presence of acidic soil in APR villages reduces agricultural land by 0.3%.

The effects of travel time to market and acidic soil disappear in NPR villages: the travel time coefficient for NPR villages = 0.032; z= 1.12; P>Z = 0.26) and, acidic soil dummy for NPR villages = 0.033; z= 0.48; P>z = 0.63). Presence of sufficient water for long run crops increases the total agricultural land in a village by 0.14%.

5.4.2.2 BAAC credit use equation for agricultural land

To estimate the equation in column (6) in Table 5.18, I estimate a first stage random effects equation for BAAC credit use. Results are presented in Table 5.19. A 1% increase in village population increases probability of BAAC credit use by 0.06%. Sufficient water for short run crops increases the probability of BAAC credit use by 0.05%. The identifying instruments are all significant in explaining BAAC credit use: A 1% increase in the proportion of population with compulsory education increases the likelihood of BAAC credit use by 0.12%; A village that grows HYV rice during the study period is 0.26% more likely to use BAAC credit; and, an increase in travel time to district by 1% reduces the likelihood of BAAC credit use by 0.06%.

For the subset of NPR villages in this estimation sample, the effect of population disappears. A 1% increase in the proportion of people who have compulsory education reduces the likelihood of BAAC credit use by 0.08%.

The variables that are significant in explaining BAAC credit use in this sample are the same as those in the intensity of cultivation estimation sample, with some exceptions. In the intensity of cultivation sample, village population has no effect on BAAC credit use and travel time to market has a significant and negative impact on the probability of BAAC credit use. The proportion of adults in the village also has a significant effect on BAAC credit use in the intensity of cultivation sample. It does not in this sample. Acidic soil has a negative impact on the intensity of cultivation in NPR villages. The effect is much larger than the effect in this estimation sample (presence of acidic soil decreases the probability of BAAC credit use by 0.8% in NPR villages in the intensity of cultivation sample). The variables that are used to identify the BAAC credit use equation are all significant in both estimation samples, but the magnitudes are different. Particularly growing HYV rice in a village included in the intensity of cultivation sample, increases probability of BAAC credit use by 2%. In the agricultural land estimation sample, this increase is only 0.2%. Although the magnitudes are small, these differences can be explained by the fact that the estimation samples are different. The number of observations in the agricultural land estimation sample is 1989 (no. of villages are 622). The number of observations in the intensity of cultivation sample is 2204 (no. of villages are 628).

	RE w BAAC dummy	RE w/ compulsory education	RE compulsory education and HYV rice dummy	RE compulsory education & Travel time to district	RE compulsory education & Travel time to district & HYV rice dummy	IV RE BAAC w/ compulsory education & Travel time to district & HYV rice dummy
	(1)	(2)	(3)	(4)	(5)	(6)
NPR dummy =1	1.023	0.966	**1.963**	**1.419**	**2.43**	-0.651
	(1.19)	(1.15)	(2.29)*	(1.66)+	(2.79)**	(-0.35)
Year	0.005	0.006	0.006	**0.008**	**0.008**	**-0.022**
	(0.97)	(1.27)	(1.27)	(1.54)	(1.56)	(1.76)+
(NPR=1) x year	-0.002	0	0	-0.001	-0.001	0.018
	(-0.32)	(-0.01)	(-0.05)	(-0.19)	(-0.17)	(0.86)
Log(Village Population)	**0.498**	**0.495**	**0.467**	**0.504**	**0.476**	**0.427**
	(7.63)**	(7.63)**	(7.22)**	(7.78)**	(7.37)**	(5.33)**
(NPR=1)x Popn	-0.085	-0.089	-0.075	-0.096	-0.081	0.021
	(-0.97)	(-1.01)	(-0.85)	(-1.09)	(-0.93)	(0.21)
Log(Trv time to mkt.)	**0.113**	**0.119**	**0.117**	**0.074**	**0.071**	**0.158**
	(3.75)**	(3.98)**	(3.94)**	(2.27)*	(2.17)*	(4.04)**
(NPR =1)xL(Trv time)	**-0.088**	**-0.095**	**-0.091**	-0.056	-0.051	**-0.126**
	(2.23)*	(2.42)*	(2.34)*	(-1.31)	(-1.2)	(2.59)**
SR water dummy	-0.003	0.011	0.005	0.017	0.012	-0.055
	(-0.09)	(-0.28)	(0.13)	(0.45)	(0.31)	(-1.12)
(NPR=1)x SR water	-0.045	-0.057	-0.052	-0.065	-0.06	0.005
	(-0.81)	(-1.03)	(-0.94)	(-1.18)	(-1.1)	(0.08)
LR water dummy	-0.072	-0.078	-0.073	-0.075	-0.07	-0.041
	(-1.28)	(-1.41)	(-1.32)	(-1.35)	(-1.26)	(-0.62)
(NPR=1)x LR water	**0.181**	**0.191**	**0.192**	**0.189**	**0.19**	**0.145**
	(2.23)*	(2.38)*	(2.39)*	(2.35)*	(2.36)*	(1.52)
Proportion of adults	0.003	-0.017	-0.027	-0.009	-0.019	-0.056
	(0.02)	(-0.11)	(-0.18)	(-0.06)	(-0.12)	(-0.31)
(NPR=1)x Propn adult	0.209	0.224	0.232	0.222	0.231	0.227
	(0.93)	(1)	(-1.04)	(0.99)	(1.03)	(0.83)
Acid soil dummy	**-0.231**	**-0.228**	**-0.23**	**-0.217**	**-0.218**	**-0.28**
	(4.05)**	(4.05)**	(4.08)**	(-3.83)**	(3.86)**	(4.13)**
(NPR =1) x Acid soil	**0.257**	**0.242**	**0.245**	**0.23**	**0.233**	**0.314**
	(3.48)**	(3.32)**	(3.36)**	(3.15)**	(3.19)**	(3.22)**
HYV rice dummy			**1.376**		**1.384**	
			(5.75)**		(5.84)**	
(NPR=1)x HYV rice			**-1.152**		**-1.158**	
			(4.33)**		(4.39)**	
L (Tr. Time to distt)				**0.129**	**0.133**	
				(3.28)**	(3.41)**	
(NPR=1)x Time to dist				**-0.116**	**-0.118**	
				(-2.52)*	(2.58)**	
Propn w comp edn.		**0.27**	**0.258**	**0.275**	**0.263**	
		(3.12)**	(2.98)**	(3.17)**	(3.03)**	

(NPR=1)*Propn w		-0.156	-0.15	-0.161	-0.155	
Comp. education		(-1.31)	(-1.26)	(-1.35)	(-1.3)	
BAAC credit use	0.015					**1.11**
	(0.29)					(2.41)*
NPR=1*BAAC credit	0.084					-0.83
	(1.19)					(-1.32)
Constant	**2.313**	**2.062**	**1.005**	**1.567**	0.49	**4.339**
	(3.78)**	(3.41)**	(1.6)	(2.52)*	(0.76)	(3.94)**
Observations	1989	1989	1989	1989	1989	1989
Number of ID	622	622	622	622	622	622
Sigma u						0.96
Sigma e						0.40
Rho						0.85
Rsq within						0.0096
Rsq between						0.14
Rsq overall						0.122

Notes: NPR =1 if villages have no secure property rights; =0 otherwise. Source: Data provided by Thammasat University, Thailand.

Table 5.18: Dependent variable Log(Agricultural area in village, in rais), Structural and Reduced form single equation Random Effects Model estimates for Log(Village area in Rais), Forest Reserve Villages, Chiang Mai, Thailand 1986-1996.

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First-stage		regression		
Number	Of		Obs	1989
Wald			Chi(21)	400
Dependent var: BAAC dummy			Chi2	0
	Coef.	S.d	Z	P>z
NPR dummy	**-1.0051**	**0.5533**	**-1.82**	**0.069**
Year	**0.0245**	**0.0033**	**7.53**	**0**
NPR=1 x year	**0.0127**	**0.0047**	**2.71**	**0.007**
Log(village population)	**0.0632**	**0.0406**	**1.56**	**0.12**
NPR=1 x L(population)	**-0.1026**	**0.0549**	**-1.87**	**0.062**
Log(Travel time to mkt.)	-0.0172	0.0211	-0.82	0.414
NPR=1 x L(Tr. Time to mkt.)	0.0250	0.0275	0.91	0.364
SR water dummy	**0.0514**	**0.0248**	**2.07**	**0.038**
NPR=1 x SR water dummy	-0.0172	0.0359	-0.48	0.632
LR Water dummy	-0.0384	0.0360	-1.07	0.286
NPR =1x LR water dummy	0.0708	0.0523	1.35	0.176
Proportion of adults	0.0232	0.1016	0.23	0.819
NPR=1 x Prop. Of adults	0.1897	0.1449	1.31	0.191
Acid soil dummy	0.0335	0.0367	0.91	0.361
NPR=1 x acid soil dummy	**-0.1326**	**0.0474**	**-2.8**	**0.005**
Propn compulsory edn.	**0.1193**	**0.0562**	**2.12**	**0.034**
NPR=1 x Propn comp. edn.	**-0.2012**	**0.0769**	**-2.62**	**0.009**
rice HYV dummy	**0.2681**	**0.1355**	**1.98**	**0.048**
NPR=1 x rice HYV dummy	-0.0663	0.1509	-0.44	0.661
Log(Travel time to distt.)	**-0.0623**	**0.0252**	**-2.47**	**0.013**
NPR=1 x L(Tr. Time to distt)	0.0265	0.0296	0.89	0.371
Constant	**-1.9417**	**0.4102**	**-4.73**	**0**

Notes: NPR =1 if villages have no secure property rights; =0 otherwise. Source: Data provided by Thammasat University, Thailand.

Table 5.19: First stage equations for Log(agricultural land) IV Random Effects regression, Forest Reserve Villages, Chiang Mai, Thailand 1986-1996.

6 Discussion

6.1 Introduction

In this dissertation I examine the key factors that influence decisions regarding adoption and area devoted to three main crops grown in the Forest Reserves of Chiang Mai province, Thailand.

On the policy level, such a crop-wise exploration is useful for many reasons: First, if certain crops are responsible for encouraging new land being brought under cultivation or if agricultural practices associated with them are detrimental to the ecosystem, then a crop-wise analysis can help understand the factors affecting their cultivation. Secondly, if there has been an effort to promote certain crops, as there has been to promote soybean in North Thailand, then a crop-wise analysis can highlight factors affecting its adoption and acreage. Finally, understanding the magnitudes of impacts on crop adoption and acreage of population and roads can also help understand certain trade-offs. If for example, road building is being considered as a policy option in a region, but there is evidence that it affects crop adoption and acreage, then understanding which crops are affected most can help to understand otherwise unintended repercussions of this policy.

I also explore the extent to which agricultural land within Forest Reserve villages is affected by the same factors as those influencing crop decisions. Although I cannot gauge the extent to which the three crops are driving agricultural expansion, an analysis such as this can help to assess what factors are important to keep in mind when understanding the forces behind agricultural expansion.

6.2 Summary of main results

In this dissertation I estimate random effects reduced form equations for three main crops – paddy rice, upland rice and soybean. I also estimate reduced form random effects equations for village agricultural land and intensity of cultivation. Some conclusions with respect to the main explanatory variables are below:

Effect of population

Results from crop area equations show that a 10% increase in population leads to an 8% increase in area devoted to paddy rice and a 4.4% increase in area devoted to upland rice. This finding is consistent with home consumption constituting an important part of the Thai farmer's production decisions. (The National Food and Nutrition survey of Thailand found that in 1986, home production accounted for almost 40% of food consumed at home for agricultural farmers in North Thailand.) Upland rice is mainly a subsistence crop; paddy rice is grown for the market and for home consumption. Significant population effects on the acreage of these two crops are expected.

The study also finds that a 10% increase in population leads to a 4.3% increase in agricultural land. This is consistent with the findings in Cropper et al. (1999), who report that a 10% increase agricultural household density in North Thailand increases agricultural land by 4%. However, it is higher than the elasticity of cleared land with respect to population reported in a spatially explicit study of the effects of population and transportation costs in Cropper et al (2001): In that study, a 10% increase in population leads to a 1.5% increase in cleared land in the forested areas of North Thailand.[46] It is lower than the elasticity reported by Panayatou (1991) for Northeast Thailand. That study reports that a 10% increase in population leads to a 15% decrease in forest cover.

The effects of population do not differ across the two sets of villages explored in this dissertation – Villages with ambiguous property rights and villages with no secure property rights. There is some evidence of a significant difference in direction of impact for soybean cultivation, but the magnitudes of impact are very small.

Effect of travel costs

I find that transportation cost has a quantitatively modest impact on agricultural decisions in the study area.

A 10% increase in travel time to the market leads to a 4.5% increase in upland rice area for the sample – with most of the increase being explained by an increase in acreage (and not adoption). The likelihood of adoption increases only by 1%. The effect on upland rice is much smaller for villages with no secure property rights (=0.2%). Although the direction of impact of travel time may seem counter-intuitive, it is important to note that upland rice is a subsistence crop. An increase in the likelihood of adoption and of area devoted to upland rice, due to an increase in travel time, may be driven by the propensity to produce a staple at home, rather than depend on the market.

[46] In this study the elasticity for cleared land with population is smaller.

Conversely, a reduction in travel time is likely to decrease this dependence on home production since markets become easily accessible.

Area devoted to soybean is not affected much: A 10% increase in travel time to the market decreases soybean area by 0.8%. To the extent that travel time to market represents the main source of variation in prices in the area, these results may suggest that cropping decisions in the area are not very responsive to markets. But it is important to refrain from such a conclusion. To assess responsiveness to markets it is important to conduct a household level analysis of behavior in the vein of Sadoulet et al. (1991). Anecdotal evidence suggests that there are market failures in the region. In the absence of complete markets household level shadow prices should be estimated, which the data for this study does not allow. Secondly, some effects of remoteness are also captured by the dummy for NPR villages, which are on average further away from markets than APR villages. Finally, these results are estimates from cross-sectional data. To the extent that villages in the panel do not witness a significant change over time in travel time to markets, these results may indicate an important role of location of villages rather than sensitivity to travel time.

For total agricultural land in a village, the effects of travel time remain small. A 10% increase in travel time to the market increases agricultural land by 1.6%.

This finding that travel time has modest effects on agricultural decisions in Forest Reserves of Chiang Mai is consistent with other studies of the region: Cropper et al. (1999) find that a 10% increase in road density leads to a 2% decrease in forest cover in North Thailand. Cropper et al. (2001) find that a 10% increase in travel time to the market leads to a 2.4% decrease in forested area in the forest areas of North Thailand. Similarly in North-east Thailand, Panayatou (1991) finds that changes in road density have an insignificant impact.

One policy conclusion from this is that road building may not have a deleterious effect on forest cover in this area, contrary to what has been found in other parts of the world. To the extent that roads provide increased access to services and markets, improving access within Forest Reserves might help to alleviate poverty without affecting forests. However this result should also be treated with caution. The random effects estimators in the study reflect primarily cross-sectional variation in the data. Differences in effects of transportation costs could thus be picking up differences between location of villages.

Property Rights

In this study, I make a distinction between NPR villages and APR villages. It is important to make this distinction: villages with no secure property rights are likely to be more remote and poorer than villages that have ambiguous property rights. However the importance of this distinction in affecting agricultural decisions is mixed.

Two important effects in the study are that villages with no property rights are less likely to grow soybean and are likely to cultivate their land less intensively (being in an NPR village reduces intensity of cultivation by 71 percentage points). However magnitudes of impact of the two main variables—travel time and population—on cropping decisions are not very different for the two groups of villages. Particularly, travel time to market has a negligible effect on upland rice cultivation and agricultural land in NPR villages.

The mixed evidence is explained by the fact that the distinction between the two groups with respect to their property rights is not sharp. The data do not allow a sharper distinction. Villages with no property rights (NPR villages) are located in the same region as those with ambiguous property rights and are likely to behave similarly. First stage results also show that the two groups of villages do not differ significantly in their use of BAAC supplied credit. Feder et al. (1988) in their study of Forest Reserves in Northeast Thailand show that villages without secure property rights are less likely to invest in land. This may help to explain the significantly lower intensity of cultivation in NPR villages. They also conclude that secure property rights allow better access to credit. I am not able to draw such a conclusion from my study mainly because of the fuzzy distinction between the two groups, and, because such a conclusion merits a more detailed model of credit supply and demand. The distinction between the two groups may also be muted because residents may have different perceptions about their claims to land they occupy according to their length of residence (see for example Lanjouw and Levy (2002)). But my data does not allow this distinction.

6.3 The role of crops

A more detailed study of agricultural expansion should be based on a dataset that allows the study of household behavior. Particularly it would be useful to examine the effect that individual crop areas have on total agricultural land and the effect of the latter on deforestation. Both these links are qualitatively established in case-studies of the region and I assume them in this dissertation. However, using strong qualitative information from the region, it is possible to reach some further conclusions regarding the role of crops.

Anecdotal evidence in Thailand shows that North Thailand witnessed a large increase in deforested area. One of main reasons for this is claimed to be agricultural expansion. A large literature also supports the view that upland rice area grew at a rapid rate during the study period (ASB, (2004)). Most of these findings are supported by the study: Area devoted to upland rice grew by 14% during 1986-1996 in the study villages. Agricultural area also grew by 1.8% during the period. To the extent that both these occurred concomitantly, and that upland rice cannot be grown on land devoted to other crops, the study suggests that it may be important to do a more detailed analysis of the factors affecting rice cultivation is detrimental to the environment. Upland rice is grown on mountain slopes with thin soil and low fertility, i.e., on land that is otherwise agriculturally marginal and undisturbed. Upland rice also has a much larger surrounding ecosystem compared to paddy rice and soybean. Paddy rice and soybean can be intercropped and are usually grown on agriculturally important land. Upland rice cannot be grown with other crops. Upland rice is grown on lands which are then deserted after two or three crops have been harvested. Understanding factors that may affect the growing of upland rice is thus important. One such factor suggested by the study is travel time to market. A reduction in travel time to market reduces the area devoted to upland rice. Along with not affecting forest cover, a reduction in travel time to market may also help to reduce the incentive to adopt and cultivate upland rice. Another policy may be to encourage crops that allow multiple rotation in the lowlands, and thus reduce pressures that push the agricultural frontier to mountain slopes that are easily erodable.

7 Appendices

7.1 A Review of the literature on agriculture led deforestation

In this Appendix I discuss studies that have examined the role of transportation costs and population in determining agricultural practices and deforestation. The underlying assumption of this dissertation is that agriculture is one of the main, but not the only driver of deforestation in Forest Reserves. It is relevant to examine other studies that analyze the causes of land use and deforestation.

The first seminal study on the effect of population on tropical agriculture was done by Esther Boserup in 1965. In the study, Boserup asserted that the main effect of a change in population was on the intensity of cultivation, defined as the frequency of cropping. Population increases lead, in the long run to a shift, from extensive to more intensive systems of land use. The other contribution she made to the literature was, classifying systems of land use, to show increasing intensity. These were: Forest-fallow cultivation, Bush-fallow cultivation, short-fallow cultivation, annual cropping and multiple cropping. Under the forest-fallow system for instance, plots of land are cleared in forests each year and then planted on, for two years. Then land is left fallow for a number of years sufficient for forests to re-appear. Multiple cropping – the most intensive form of land use – occurs when the same plot of land bears two or more successive crops per year. The fallow period is non-existent.

Both variables – population and transportation costs – have been cited in the literature examining agricultural expansion although few studies examine their impact in Thailand. Cropper, Griffiths and Mani (1999) and Panayatou (1991) are especially relevant since both examine the impacts of population and transportation costs in Thailand. Cropper et al. (1999) use province-level data to estimate an equilibrium model of land clearing between 1976 and 1989. They find that population density had a large impact on land clearing in North Thailand. Road density (measured as length of road network divided by provincial area) however has no statistically significant impact on cleared area. Panayatou (1991) and Panayatou and Sungsuwan, (1989), support these conclusions in their study of population impact in Thailand. Panayatou and Sungsuwan highlight population growth as the most important driver of land use change, using state level panel data for the period 1962-1989.[47] Explanatory variables include agricultural prices, provincial income, population density and road density. They find the elasticity of forest cover with respect to road density is -0.11. However, this effect is probably biased, because the cost of access is also capitalized in land and timber prices, which are also found to be significant.

In the larger agricultural land use literature, there are broadly two types of studies in the literature that examine agricultural land use.

Population and Transport Costs in Spatially Explicit Models

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[47] It is interesting that there are several studies – albeit not in the applied economics literature – that assert that roads have had *no* impacts or very little impact in Thailand. Jones (1973) while studying the impact of improved primary highways, finds little impact on agricultural area in Northern Thailand and concludes that "*most indicators continued much as they had earlier*". He also concludes the same in Southern Thailand "*a greatly improved primary highway appeared not to have altered a declining economy*". Howe and Richards (1984) confirm their support (pp 158) to say that there seems "*…no consistent pattern of response to the presence of new or significantly improved roads, either trunkline highways or feeder roads…*". They also comment on a baseline impact of roads, over and above which there seems little incremental impact "*…No doubt the efficacy of peasant farming is dominated by factors other than the economic cost of farm-to-market transport, provided there is some kind of road available at the time of year it is needed*."

The first of these follow Von Thunen (1965), and use a reduced form econometric model to explain and predict land use at the level of a pixel, assuming that land will be devoted to its most profitable use. This group of studies (see for example Chomitz and Gray, (1996); Nelson and Hellerstein (1996); Pfaff, (1997); Cropper, Puri and Griffiths (2001); Deininger and Minten (1996); and, Muller (2004)) customarily use physiographic information at the level of the pixel, such as soil type, elevation, slope to explain land use. Data is derived from a compendium of spatially explicit layers. Additional information such as population (usually measured at a much coarser level of aggregation, such as district or county or province) is used along with a complex measure of access to the market. This access variable is usually weighted for road presence, road quality and location of population centers (a proxy for market locations). The results from such models are fairly straight forward and explicit: Steeper slopes, higher elevations and bad soil reduce the probability that land is converted to agriculture (from forest); Commercial crops are likely to be grown closer to markets, while subsistence crops are grown further away; and, higher population is correlated with a higher probability of the pixel of land being cultivated.

Chomitz and Gray (1996), in one of the first analyses to employ farm-gate prices to this end, find evidence of strong declines in farm-gate price, and hence deforestation, with increasing distance from the road and with increasing on-road distance to market. They find each of these declines to be notably more pronounced for commercial than for semi-subsistence farming. They estimate a multinomial logit model for a spatially explicit GIS data set, and exclude forested areas in National Parks and Sanctuaries. Specifically they find that roads are much more important for commercial farming than for semi-subsistence farming. Plots of land that are otherwise well-suited to agriculture (moderate slope, moderate nitrogen and suitable soils) and located on a road have a probability of 63% of being cultivated (49% of which is the probability of being used for commercial cultivation, and 13% is the probability of being used for semi-subsistence cultivation). As distance to the road increases, the probability that land is being used for commercial cultivation reduces much more than the probability that the land is used for semi-subsistence cultivation. At a distance of 10 km from the road, the likelihood that a plot of land is cultivated is negligible (about 2%).

Nelson and Hellerstein (1997) analyze the impact of access on different land uses using raster-based spatially explicit data for Mexico. They use three different measures of access: access of plot the nearest road, access to the nearest population center and access to the nearest small population center or village. Using a multinomial logit model that weights the attributes of neighboring pixels to account for spatial dependence, they find, as predicted, that increasing the cost of access to the road and to a village increases the probability that a pixel remains forested. A fall in costs increases the probability that the plot is devoted to crop area.

Most of these studies also find that physiographic variables have stronger explanatory power than socio-economic variables in predicting land use although socio-economic variables such as population are measured at a much coarser level. Most studies (with two exceptions – Muller (2004); and, Cropper, Griffiths and Mani (1992)) use a single cross-section dataset for examining land use.

To my knowledge there is only one other study that examines factors impacting land use *within* forest reserve areas: Nelson, Harris and Stone (2001) combine spatial and institutional analysis. They mainly analyze whether providing land users with secure property rights results in less deforestation in the Darien province of Panama. They estimate a multinomial logit model with spatial and socio-economic data using land use maps for 1997 and raster grids of 500 x 500 meters.[48] Although no economic activity is supposed to take place within the study area, the study finds that farmers have been able to encroach into these areas and clear them for agriculture. Other than geographic variables like slope of plot, elevation and soil quality, they use protection dummies and land use adjusted cost of travel to instrument for socio-economic variables. Their main conclusion is that protecting an area has not reduced the likelihood of deforestation. However the study does not provide any other implications for policy: Since it mainly uses geographical variables to explain the likelihood of deforestation, it does not provide any other tools to policy makers such as what demographic or socio-economic category of households are more likely to undertake deforestation related activities. They also do not differentiate between land uses such as annuals and perennials – both of which have different implications for soil fertility and subsequent land quality. Neither is the study able to make any conclusions about intensity of land use.

There are two other studies that examine the role of access. Deininger and Minten (1996) and Cropper, Griffiths and Puri (2001) use impedance weighted access

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[48] Although the study mentions a land use map for 1987 and present a transition matrix for it, they do not estimate the probability of transition. Only data for land use in 1997 is used.

as an explanatory variable to measure the effect of access on deforestation. The effect of road building on the probability that a pixel is cleared, within a protected area, obviously diminishes, but remains significant. Deininger and Minten (1996) use cross-sectional data for two Mexican states and use a 'protected area' dummy to identify pixels located in protected areas. Cropper, Puri and Griffiths (2001) similarly use cross-sectional data for Northern Thailand, and infer that plots of land located within protected areas in Thailand, are as likely to be cleared as those outside, if one accounts for the fact that plots located within protected areas are less fertile. The study assumes protected area (which include both, National Parks and Wildlife Sanctuaries) boundaries and locations to be endogenous. Additionally, the study finds that plots of land located within Wildlife Sanctuaries – that are more effectively protected from encroachers than National Parks are – are less likely to be deforested. The elasticity of population density in forest areas, measured at the means of explanatory variables is 0.15, the elasticity of cost of impedance weighted travel is -0.24. Effectively this means that doubling population density within forest areas, from an average of 40 persons per square kilometer, increases the probability of clearing, from 0.15 to 0.18. The impact of travel costs is higher. Bringing a pixel closer to a paved road by 1.5 kms increases the probability of clearing by 5%. Both studies group different non-forest land uses into one category, 'cleared', thus ignoring the different motivations that may affect different land uses. Both these studies use primarily plot level characteristics (other than population which is measured at the district/municipio level) to infer the likelihood that plots of land are cleared.

The advantage of these studies is that all the explanatory variables are truly exogenous and study estimates are not biased by possible endogeneity. On the other hand, although these models are fairly rigorous, one disadvantage is that they are ill-suited to providing insights into how socio-economic factors can affect agricultural decisions. An exception is a study by Deininger and Minten (1996), in Mexico, that concludes that poverty has a significant impact on the likelihood that a plot will be cleared and consequently cautions that statements such as “roads cause deforestation” may be an exaggeration.

This limitation, that most studies using the pixel as the level of analysis are unable to explain the role of socio-economic characteristics in explaining deforestation, is alleviated, to some extent, by studies using the agricultural household as their main unit of analysis. These studies use socio-economic variables to analyze the role of main determinants with respect to the household.

Population and Transport costs in Agricultural Household Models.

The role of population has been famously discussed by Boserup (1965) in her classic exposition of agricultural practices in Asia. Boserup laid out the fundamentals of agricultural expansion in under-developed and developing countries. Her main thesis was to emphasize the importance of population in determining the intensity of cultivation (and frequency of fallow).

Studies that consider the subject of agricultural expansion often tend to concentrate on the role of population but ignore the role of market access. The role of population is fairly straight-forward: An increase in population should lead to an increase in the demand for agricultural land. The magnitude of this effect depends on other counter-vailing attributes. Thus if the increase in population is absorbed by the manufacturing or the services sector, agricultural expansion is expected to be modest. Effects on the agricultural frontier are also not straight-forward if labor mobility is low or markets are not well developed.

Angelsen and Kaimowitz (1996) in their study of factors affecting the agricultural frontier, define three types of agricultural households, depending on their objective functions. These are: 'subsistence households' – or households that aim to only achieve an exogenously specified consumption level; 'perfect market households' or households that face complete and perfectly functioning markets; and, households that face imperfect markets. Implicit in this typology is the assumption that transportation costs are exogenously imposed on households.[6]

It is instructive to see the implications of transportation costs and population changes in studies that use this typology:

The subsistence household model is frequently used for households that are known to be remote from markets. In these models, as productivity of agricultural land increases (diminishes), households reduce (increase) the amount of land cultivated. Similarly as prices of agricultural commodities increase, the amount of land cleared increases. In these models, since the production target is to meet an exogenously determined consumption goal, the per hectare labor intensity is endogenous and since each farmer clears the same amount of land, the total amount of land cleared is a function of population which is assumed to be exogenous. A fall in transport costs reduces the amount of area devoted to agriculture *if* it reduces costs of inputs. Outputs are not, typically, marketed. These models follow Boserup (1965) in that agricultural area, intensity of cultivation, frequency of fallow, are all determined by the farmer's desired consumption goal, and not by the market.

The subsistence model paradigm is used by, for example, Dvorak (1992) and Godoy et al. (1997). Godoy et al. (1997) examine a sample of 200 Amerindians (from Honduras) to assess the impact of roads and population on deforestation, using a Tobit model. The dependent variable is area of primary forest cleared. An important feature of the study is its discussion of the "continuum of integration to the market" which is a function of villages attributes. Villages thus differ in their responses to policy, depending on where they lie on this 'autarky-market continuum'[49], which in itself is a function of presence of physical infrastructure such as roads.[50] However the 'autarky-market continuum' or indeed the different effects of varying degrees of market access, are also not discussed further. Instead income levels are hypothesized to be correlated with access and accordingly, different effects on agricultural land. Income levels evolve as part of the household's 'life-cycle'. The life-cycle hypothesis used by the study, postulates that at low levels of income (and at relatively remote locations), households have primitive technology and clear small plots of land. Asset accumulation takes place by tree planting and leaving land fallow. At higher incomes, associated with better access to markets, households invest in annual crops. At the third level, still richer households reduce land clearing because of greater off-farm

[49] The economics literature generally discusses as a bifurcation – presence, or, absence of markets.

[50] They assume road placement and construction to be exogenous.

labor mobility and larger investments in productivity enhancing technologies. Their results are not very robust since these suffer from small sample limitations. Further though they present the 'life-cycle hypothesis' of forest clearing, they don't test it.[51]

The second type of models considered in the context of the agricultural households, are the Chayanovian models, named after a Russian Economist of the 1960s. These assume that farmers maximize utility functions, which is a function of consumption and leisure. Similar to subsistence models, farmers make trade-offs between consumption and leisure.[52] Models assume that labor markets are not perfect. So market prices do not guide the trade-off between consumption (labor) and leisure, and there is both, an income effect and a substitution effect. Thus when prices or agricultural productivity increase, a farmer desires more leisure (the income effect) but also increases the amount of cleared area, since per hectare output has increased (the substitution effect).

Angelsen (1996) analyzes subsistence and Chayanovian models where labor is the only input, technology is specified and production costs are related to the time spent clearing plots of land. Transportation costs enter this study via a measure of the time taken to reach plots cleared. He uses a Stone Geary type of utility function with a pre-specified subsistence consumption target. For farmers that derive a large part of their income from agriculture, the impact on leisure (the income effect) is dominant. Thus increases in output farm gate prices (which may be generated by a fall in

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[51] They also use the household head's perception of the definition of primary forest, which respondents had difficulties identifying, especially while distinguishing between primary forest or long time secondary forest.

transport costs) or increases in agricultural productivity, lead to a decrease in the amount of land cultivated – as in the case of subsistence models. At higher levels of income, farmers are less willing to give up leisure. Importantly, an increase in population leads to a less than proportional rise in amount of land cleared, because farmers have to walk further. A decrease in transportation costs, on the other hand, leads to more cleared forest since the income and the substitution effects work in the same direction.

The third type of household model – the perfect markets model – assumes agricultural households are price takers and prices are exogenously specified. These models assume that labor markets exist and are perfect. Thus labor is perfectly mobile and individuals can always find employment at the existing wage rate. Implicitly population is endogenous in these models.[53] There are very few models of agricultural households that examine land area decisions and assume markets to be perfect (see for example, Dwayne, (1992); Lopez, (1984)). This is because small-holder farmers are usually located in under-developed remote areas, and it is extremely unlikely that farmers face complete and perfect markets. An exception is a study of agricultural households by Deininger and Minten (1996a). Deininger and Minten model households that divide their time between on-farm activities and wage labor but they don't hire labor to work on the farm.[54] Depending on the constraint that

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[52] And consumption is a function of (family) labor.

[53] Since households maximize utility and markets are perfect, it implies that production decisions are separate from consumption decisions.

[54] In their model, family and hired help are not perfect substitutes, and prices are determined exogenously.

is binding, this model could be seen as either a Chayanovian model or a perfect markets model. If the hiring constraint is not binding, households are net sellers of labor and this can be seen as the typical open economy/ perfect model model. On the other hand, if the hiring constraint is binding, then the model is Chayanovian.

The main message to take away from this section is that households are modeled differently depending on how well they are integrated with input or output markets and integration with markets is usually measured by transportation costs. Effects of changes in population and transportation costs on agricultural decisions vary depending on whether households operate within perfects markets (transportation costs have most impact) or if they operate in autarky (population changes have most impact), or if they operate somewhere in the middle of this continuum (the relative weights matter). This discussion also underscores the importance of measuring magnitudes of impacts of these two factors on agricultural decisions.

Transport costs in 'Missing' Markets

More recently these two broad motivations for household decision-making – one household wanting to achieve a subsistence consumption target and another wanting to maximize profits – has been re-interpreted and re-cast in the 'missing markets' paradigm (Sadoulet and DeJanvry, (1995)). This paradigm avers that all households are profit maximizers. But, one of the reasons that some households do not participate in markets (markets are thus 'missing'), is that difficult or lack of physical access causes high transaction costs.[55] These transaction costs include not just search costs, bargaining costs and other costs that are not priced by the market but also the cost of transportation that also exacerbate them. Thus most studies use transportation costs as a proxy for transaction costs (See for example, Minten and Kyle (1999); Jacoby (2000); and Puri (2001a, 2001b)). Transportation costs lower (raise) the effective price for the seller(buyer), compared to his shadow price, and depending on how large the 'acceptable' band is, households choose to participate or not, in markets.

One implication of this is that households that are typically perceived by the outsider as being insensitive to market prices or uninterested in achieving higher levels of consumption/utility, may not be as insensitive. In Africa, De Janvry, Fafchamps and Sadoulet (1991) find the elasticity of peasant supply response of cash crops is 0.18% (implying a very low response). Peasants treat food consumption as a necessity and subsistence production is undertaken to hedge against the possibility of income shocks. A positive income shock also does not alleviate this (perceived) low response. This is explained by most economists as an increased desire for leisure and an inability to hire non-family labor. But once the authors account for shadow prices, the results are different: Increases in output response come mainly from an increased use of fertilizers. The study finds that shadow prices of food and labor increase by 8.8% and 9.3% respectively in response to cash crop price increases. Peasants for

[55] Missing markets in labor (Fafchamps, (1993)), for food (De Janvry (1991); Onamo, (1998)), credit (Eswaran and Kotwal (1996)); Rosensweig and Wolpin (1993)) and insurance (Bromley and Chavas (1988)) have been explored variously.

their part see themselves as responding sharply to external incentives, although this is not seen by outsiders.

Although with the available data, I cannot estimate subjective shadow prices, one result of the missing markets discussion is important: Households *as a whole* cannot be characterized as subsistence oriented or operating in perfect markets. Rather goods produced and bought/sold are individually characterized as either 'for subsistence' or 'for the market' or indeed as both. Thus agricultural goods become differentiated depending on their shadow values, and, transportation costs and market prices. Whether a good is produced for subsistence (i.e. the household produces the good but does not sell it) or for the market (the household produces the good and sells all of it) or partly consumes it and partly sells it, is determined not only by the shadow price of the good (to the household) but also the market price of the agricultural good. Transportation costs are one of the main reasons that market prices and shadow prices diverge and agricultural product differentiation occurs. Thus one good may be consumed as a staple (a necessity, with low market supply responses) while another may be a luxury. This implication has been hitherto ignored in the literature.

Transport Costs in Agricultural Crop Choice and Area

Studies that use the pixel as the unit of analysis are discussed in Section 1.3.1. This section discusses impacts of transportation costs, using the agricultural household as a decision making unit. Studies presented in this section underscore the role of transportation costs in affecting crop choice and decisions to participate in the market. Overall, transportation costs increase the intermediate costs to farmers and reduce farm gate prices for sellers, while increasing their prices for inputs. This affects households decisions to participate in the market (see for example, Stifel, Minten and Dorosh (2003), Jacoby (2000); Minten and Kyle (1999); Fafchamps and Shilpi (2003); Puri (2001b)); and, the mix of crops they grow (Omamo, (1998); Goetz (1992); DeShazo and DeShazo (1995); Lendleton and Howe (2000), Vance and Geoghan (1997); and, Chomitz and Gray (1996)).

The genesis of the literature studying the impact of transport costs on crop mix is also Von Thunen's (1965) study. Von Thunen suggests that differences in crop choice can be attributed to transport costs alone. (He assumes homogeneous soil fertility.) He shows that farther farmers are more likely to shift from growing perishable cash crops such as vegetables, to growing crops that are more hardy such as staples and pulses – that can be stored.

Using these insights, Stifel, Minten and Dorosh (2004) study productivity and agricultural production in Madagascar, and confirm that there is a decline in land area devoted to vegetables, associated with greater isolation. However they also find that staples (the most important of which is rice) and pulses also decline in land area. This is because in more isolated areas, more land is devoted to industrial and export crops such as vanilla, cloves and coffee. Similarly Minten and Kyle (1999) examine the effect of distance and road quality on food collection in the former Zaire and contend that road infrastructure is one of the main determinants of food price variation. Road quality, which has a large impact on access, has a significant impact on farm gate prices. They also conclude that margins earned by intermediate traders increase with worsening road quality.

Omamo (1998) shows that presence of transportation induced transaction costs can explain the seemingly 'inefficient' cropping choices of farmers in Kenya where greater resources are devoted to low-yielding food crops, instead of cash crops that have higher market returns. Omamo argues that one of the main reasons that agricultural households diversify their crops is that diversification reduces transaction costs.[56] Despite low yields associated with mixed crop strands (compared to pure crop strands) small-holder farmers decide to grow mixed crops because of high transaction costs associated specialization (pure strands). These transaction costs are often ignored by studies who thus undervalue purchased goods and overvalue goods sold. External observers therefore perceive the cropping decisions of these small holders as irrational. He uses a GAMS (Generalized Algebraic Modelling System) to simulate a linear programming production system and parametrizes it using data from East Africa.[57]

Goetz (1992) uses transport costs to model market participation and quantity decisions conditional on participation using cross-sectional data for 142 households in South-eastern Senegal. His principal thesis is that high fixed transaction costs result in failure to participate in markets. He uses a selectivity framework (bivariate probit specification) to model households switching between participation and non-

[56] Omamo draws from Douglas North's 'tension between specialization and transaction costs' as the mainstay of his hypothesis.

[57] Contrary to this, Perz (2004) claims that agricultural diversity leads to higher and more stable incomes among remote small-holders in the Amazon, while ensuring the same level of forest cover. Although he does not examine the impact of market access on participation and productivity amongst remote farmers, he hints at these considerations when he concludes that diversification stabilizes incomes, and hence is a 'win-win' strategy.

participation, thus correcting for bias caused by the exclusion of unobservable variables affecting both discrete and continuous decisions. He finds that improved market information increases the probability of participation by sellers, and access to technology increases quantities transacted by market participants.

Lendleton and Howe (2000) measure the extent of market participation use an array of variables in their household level study of agricultural decisions in Bolivia. These include distance to the road, distance to closest major town and the ratio of future prices to present prices. Since they do not have a panel dataset, they cannot measure the change in transaction costs. They assume that village prices reflect market prices plus transaction costs. Thus a change in price may indicate a change in transaction costs, or, a change in price at the central market (although that change would be the same across all villages). Thus the relative difference in change in prices reflects village specific characteristics – most of which, they assume, is derived from the difference in the degree of market integration. They use the ratio of future prices to present prices for bananas (a cash crop in this region) as a unitless proxy for the rate of market integration. However they do not define market integration and although they find that "an increasing rate of market integration leads to a large and significant increase in forest clearance", their result remains unexplained. They also find that distance to the road has a negative impact on forest clearance while distance to the closest major town has a positive impact on forest clearance. These results remain unexplained.

7.2 Appendix: Variable List for Thailand Study

Variable	Description	Pg. on Q'aire	Years missing
id	Village ID (8 digit, 1.2.3.4.5.6.7.8.) 1.2. changwat name, 3.4. amphoe name, 5.6 tambon name, 7.8 village name	1	
hh	No. of households in village	1	
male	No. of males in village	1	
fem	No. of females in village	1	
adlmale	No. of males aged 18-50 in village	1	86, 88
adlfem	No. of females aged 18-50 in village	1	86, 88
adltot	No. of people aged 18-50 in village	1	
fordum	whether village is situated in reserved forest area (1=No, 2=Yes.)	1	
ag_w2r	Does water supply for agr. use adequately supply water for second rice farming? (1=not enough, 2=enough, 3=N.A., i.e. don't use water)	3	
ag_wsc	Does water supply for agr. use adequately supply water for short-lived upland crops? (1=not enough, 2=enough, 3=N.A., i.e. don't use water)	3	
ag_wlc	Does water supply for agr. use adequately supply water for long-lived upland crops? (1=not enough, 2=enough, 3=N.A., i.e. don't use water)	3	
ag_wve	Does water supply for agr. use adequately supply water for vegetables/flower gardens? (1=not enough, 2=enough, 3=N.A., i.e. don't use water)	3	
ag_wfr	Does water supply for agr. use adequately supply water for fruit orchards? (1=not enough, 2=enough, 3=N.A., i.e. don't use water)	3	
eledum	Is there electric supply in village? (1=No, 2=Yes.)	4	
elehh	If yes, how many households?	4	
eledis	If no, how far in kms is village located from nearby village with power supply?	4	
no_tv:	no. of TVs in the village	4	
roddum	Is there any through road from village to district? (1=No, 2=yes.)	4	
Rddnum	How many routes connect the village to the district?	5	

	The most convenient routes from the village to the district can be divided into (kms each):		
aspdkm	asphalt/concrete	5	
dirdkm	dirt, or just like previous (good road) but without the top asphalt layer	5	
eardkm	just plain earth road, or simple path cleared		
trdmin	How long does it generally take to travel by most popular vehicle from district? (not counting return trip, in minutes)	5	
romdum	Is there any through road from village to market? (1=No, 2=Yes.)	5	
rdmnum	In case yes, how many routes are there?	6	
	The most convenient routes from the village to the market can be divided into (kms each):		
aspmkm	asphalt/concrete	5	
dirmkm	dirt, or just like previous (good road) but without the top asphalt layer	5	
earmkm	just plain earth road, or simple path cleared		
trmmin	How long does it generally take to travel by most popular vehicle from village to market (not counting return trip, in km)?	6	
hhpkp	No. of hhlds owning pickup trucks	6	
pkpnum:	No. of pickup trucks in village	6	
hhmbk	No. of hhlds owning motorbikes	6	
mbknum:	No. of motorbikes in village	6	
hhbck	No. of hhlds owning bicycles	6	
bcknum:	No. of bicycles in village	6	
hhmct	No. of hhlds owning E-Tan/power cart	6	
mctnum:	No. of E-Tan/power cart	6	
hhovh	No. of hhlds owning other vehicles	7	
ovhnum:	No. of other vehicles in village	7	
prddum	Are there any places for selling input factors? (fertlizer, machinery,..) (1=No, 2=Yes.)	7	86, 88,90
cemdum	Are agr. products sold at central market? (1=No, 2=Yes.)	7	86, 88,90
sumdum	Are agr. products sold at Sunday market? (1=No, 2=Yes.)	7	86, 88,90
cosdum	Are agr. products sold at Co-op store? (1=No, 2=Yes.)	7	86, 88,90
fagdum	Are agr. products sold at store of Farmers' Assocn. Group (1=No, 2=Yes.)	7	86, 88,90
oshdum	Are agr. products sold at other places? (1=No, 2=Yes.)	7	86, 88,90

Ftydum	What do most villagers use as fuel for cooking? (1=gas, 2=charcoal or fuelwood)	8	
Fdum	If villagers use wood and charcoal, do they buy it or prepare it themselves? (1=buy, 2=prepare themselves)	8	
Flotkm	If prepare themselves, how far is woodlot from village in km?	8	
Ftrmin	if prepare themselves, how long (in minutes) usually to get there, one way?	8	
Fredum	If prepare themselves, is woodlot located in reserve forest? (1=No, 2=Yes.)	8	
agrmem	No. of villagers who are members of agricultural cooperative**	8	86
agrpro	No. of villagers who are members of agricultural occupational group**	8	86
crsvdu	Do villagers use credit from “Saving for Production group”? (1=No, 2=yes.)	8	
crcodu	Do villagers use credit from cooperatives? (1=No, 2=Yes.)	8	
crbadu	Do villagers use credit from BAAC (agricultural and cooperative bank)? (1=No, 2=yes.)	8	
crbkdu	Do villagers use credit from commercial banks? (1=No, 2=yes.)	8	
crpvdu	Do villagers use credit from private credit institution? (1=No, 2=Yes.)	8	86, 88,90
crgvdu	Do villagers use credit from Revolving Loan fund from government? (1=No, 2=Yes.)	8	86, 88,90
crmrdu	Do villagers use credit from businessmen/ merchants? (1=No, 2=Yes.)	8	
crotdu	Do villagers use credit from others? (1=No, 2=Yes.)	8	
mildum	Are there any rice mills in village?	8	
milnum	If yes, how many are there?	8	
hhhag	How many households in this village do agricultural activities in the housing area for home consumption and only the surplus is sold (e.g. vegetables, fruits and others)? ***		
hhagr	How many households earn a living (occupation) by agriculture (e.g. rice growing, farming, orchard planting and others?) ***	8	86, 88,90
hhmnum	no. of hhlds having more than one occupation	9	86, 88,90

hhminc	average income of such hhlds(baht/year)	9	86, 88,90
hhsnum	no. of hhlds having just one occupation	9	
hhsinc	average income of such hhlds (baht/year)		86, 88,90
hhrnum	no. of hhlds engaged in just rice farming	9	86, 88,90
hhrinc	average income of such hhlds (baht/year)	9	86, 88,90
hhpnum	????no. of hhlds engaged in just plantations/ upland cropping	9	86, 88,90 86, 88,90
hhpinc	average income of such hhlds (baht/year)	9	86, 88,90
hhanum	no. of hhlds engaged in just annual farming	9	86, 88,90
hhainc	average income of such hhlds (baht/year)	9	86, 88,90
hhfnum	no. of hhlds engaged in just fishing	9	86, 88,90
hhfinc	average income of such hhlds (baht/year)	9	86, 88,90
hhonum	no. of hhlds engaged in just one other agr. activity	9	86, 88,90
hhoinc	average income of such hhlds (baht/year)	9	86, 88,90
hhgnum	no. of hhlds engaged just in agriculture but not necessarily in only one kind of (This appears only in 1986-1990 surveys. In 1992-1996 surveys this question is dropped, and instead replaced by (5) questions asking how many households are engaged (i) only in rice farming (hhrnum); (ii) only in plantations (hhpnum); (iii) only in annual farming (hhanum); (iv) only in fishing (hhfnum); (v) only in one other agricultural activity other than the above 4 (hhonum). These variables are listed above.)		92,94,96
hhcnum	no. of hhlds engaged in just trading/ commerce	9	
hhcinc	average income of such hhlds (baht/year)	9	86, 88,90
hhhnum	no. of hlds engaged in just household industry/cottage industry	9	
hhhinc	average income of such hhlds (baht/year)	9	
hhenum	no. of hhlds engaged in just paid employment/hired labor	9	
hheinc	average income of such hhlds (baht/year)	9	
hhtdum	common type of paid employment 1=factory 2=agriculture 3=fishing 4=services e.g. taxis 5=skilled services, e.g. mechanic, carpenter, bricklayer, plumber 6=miner 7=plantation worker (forestry worker) 8=rubber 9=others	9	

hh?num	no. of hhlds engaged in other occupations (but just one occupation)	9	
hh?inc	average income of such hhlds (baht/year)	9	86, 88,90
agwage	average wage for hired labor (baht) (per day) *For any type of activity, i.e. general wage and not just agricultural wage.	9	86, 88
hh1rai	no. of hhlds with less than 1 rai of rice paddies	9	
hh5rai	no. of hhlds with 1-5 rais of rice paddies	9	
hh10rai	no. of hhlds with 5-10 rais of rice paddies	9	
hh20rai	no. of hhlds with 10-20 rais of rice paddies	9	
hh50rai	no. of hhlds with 20-50 rais of rice paddies	9	
hhmorai	no. of hhlds with more than 50 rais of rice paddies	9	
r1frq	no. of hhlds growing rice once a year	9	86
rn2frq	no. of hhlds growing rice twice a year (but not every year)	9	86
r2frq	no. of hhlds growing rice twice a year	9	86
rm2frq	no. of hhlds growing rice more than twice a year	9	86
rkgrai	yield (harvest) per rai for majority of hhlds in previous year, in kg	9	
rprba	average selling price of rice in baht (per kg)	10	
rprsa	average selling price of rice in satang (per kg)		
rmos	common method of selling rice 1=sell to cooperative 2=sell to rice-mill 3=advance selling (futures selling) 4=trader comes to buy rice 5=others	10	86
ricesup	no. of hhlds using rice crops promoted by government (improved variety)	10	86
hhfenm	no. of hhlds using fertilizer	10	
hhfeex	fertilizer expenses per household (baht/rai)	10	86
hhfeap	common type of fertilizer application 1=natural (e.g. manure, compost, fresh vegetation) 2=chemical 3=mixture of natural and chemical	10	
*sr1c	most-grown short-lived crop This is defined as crops with growing period 4 months or less. It includes corn for animals (only, not humans), mung beans, yellow beans (soybeans?), peanuts, ??, ??, a type of rice. It does not include vegetables like	10	

	pepper, garlic, cucumber, young corn, corn-on-cob, potatoes, sweet potatoes, taro, asparagus, tomato, and other vegetables.		
hhsr1c	no. of hhlds. growing this crop	10	
sr1frq	no. of times of farming/cropping per year	10	
sr1se	What season was crop grown? 1= rainy season (June to September) 2=dry season	10	
sr1rai	area used for each hhld's crop (rai)	10	
sr1nga	area used for each hhld's crop (ngan)	10	
sr1kgrai	harvest/yield per rai in kg (for majority of hhlds)	10	
sr1prba	average selling price per kg (baht)	10	
sr1prsa	average selling price per kg (satang)	10	
sr1mos	most common method of selling 1=sell to cooperative 2=sell to mill or processing plant 3=advance selling (futures selling) 4=trader comes to buy crop 5=others	10	86
sr1hhfe	no. of hhlds using fertilizer	10	86
sr1hhfex	each hhlds' expense on buying fertilizer	10	86
sr1fert	most common method of fertilizer used 1=natural (e.g. manure, compost, fresh vegetation) 2=chemical 3=mixture of natural and chemical	10	86
*sr2c	2nd most-grown short-lived crop (See notes above for sr1c.)	10	
hhsr2c	no. of hhlds. growing this crop	10	
sr2frq	no. of times of farming/cropping per year	10	
sr2se	What season was crop grown? 1= rainy season (June to September) 2=dry season	10	
sr2rai	area used for each hhld's crop (rai)	10	
sr2nga	area used for each hhld's crop (ngan)	10	
sr2kgrai	harvest/yield per rai in kg (for majority of hhlds)	10	
sr2prba	average selling price per kg (baht)	11	
sr2prsa	average selling price per kg (satang)	11	
sr2mos	most common method of selling 1=sell to cooperative 2=sell to mill or processing plant 3=advance selling (futures selling) 4=trader comes to buy crop 5=others	11	86
sr2hhfe	no. of hhlds using fertilizer	11	86

sr2hhfex	each hhlds’ expense on buying fertilizer	11	86
sr2fert	most common method of fertilizer used	11	86
	1=natural (e.g. manure, compost, fresh vegetation)		
	2=chemical		
	3=mixture of natural and chemical		
*sr3c	3rd most-grown short-lived crop	11	
	(See notes above for sr1c.)		
hhsr3c	no. of hhlds. growing this crop	11	
sr3frq	no. of times of farming/cropping per year	11	
sr3se	What season was crop grown?	11	
	1= rainy season (June to September)		
	2=dry season		
sr3rai	area used for each hhld’s crop (rai)	11	
sr3nga	area used for each hhld’s crop (ngan)	11	
sr3kgrai	harvest/yield per rai in kg (for majority of hhlds)	11	
sr3prba	average selling price per kg (baht)	11	
sr3prsa	average selling price per kg (satang)	11	
sr3mos	most common method of selling	11	86
	1=sell to cooperative		
	2=sell to mill or processing plant		
	3=advance selling (futures selling)		
	4=trader comes to buy crop		
	5=others		
sr3hhfe	no. of hhlds using fertilizer	11	86
sr3hhfex	each hhlds’ expense on buying fertilizer	11	86
sr3fert	most common method of fertilizer used	11	86
	1=natural (e.g. manure, compost, fresh vegetation)		
	2=chemical		
	3=mixture of natural and chemical		
*lr1c	most-grown long-lived crop	11	
	This is defined as a crop having growing period more than 4 months in length, but is still an annual crop, e.g. sugarcane, rice, tapioca, jute/seisel, cotton, pineapple, tobacco, ?? (some fibercrop), ??, big watermelon). Note that perennial crops or tree crops such as mangoes, fruits, coconuts, are not included. (See later for question on these, under “tre”.)		
hhlr1c	no. of hhlds. growing this crop	11	
lr1rai	area used for each hhld’s crop (rai)	11	
lr1nga	area used for each hhld’s crop (ngan)	11	
lr1kgrai	harvest/yield per rai in kg (for majority of hhlds)	11	
lr1prba	average selling price per kg (baht)	11	

lr1prsa	average selling price per kg (satang)	11	
lr1mos	most common method of selling 1=sell to cooperative 2=sell to mill or processing plant 3=advance selling (futures selling) 4=trader comes to buy crop 5=others	11	86
lr1hhfe	no. of hhlds using fertilizer	11	86
lr1hhfex	each hhlds' expense on buying fertilizer	12	86
lr1fert	most common method of fertilizer used 1=natural (e.g. manure, compost, fresh vegetation) 2=chemical 3=mixture of natural and chemical	12	86
lr2c	2nd most-grown long-lived crop (See notes above under lr1c for this.)	12	
hhlr2c	no. of hhlds. growing this crop	12	
lr2rai	area used for each hhld's crop (rai)	12	
lr2nga	area used for each hhld's crop (ngan)	12	
lr2kgrai	harvest/yield per rai in kg (for majority of hhlds)	12	
lr2prba	average selling price per kg (baht)	12	
lr2prsa	average selling price per kg (satang)	12	
lr2mos	most common method of selling 1=sell to cooperative 2=sell to mill or processing plant 3=advance selling (futures selling) 4=trader comes to buy crop 5=others	12	86
lr2hhfe	no. of hhlds using fertilizer	12	86
lr2hhfex	each hhlds' expense on buying fertilizer	12	86
lr2fert	most common method of fertilizer used 1=natural (e.g. manure, compost, fresh vegetation) 2=chemical 3=mixture of natural and chemical	12	86
*lr3c	3rd most-grown long-lived crop (See notes above under lr1c for this.)	12	
hhlr3c	no. of hhlds. growing this crop	12	
lr3rai	area used for each hhld's crop (rai)	12	
lr3nga	area used for each hhld's crop (ngan)	12	
lr3kgrai	harvest/yield per rai in kg (for majority of hhlds)	12	
lr3prba	average selling price per kg (baht)	12	
lr3prsa	average selling price per kg (satang)	12	
lr3mos	most common method of selling 1=sell to cooperative 2=sell to mill or processing plant	12	86

	3=advance selling (futures selling)		
	4=trader comes to buy crop		
	5=others		
lr3hhfe	no. of hhlds using fertilizer	12	86
lr3hhfex	each hhlds' expense on buying fertilizer	12	86
lr3fert	most common method of fertilizer used	12	86
	1=natural (e.g. manure, compost, fresh vegetation)		
	2=chemical		
	3=mixture of natural and chemical		
hhfro	no. of hhlds with fruit orchards	12	
	Note: This does not include households doing these activities on a small-scale basis, i.e. for their own consumption only or selling just surplus; it does not include households included in 9-5 of survey (hhhag).		
arfror	average orchard size per hhld (rai)	12	
arfron	average orchard size per hhld (ngan)	12	
incfro	average income (per hhld) from orchards	12	
hhveg	no. of hhlds with vegetable gardens	12	
	Note: This does not include households doing these activities on a small-scale basis, i.e. for their own consumption only or selling just surplus; it does not include households included in 9-5 of survey (hhhag).		
arvegr	average veg. garden size per hhld (rai)	12	
arvegn	average veg. garden size per hhld (ngan)	12	
incveg	average income (per hhld) from veg. gdns.	12	
hhflo	no. of hhlds with flower gardens	13	
	Note: This does not include households doing these activities on a small-scale basis, i.e. for their own consumption only or selling just surplus; it does not include households included in 9-5 of survey (hhhag).		
arflor	average flo. garden size per hhld (rai)	13	
arflon	average flo. garden size per hhld (ngan)	13	
incflo	average income (per hhld) from flo. gdns.	13	
*tre	Most common tree crop or perennial crop. These are crops with growing periods or cycles exceeding a year (not annual crops). They include coconut, pine, palm, coco, cashew nut, tea, teak, betel nut, rubber, eucalyptus, gum, other trees with rubbery sap like rubber and eucalyptus.		
hhflo	no. of hhlds engaged in commercial crop plantation, of this crop	13	
arflor	average plantation size per hhld (rai)	13	

arflon	average plantation size per hhld (ngan)	13
incflo	average income (per hhld) from these plantations	13
*mengag	Other than what has been mentioned, most-engaged-in agricultural activity. These include bamboo planting, mushroom farming, silkworm rearing, jute, palm-tree type (?).	14
hhmeng	no. of hhlds in this activity	14
incmen	income from this activity, for majority of hhlds	14
*2engag	Other than what has been mentioned, 2nd most-engaged-in agricultural activity	14
hh2eng	no. of hhlds in this activity	14
inc2en	income from this activity, for majority of hhlds	14
*3engag	Other than what has been mentioned, 3rd most-engaged-in agricultural activity	14
hh3eng	no. of hhlds in this activity	14
inc3en	income from this activity, for majority of hhlds	14
dryagr	Is there dry season farming in village? (1=No, 2=Yes.)	14
watdry	If yes, what is source of water? 1=surface water, e.g. pond, river 2=underground water, e.g. well 3=rainwater collected or leftover water from rice-farming	14
hhdrya	no. of hhlds engaged in this type of farming	14
incdry	gross income earned last year from this activity	14
pastan	Is there any public pasture for raising animals in village? (1=No, 2=Yes.)	14 14
arpast	If yes, how many rais?	14
hhcow	no. of hhlds raising cows for sale	14
inccow	income earned per hhld per year	14
numcow	number of cows in village	14
hhcowg	no. of hhlds breeding improved breeds, promoted by gov't (including artificial fertilization)	14
hhbuf	no. of hhlds raising buffaloes for sale	14
incbuf	income earned per hhld per year	14
numbuf	number of buffaloes in village	14
hhbufg	no. of hhlds breeding improved breeds, promoted by gov't (including artificial fertilization)	14

*1hhind	most popular cottage/hhld industry	16	
	1=cloth weaving/knitting		
	2=weaving but not from cloth and not from fibers/fibrous materials		
	3=weaving from fibers/materials from fibrous plants		
	4=food preservatives using vegetables		
	5=food preservatives using animal foods		
	6=making tools from metals (e.g. knives)		
	7=making tools from clay (e.g. bricks, pottery)		
	8=jewellery, cutting gems, etc.		
	9=sculpture		
	10=embroidery		
	11=househod products from wood/fibers, e.g. rattan chairs		
	12=cement products		
	13=others		
nh1hin	no. of hhlds engaged in this activity	16	
inc1hi	income per hhld/yr from such industry	16	
sal1hi	common method of selling	16	
	1=retail		
	2=wholesale		
	3=both retail and wholesale		
	4=household hired out labor only; person buying this labor bought the raw materials and took care of selling final product		
mth1hi	month when activity begins	16	
end1hi	month when activity ends	16	
raw1hi	sources of raw materials	16	86, 88,90
	1=within village		
	2=from nearby source outside village		
	3=from faraway source outside village		
pkg1hi	packaging method	16	86, 88,90
	1=no packaging		
	2=use natural materials for packaging (e.g. palm leaves)		
	3=paper packaging		
	4=metal-based packaging		
	5=plastic packaging		
	6=foam packaging		
	7=glass bottles		
	8=others		
2hhind	2^{nd} most popular cottage/hhld industry (See 1hhind for codes.)	17	
nh2hin	no. of hhlds engaged in this activity	17	
inc2hi	income per hhld/yr from such industry	17	
sal2hi	common method of selling	17	

	(See sal1hi for codes.)		
mth2hi	month when activity begins	17	
end2hi	month when activity ends	17	
raw2hi	sources of raw materials (See raw1hi for codes.)	17	86, 88,90
pkg2hi	packaging method (See pkg1hi for codes.)	17	86, 88,90
3hhind	3rd most popular cottage/hhld industry (See 1hhind for codes.)	17	
nh3hin	no. of hhlds engaged in this activity	17	
inc3hi	income per hhld/yr from such industry	17	
sal3hi	common method of selling (See sal1hi for codes.)	17	
mth3hi	month when activity begins	17	
end3hi	month when activity ends	17	
raw3hi	sources of raw materials (See raw1hi for codes.)	17	86, 88,90
pkg3hi	packaging method (See pkg1hi for codes.)	17	86, 88,90
mthleis	month when farmers begin to have leisure time	17	86
endleis	month when leisure time ends	17	86
hhoct	no. of hhlds owning animals for own labor use (cattle)	17	
hhorct	no. of hhlds owning and also partly renting animals for own labor use (cattle)?	17	86
hhrct	no. of hhlds not owning and having to rent animals for own labor use (cattle)	17	86
hhrct86	no. of hhlds renting animals for labor use, but not specific about whether or not these hhlds also own some animals. This question appears only in the 1986 survey, and is replaced in later years by hhorct and hhrct (see above)		88-96
ctrent	rent for the above (baht/year)	17	
hhost	no. of hhlds with small (2-wheel) farm tractors	17	
hhorst	no. of hhlds renting small farm tractors	17	
strent	rent for the above (baht/year)	17	
hholt	no. of hhlds with large (4-wheel) farm tractors	17	
hhorlt	no. of hhlds renting large farm tractors	17	

ltrent	rent for the above (baht/year)	17	
useland	What percentage of agricultural land was used, of total agr. land in village? 1: Agland is >=90% of ldag 2: Agland is 75-90% of ldag 3: Agland is 50-74% of ldag 4: Agland is <50% of ldag	18	
nuse?l	reason for land not being fully used 1=bad soil 2=not enough labor 3=not profitable 4=no knowledge of how to plant 5=not enough water 6=low-lying land, prone to flooding 7=others	18	
sqlprb	what is quality of soil? 1=no problem 2=not deep enough 3=too much sand 4=??? 5=no nutrients 6=too salty (Or Alkaline) 7=too sour (Or Acidic) 8=not enough topsoil (erosion)	18	
hhorgf	no. of hhlds using organic fertilizer	18	86, 88,90
hhsltr	no. of hhlds increasing soil fertility by growing plants with nitrogen-fixing bacteria	18	86, 88,90
hhold	no. of hhlds who own land, and don't rent at all	18	
hhrpld	no. of hhlds partly owning and partly renting land	18	
hhrald	no. of hhlds owning no land (having to rent all)	18	
llds	For those referred to in last question, who mostly do they rent from? 1=family/relatives 2=others (not family) in same village 3=others (not family) but from different village	18	
sizld	total land area in village	18	
ldtitle	Mostly the type of land certificates held is: 1=title ownership 2=Naw Saw 3 3=Naw Saw 3 Kaw 4=reserve (Appln for landuse)	18	

	5=Saw Kaw 1 6=Saw Taw Kae 7=other document 8=no document		
ldagr	Out of total land, how much land is for agriculture?	18	
arffor	area set aside for community forest	18	86, 88,90
arpfor	area of comm. forest already planted	18	86, 88,90
comped	no. of villagers who have completed compulsory education but not beyond	19	
jhsch	no. of villagers who have completed junior high school	19	86
hsch	no. of villagers who have completed high school	19	
mohsch	no. of villagers who have education beyond high school	19	
phsch	no. of villagers currently in junior high school	19	86, 88,90
pmosch	no. of villagers currently in high school	19	86, 88,90
illitr	no. of those aged 14-50 who cannot read or write their names	19	
vctrng	no. of villagers getting vocational training	19	86
wkotmb	Do any villagers work outside tambon? (1=No, 2=Yes.)	22	
hhotmb	no. of hhlds with members working outside tambon	22	
wotmb	no. of women working outside tambon	22	86, 88
motmb	no. of men working outside tambon	22	86, 88
potmb	no. of people working outside tambon	22	
lagwot	lowest age of women working outside tambon	22	86, 88
hagwot	highest age of women working outside tambon	22	86, 88
lagmot	lowest age of men working outside tambon	22	86, 88
hagmot	highest age of men working outside tambon	22	86, 88
lagpot	lowest age of people working outside tambon	22	
hagpot	highest age of people working outside tambon	22	

wktype	common type of work (for jobs outside tambon) 1=factory 2=agriculture 3=fishing 4=services e.g. taxis 5=skilled services, e.g. mechanic, carpenter, bricklayer, plumber 6=miner or plantation/forestry worker 7=rubber 8=others	22	
wktpw	common type of work for women (for jobs outside tambon) (Codes same as for wktype.)	22	86, 88
wktpm	common type of work for men (for jobs outside tambon) (Codes same as for wktype.)	22	86, 88
wkpl	common job site (for jobs outside tambon) 1=within ampho (county) 2=within changwat (province) 3=outside changwat but within same region 4=other regions (there are 5 regions in all in Thailand) 5=in Bangkok 6=in other countries	22	
wkplw	common job site for women (for jobs outside tambon) (Codes as for wkpl.)	22	86, 88
wkplm	common job site for men (for jobs outside tambon) (Codes as for wkpl.)	22	86, 88
wktime	common time period of work (for jobs outside tambon) 1=every day 2=in between rice planting (i.e. during off-season) 3=less than 3 months 4=more than 3 months	22	
wktmw	common time period of work for women (for jobs outside tambon) (Codes as for wktime.)	22	86, 88
wktmm	common time period of work for men (for jobs outside tambon) (Codes as for wktime.)	22	86, 88

7.3 Appendix: Summary of Agricultural Policy Measures in Thailand

Measure	Soybean	Rice
Farm Level		
Input subsidies: Fertilizer, seed, cheap credit for inputs	+ 1967-now	+ 1966-now
Investment grants: machinery, irrigation or land leveling	Irrigable area 1974-now	Irrigable area 1950-now
Production or acreage controls		+
Guaranteed price	+	
Marketing and Processing level		
Intervention buying or price support program		+
Public Investment: research, training and extension	+ 1982-now	+ 1975-now
International trade		
Import tariff or surcharge	+ 1977-now	
Import/export quota	+*	
Export subsidies or taxes		+ 1950-86
Non-tariff barriers	+*	

Source: Adapted from Kajonwan Itharattana *Market prospects for Upland crops in Thailand* The CGPRT Working Paper series, November 1996. *The WTO commitment of import volume in 1995 for soybean was 278,947 tons with the tax rate of the import in quota of 5% and 88.1 % for the Non-quota import.

Table 1: Summary of Policy Measures In Thailand for rice and soybean

Commodity	Price elasticity	Income Elasticity
Soybean		
Direct consumption	-1.74	0.39
soybean Meal	-0.87	1.77
soybean oil	-0.62	1.23
Rice		
rice and rice products	-0.08	0.013

Source: Kajonwan Itharattana *Market prospects for Upland crops in Thailand* The CGPRT Working Paper series, November 1996

Table 2: Price and Income Elasticities for demand of Major Upland Crop Products (UCPs)

7.4 Appendix: Selectivity of Response

In the first step, I estimate four different models – a fixed effects model for the unbalanced panel, a fixed effects model for the balanced sub-panel, a random effects model for the complete unbalanced panel and finally, a random effects for the balanced sub-panel. I compare the coefficients on regressors. A rejection of the null hypothesis that the coefficients are identical, uses the caveat of the Hausman test. The Hausman specification test is used to determine if the random effects model should be used or the fixed effects model. (It assumes that the specified model is correct.) Thus a rejection of the test (christened hereon the quasi-Hausman test) of equality of the coefficients from the balanced panel and the unbalanced panel is an indicator that there is some selectivity.

The empirical model that I estimate for rice area is as follows:

$$\log(ricearea)_{it} = \alpha_0 + \sum_{k=1}^{K} \beta_{kit} x_{kit} + u_i + \varepsilon_{it}$$

where *ricearea* is the village level rice area measured in rai, α_0 is the constant, x_k is the vector of K exogenous explanatory variables, u_i is the village level effect *or* the unobserved village level heterogeneity depending on specification, and ε_{it} is the idiosyncratic error term so that $E(\varepsilon_{it}) = 0, Var(\varepsilon_{it}) = \sigma^2, Cov(u,\varepsilon) = 0$ for all villages *i* and all time periods *t*. Depending upon the specification, u_i is allowed to be correlated with the other exogenous regressors (fixed effects estimation) or not (random effects estimation).

Estimating the equation from a balanced sub-panel only, may make the estimates inconsistent if selection is correlated with either of the error terms. Using this intuition, Nijman and Verbeek (1992) construct tests to test for non-random selection. For the fixed effects estimation,

$E\{\tilde{\varepsilon}_{it} \mid \text{village is present}\} = 0$ for all villages i and all time periods t

(1)

is necessary and sufficient to prove that villages have been randomly selected. Random selection of villages will ensure consistency of fixed effects estimates. $\tilde{\varepsilon}_{it}$ is the deviation of the idiosyncratic error term from its mean, where the mean is evaluated over the villages that are observed. Note that selection of villages can be dependent upon individual village effects here since the village level fixed effect u_i does not enter the condition. Intuitively this makes sense because the village level effects capture this propensity to be selected.

For random effects estimation model[58] the condition for ensuring consistency is much stronger than the one for fixed effects estimation since the error term is different:

$E\{u_i + \varepsilon_{it} \mid \text{village is present}\} = 0$ for all villages i and all time periods t

(2)

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[58] Following Woolridge (2002), the only distinction between a fixed effects estimation model and a random effects estimation model is, that in the former the village level effect is allowed to be correlated with other exogenous regressors in the estimation equation. In the Random effects estimation model, this is not allowed. This is the only distinction I make.

This condition requires the unobserved village level heterogeneity to also be independent of selection, along with the idiosyncratic error term. This condition is thus much stronger than the one required for fixed effects estimates to be consistent. Using these rules, tests may be constructed to test if villages have been non-randomly selected in the dataset:

$$H_0^1 : \hat{\beta}_{FE}(B) = \hat{\beta}_{FE}(U)$$
$$H_0^2 : \hat{\beta}_{RE}(B) = \hat{\beta}_{RE}(U)$$
$$H_0^3 : \hat{\beta}_{FE}(B) = \hat{\beta}_{RE}(B)$$
$$H_0^4 : \hat{\beta}_{FE}(U) = \hat{\beta}_{RE}(U)$$

where *B* represents the balanced sub-panel, *U* the unbalanced, complete panel dataset and $\hat{\beta}_{FE}$ and $\hat{\beta}_{RE}$ represent the estimates from the fixed effects model and random effects model respectively. Hypothesis 1 (H_0^1) is a test of the equality of estimates from a fixed effects model applied to the complete panel and from the balanced sub-panel. With random selection, there should be no difference between these estimates. In the alternative, the estimates from the balanced sub-panel are inconsistent. Hypothesis 2, 3 and 4 are tests for the random effects estimator. Notice that hypothesis 4, i.e. H_0^4 is the traditional Hausman test of specification and hypothesis 3, i.e. H_0^3 is the Hausman test applied to the balanced sub-panel. If all the null hypotheses are rejected then all the estimates are inconsistent and selection must be modeled.

Results in the tables below show the following (results for the fourth null hypothesis are discussed in the main text). Table 1 below shows that one cannot reject the null hypothesis that there is no systematic difference between fixed effects estimates from the balanced data (i.e. villages that are only present for all six years) are different from the Fixed effects estimates from the complete data. Table 2 shows that the random effects estimates for the two datasets are significantly different. Table 3 shows that one cannot reject the null hypothesis that there is no systematic difference between the fixed effects estimates and random effects estimates from the balanced dataset.

	(b) IV (FE) for balanced data	(B) IV FE estimates for complete data	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
BAAC credit use	-1.3906	-1.6200	0.2294	1.0557
NPR=1 x BAAC credit use	1.5278	0.3465	1.1813	1.3399
Year	-0.0128	-0.0036	-0.0092	0.0210
NPR=1 x year	-0.0328	0.0134	-0.0462	0.0433
Log(Population)	0.4883	0.6694	-0.1810	0.1137
NPR=1 x L(Population)	0.0897	-0.2776	0.3674*	0.1548
L(Travel time to mkt.)	-0.1006	-0.0398	-0.0608	0.0816
NPR x L(Travel time)	-0.0366	0.1040	-0.1406	0.1033
Short run water dummy	0.0793	0.1032	-0.0239	0.0891
NPR x SR water dummy	-0.0209	-0.0369	0.0160	0.1138
Proportion of adults	0.5717	0.5740	-0.0023	0.2428
NPR x Propn. Of adults	-0.9666	-0.5801	-0.3865	0.3694
Acidic soil dummy	-0.0097	-0.0517	0.0420	0.1014
NPR x acidic soil dummy	0.1321	0.0136	0.1185	0.1725
No. of observations	1349	2268		
Test for H0:Difference in coefficients not systematic				
Chi2 (14 df)	18.2			
Prob>Chi2	0.1977			

Table 1: Estimates from Fixed effects Instrumental variables regressions, comparing balanced data and complete data, Forest Reserve Villages, Thailand (1986-1996)

	(b) IV RE for balanced	(B) IV RE for complete	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E. of difference

	data	data		
BAAC credit use	-0.3577	-1.3103	0.9526	0.6730
NPR x BAAC credit use	-0.7159	-1.1861	0.4702	0.6687
NPR dummy	-4.2295	-4.2599	0.0304	2.2521
Year	-0.0334	-0.0125	-0.0209	0.0121
NPR x year	0.0418	0.0710	-0.0292	0.0319
Log(Population)	0.5989	0.8121	-0.2132	0.0942
NPR x L(Population)	0.2698	-0.1722	0.4420	0.1276
L(Travel time to mkt.)	-0.0039	-0.0329	0.0290	0.0800
NPR x L(Travel time)	-0.0501	0.1061	-0.1562	0.0926
Short run water dummy	0.0458	0.0878	-0.0421	0.0593
NPR x SR water dummy	0.1163	0.0354	0.0809	0.0790
Proportion of adults	0.3947	0.4994	-0.1046	0.1472
NPR x Propn. Of adults	-0.8418	-0.2932	-0.5486	0.2393
HYV rice dummy	3.2355	2.6736	0.5619	0.5452
NPR x HYV rice dummy	-1.0317	-1.8393	0.8076	0.5616
Acidic soil dummy	-0.1278	-0.1577	0.0299	0.0643
NPR x acidic soil dummy	0.0891	-0.0306	0.1197	0.1412
Test for H0:Difference in coefficients not systematic				
Chi2 (17 df)*	98.33			
Prob > chi2**	0.00			

* chi2(17)= (b-B)'(b-B)/[(V_b – V_B)]; ** (V_b – V_B) is not positive definite.

Table 2: Comparison of Estimates from Random effects Instrumental variables regressions, from balanced data and complete data, Forest Reserve Villages, Thailand (1986-1996)

	(b) IV FE estimates for balanced data	(B) IV RE estimates for balanced data	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
BAAC credit use	-1.3906	-0.3577	-1.0329	1.1840
NPR x BAAC credit use	1.5278	-0.7159	2.2437	0.8104
Year	-0.0128	-0.0334	0.0206	0.0266
NPR x year	-0.0328	0.0418	-0.0746	0.0033
Log(Population)	0.4883	0.5989	-0.1106	0.1564
NPR x L(Population)	0.0897	0.2698	-0.1801	0.2032
L(Travel time to mkt.)	-0.1006	-0.0039	-0.0967	0.0306
NPR x L(Travel time)	-0.0366	-0.0501	0.0135	0.0315
Short run water dummy	0.0793	0.0458	0.0335	0.0733
NPR x SR water dummy	-0.0209	0.1163	-0.1372	0.0720
Proportion of adults	0.5717	0.3947	0.1769	0.1141
NPR x Propn. Of adults	-0.9666	-0.8418	-0.1248	
Acidic soil dummy	-0.0097	-0.1278	0.1182	0.0890
NPR x acidic soil dummy	0.1321	0.0891	0.0430	.
Test for H0:Difference in coefficients not systematic				
Chi2 (14 df)*	20.88			
Prob > chi2**	0.1048			

Table 3: Comparison of estimates from Fixed effects and Random Effects Instrumental variables regressions for villages only present for all six years, Forest Reserve Villages, Thailand (1986-1996)

7.5 Appendix: Testing for Item Non-response

Multinomial logit model results

	Short Run Crops	Long Run Crops
Travel Time to Market	-0.004 (-2.91)**	0.005 (4.54)**
Log(Population)	0.89 (5.7)**	0.25 (1.82)*
Distance to Chiang Mai	0.005 (1.87)*	0.02 (6.87)**
Adequate Water	1.14 (4.3)**	1.23 (3.51)**
Constant	-3.82 (-4.1)**	-2.00 (-2.36)*
	N =1545	N=1535

Note: t-statistics in parentheses.

Table: Probability (Positive area devoted to crop compared to Probability of Zero area devoted to crop) without 1988

8 Glossary

AIT	Asian Institute of Technology
ALRO	Agricultural Land Reform Office
APR	Ambiguous Property Rights
ARD	Office of Accelerated Rural Development
BAAC	Bank of Agriculture and Agricultural Cooperatives
B-P	Breusch-Pagan
DLD	Department of Land Development
DOAE	Department of Agricultural Extension
DOL	Department of Land
DOLA	Department of Local Administration
FAO	Food and Agriculture Organization
FE	Fixed Effects
G2SLS	Generalized two stage least squares
HH	Household
HYV	High Yielding Variety
ICDP	Integrated Conservation and Development Programs
Kg	Kilogram
LDV	Lagged Dependent Variable
LM	Lagrange Multiplier
LSDV	Least Squares Dependent Variable
Mkt	Market
MOAC	Ministry of Agriculture and Cooperatives
MOSTE	Ministry of Science, Technology and Environment
NAREBI	National Resources and Biodiversity Institute
NESDB	National Economic and Social Development Board
NESDP	National Economic and Social Development Plan
Na	Data not available (because it was not collected)
No	Number
NPR	No secure Property Rights
NS-3	No-So-Sarm (Certificate of Use)
NS-3K	No-So-Sarm-Kor
NS-4	No-So-Sarm (Title Deed)
Obs	Observations
PA	Protected Area
Propn	Proportion
RE	Random Effects
RFD	Royal Forest Department
STK	So-tho-ko
TDRI	Thailand Development Research Institute
Vills	Villages

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