Chapter 8
Using Mixed Methods to Assess Trade-Offs Between Agricultural Decisions and Deforestation

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Abstract Policies that target poverty reduction are often at odds with environmental sustainability. Assessing magnitudes of trade-offs between improved livelihoods on one side, and forest cover on the other, is important for designing win-win development policies that may help to mitigate climate change. I use a mix of panel data for 670 villages over a 10 year period, and combine it with historical land records and grey literature, to understand the drivers of deforestation *within reserved forests* of Thailand – an area where smallholder ethnic tribes are located. Given that reserved forests are the last bastions of forests in Thailand, examining what drives land clearing *within* these areas is important. I combine econometric findings with qualitative reports to infer that (i) it is important to measure the differential effects of policies on different crops, agricultural intensity and the agricultural frontier; and (ii) within forest reserves, policies that *encourage* cultivation overall may *not* be detrimental to forest cover after all. This has important implications for evaluators and policy makers.

Keywords Trade-offs • Poverty • Forests • Agriculture • Panel data • Thailand • Environment • Sustainability • Deforestation • Property rights • Evaluation

8.1 Background

Other than the ocean, standing forests constitute the most important carbon sinks in the world. Yet forests are being threatened and agricultural expansion is widely believed to be the main reason for deforestation in developing countries.[1] 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. Barbier (2004) reports that cultivated area in the developing

[1]Barbier (2004) and Lambin et al. (2003).

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world is expected to increase by more than 47 % by 2050, with two-thirds of the new cultivated land coming from converting forests and wetland.[2] These figures underscore the importance of examining factors affecting agricultural decisions especially within forested areas, such as forest reserves.[3]

Using a mix of methods that includes an unbalanced panel dataset of 670 villages located within Forest Reserves of Chiang Mai, Thailand, and a study of historical accounts of the evolution of forest reserve legislation and land rights within forest reserves, I examine the following questions: To what extent do policies that encourage cultivation lead to deforestation? Is the forest frontier *always* adversely affected by policies that encourage cultivation or is it possible to develop win-win strategies? What is the net impact of policies that are otherwise expected to increase agricultural profitability such as secure land rights, output prices and lower transportation costs, on the *forest frontier*?

Specifically I do two things: First I measure the effect of variables that can be influenced by policy such as transportation costs, population and perceptions of land rights on the agricultural frontier and cultivation intensity. Second, I combine this data with reported land property records to understand and measure how perceptions of land tenure security affect agricultural expansion and intensity. In so doing I examine traditional assumptions about ethnic tribes that inhabit forest reserves in Thailand. This analysis thus sheds light on the extent to which assumptions about land tenure security and particularly assesses claims that ethnic tribes are significant drivers of deforestation within forest reserves.[4]

There are two main assumptions that are salient in this study. The first assumption is that population within Forest Reserves is exogenous to crop choice: during the period of this study 1986–1996, population movement and size within reserved areas of Thailand was controlled by administrative authorities who did not allow mass migrations to occur.[5] Thus although during 1986–1996, the population of Chiang Mai province rose by more than 15 %, population in villages that are located within forest reserves (and are the subject of this study) grew at less than 1 % per year. The second assumption is that access to markets is exogenous i.e. roads were not built specifically to provide the ethnic tribes access to markets.[6,7] There is now substantial evidence that road building in this region took place before the study period and was undertaken primarily to provide military access to remote areas.

[2]Also see Fischer and Heilig (1997).

[3]See for example Alix-Garcia et al. (2011, 2014), Andamet al. (2007), Andersson et al. 2011, and Bank and Sills (2014).

[4]See for example Delang (2002).

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

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

[7]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 Interior (ARD) and the Department of Land Administration (DOLA).

Since road construction and road-quality related investments within study Forest Reserves took place for security reasons or to provide access to this area, this assumption is a plausible one.[8] I measure access to market using a composite variable – travel time to the market – which is a good proxy indicator for all three measures of access, and their combination – road presence, road quality and availability of transport.[9,10,11]

8.2 Reserved Forests in Thailand

Forest Reserves are the last bastions of forests in Thailand and more than one-fifth of the Thailand's villages are located within Forest Reserves. Until 1985, North Thailand, where the province of Chiang Mai is located, had the country's lowest population density and largest forested area, including large and critical watersheds. Before the study period in 1985–1993, Thailand as a whole lost 11 % of its forested area (Royal Forest Department 1994) and specifically the province of Chiang Mai lost almost 2000 square km of forest, which equals 10 % of its provincial land area.[12] Forest loss in the province has been attributed mainly to agricultural practices.[13,14]

8.2.1 Land Titles and Property Rights

Forest reserves in Thailand lie under the jurisdiction of the Royal Forest Department (RFD) that set boundaries, but unlike protected areas, do not strictly manage or patrol these. However this jurisdiction and indeed authority has not always been clear. Over the years, this ambiguity has led to frequent changes in legislation related to user rights, as well as, changes in boundaries of forest reserves themselves. Land rights for ethnic tribes living within forest reserves have frequently changed over the years (see Box 8.1). Boundaries of Forest Reserves in northern Thailand have changed leading to changes in the types of land titles especially on the edges of forest reserves which are most affected by boundary changes. Both

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[8]Howe and Richards (1984) and Puri (2002a).

[9]Also, unlike other forms of investment, investments on roads occur in stages Puri (2002a).

[10]Puri (2002b) 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.

[11]Howe and Richards (1984) and Puri (2002a).

[12]North Thailand lost approximately the same percentage of forest area. Forest area fell from 8,4126 km^2 in 1985 to 75,231 km^2 in 1993.

[13]Panayatou (1991) and Feeny (1988).

[14]Panayatou and Sungsuwan (1994) and Feeny (1988).

these changes have contributed to ambiguity about land rights for ethnic tribes living within forest reserves. Changes in legislations are summarized in Box 8.1. Arguably ambiguity in the type of land titles has had important implications for crop choice and agricultural decisions.

Box 8.1: 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 revises. Forest 'designating' committee must now contain a sub-district head as a member. Recognizing reality, temporary residence and use of forest 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. Fist 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 recognized 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

Box 8.1 (continued)

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)

Box 8.1 shows that the government of Thailand instituted many land titling programs before and during the period of study, that aimed to 'clarify' and 're-clarify' the status of property rights, often resulting in much confusion. Indeed village level data used in this study indicate that the modal perception of land title security did not remain constant over the 11 year study period (1986–1996). Table 8.1 shows that residents within Forest Villages changed their view of how secure their hold was over their land. We believe that understanding these perceptions of security are critical if we are to understand how residents within Reserved Forests made their cropping decisions.

All villages within the study dataset lay within forest reserves at least once during the 11 year period. Table 8.1 summarizes strongly held beliefs about land titles and shows that *perceptions* of land title (and therefore security of title) did not always match the type of land title households possessed. There were seven different types of land titles in the study region (see Table 8.1). Thus for example many residents within forest reserves believed that they could use their land as collateral. However forest legislation did not allow residents to have secure land titles or to use land as collateral. After discussing the implications of these land titles[15] and consulting literature around this, I differentiate between villages depending on whether they believe they have secure land rights or not. Villages that report possessing NS-4, NS3 and NS3-K are classified as possessing secure property rights. Nineteen percent of the villages in the study sample report that they had *secure* property rights even though *de jure* residents can possess only usufruct rights.[16] Another factor that contributed to this belief of secure ownership is that most residents pay property taxes. I discuss this more in the next section.

[15]Personal communication, Gershon Feder (2004).

[16]Feder et al. (1988a, b) and Gine (2004a, b) 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.

Table 8.1 Land titles and land use rights in Thailand (1954–1990)

Title type	Year introduced	Rights	Limits (as described by Feder et al. 1988a, b)
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
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
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
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
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
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
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	

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

8.3 Study Area and Data Set and Study Area

The dataset used in this study was collected by Thammasat University for the province of Chiang Mai.[17] The data were collected for the National Economic and Social Development Board (NESDB). Data for the study were collected for six rounds, once every 2 years (biennially) starting in 1986 and then 1988, 1990, 1992 and 1996, for the province of Chiang Mai. Villages included in the study dataset all responded that they lay within Forest Reserves at least once during this 11 year study period. All villages in the dataset are registered with the Village Directory of the Department of Local Administration (DOLA). However because forest reserve boundaries changed a lot, all villages did not lie within Forest reserves during the study period. Inhabitants of Forest Reserve villages are mostly hill tribe people who are poor, and live in villages that are remote and have poor infrastructure.

Forest Reserve residents grew mainly three crops during this period – 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 grew paddy rice. On average upland rice and soybean were grown by 25 % and 26 % of villages respectively.

The resulting panel dataset is unbalanced. Of the 670 villages that appear at least once in the dataset, 255 (38 %) are present for all six rounds in the panel; in contrast, 124 villages are present for only one round (Tables 8.2 and 8.3). Attrition in panel data is common: villages may choose to not participate in certain rounds or may not be asked to participate in certain rounds for several reasons (e.g. lack of resources with the survey agency). It is important to understand the cause of attrition or selection.[18] Villages that are surveyed and respond in all six rounds are the single largest group in the dataset (38 %). The second largest group is the villages that occur only once. These constitute 18.5 % of the villages.

In the survey conducted by Thammasat University, village communities were asked in every round of survey (there are a total of six rounds) if they had secure property rights ('*What land title did you have?*') Using this information and the mapping above, from the type of land titles to the security of these land titles, I examine if these perceptions change over the different rounds. In Tables 8.2 and 8.3, I examine these responses for each round in the panel dataset. Table 8.2 shows that 62 % or 413 villages in the dataset never believed they possessed secure rights to village land. In contrast, only 36 villages claim to have secure rights during the entire study period (for all six rounds). For the remaining villages, the status of their land titles 'flips' from year to year. So for example Table 8.3 shows that 33 villages in the dataset were surveyed for all six rounds of data collection, in five of six of those rounds believed that their land title was insecure. They only report a secure

[17]The larger dataset consists of 784 villages.

[18]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 8.2 Security of land title cross-referenced with frequency of presence, forest reserve villages, Chiang Mai, 1986–1996

Number of years village is present in the panel dataset for – > perception about land title[a]	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

Source: Data provided by Thammasat University
[a]Secure title to land implies, land can be used as collateral. These are responses from village headmen

Table 8.3 Frequency of occurrence of forest reserve villages cross-referenced with number of times villages are accounted for in the study dataset (1986–1996)

		Number of times a village is classified to be located 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

land title once. Similarly Table 8.2 shows that 117 villages were present in the dataset for four rounds. Of these, 73 said they were *within* Forest Reserves all four years; 24 said they were in Forest Reserves for only three out of the four years and 20 said that they were *within* Forest Reserves for at most two out of four years.

One difficulty with this dataset is that we don't know the location of villages. However we do know that all the villages were meant to be within forest reserves at least at some point so that they were included in this panel dataset. This provides one explanation for 'flipping' land titles which reflects changes in titles. As forest reserve boundaries change, it is likely that as a consequence land titles also change. We also hypothesize that it is more likely that villages located *just outside* forest reserves or along their boundaries, will witness more change in their boundaries than those in the interior. Box 8.1 shows the frequent change in legislation that led to changes in boundaries within these Forest Reserves. Villages that are located far in the interior of Forest Reserves are unlikely to see this change in boundary, and as a consequence their permitted land titles are unlikely to change.

The panel dataset for this study is thus divided into two types of villages: The first group of villages is a group of 257 villages that has 'ambiguous property rights' over the duration of the study period, caused in large part by changing forest legislation and by changing forest reserve boundaries. These villages witnessed frequent changes and had ambiguous property rights or APR villages and constitute 38 % of the study sample. The second group consists of villages that claim to have *no* secure rights *consistently* and are likely to be located deep inside Forest Reserves, where changing Forest boundaries create no ambiguity. The latter group of villages are called 'no secure property rights' villages NPR villages.

Two other features of the survey are that (i) village headmen provide responses to questions and, (ii) the biennially conducted 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?' "*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 that crop is 'popular' *every* year.[19] Furthermore, crops are tracked in groups i.e. 'short run crops' or 'long run crops'. Other challenges with the data including absence of price data and agricultural practices are discussed and addressed in Puri (2006). Main characteristics about villages included in this dataset are presented in Tables 8.4 and 8.5.

8.4 Characteristics of Data and Hypothesized Effects

In this section I discuss the hypothesized effects that different village level attributes are expected to have on two main agricultural variables: on agricultural area within a village and on average intensity of cultivation within a village.

The intensity of cultivation variable requires a brief discussion. 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 study, I use this Boserup measure to understand intensity of cultivation: Intensity of cultivation is measured by a variable that is the response to the question "*What percentage of agricultural land is being used* (*for*

[19]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.

Table 8.4 Basic characteristics of villages located in forest reserves, Chiang Mai (1986–1996), pooled dataset

	All sample			APR villages			NPR villages		
Variable	Obs	Mean	Std. dev	Obs	Mean	Std. dev	Obs	Mean	Std. dev
Population (no. of people)	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. (min)	2408	70.6	66.4	1075	42.52	39.53	1333	93.21	74.5
Avg. one way travel time to district (min)	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

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

Table 8.5 Percentage of villages growing different crops, forest villages, Thailand, 1986–1996

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 and 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

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

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] × 100

I now discuss the hypothesized effect of village level variables on total agricultural area and on agricultural intensity.

Village Population Village population is expected to have two types of effects on total village agricultural area and cultivation intensity. The first is a scale effect: A village with a larger number of households is expected to have a higher demand for agricultural land compared to one with a fewer households. The second effect is the 'food' (or subsistence) effect. 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 because it is not possible to buy food from the market. Both these effects are expected to be in the same direction.

Travel Time to Market Travel time to the market is a proxy for the cost of transporting crops to the market and obtaining inputs from the market. I expect that farmers that are located far from the market are able to exercise less leverage in getting the best prices 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.[20] 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

[20]Minten and Kyle (1999).

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. The variable in the dataset 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.[21]

Proportion of Adult Population 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.[22,23] The presence of more adults is likely to increase the amount of land cultivated and ameliorate labor scarcity. In this study, proportion of adult population is used as a proxy for available labor in the village and for the opportunity cost of labor.

Productivity of Land There are two variables that are used as a proxy to measure land productivity. These are water availability and a dummy for acidic soil.[24] (Please see below.) Additionally I also use a time invariant binary variable to indicate whether the village grew high yielding varieties (HYV) of rice at any time during the study period. (So 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 on productivity. The first is on paddy rice area: HYV rice is more productive than non-HYV rice. I expect it to have a positive effect on area devoted to paddy rice. The other effect this variable is likely to be a proxy for is the presence (or absence) of 'attention' from local authorities. To the extent that growing HYV rice requires additional knowledge and training provided by field officers and that

[21]See for example Dawson and Barwell (1993).

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

[23]See Godoy et al. (1997) for a similar argument.

[24]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. 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 we 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 2 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 year of the study period, for soybean. Witnessing an increase in area despite there being an increase in productivity, further strengthen my results.

the government has been encouraging the cultivation of HYV rice, mostly via the BAAC (Bank of Agriculture and Agricultural Credit), the dummy is expected to be positively correlated with BAAC presence.[25]

Water Presence 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.[26] On the other hand paddy rice requires a lot of water to grow. 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.[27]

Acidic Soil The other variable used to measure the productivity of land is acidity of soil. Acidity of soil is an undesirable quality. The variable is expected to have a negative effect on agricultural area and intensity of cultivation. In this dataset it is recorded as 1 if soil within a village suffers from high acidity, and 0 otherwise.

Perceptions of Land Ownership Secure land titles are defined as titles that allow land to be used as collateral or sold. I expect that farmers who have secure land titles will be more willing to invest in land and grow cash crops. 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*".

Credit Use Credit use is expected to increase the intensity of cultivation. 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 assumed to be mainly for agriculture, unlike credit provided by private money lenders (because of the conditions that BAAC imposes). Clearly, credit use is endogenous.[28] 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.

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[25] Thus the variable is used as an instrument in the BAAC credit use equations.

[26] Although upland rice requires rainfall, it does not require standing water like paddy rice does.

[27] Palm et al. (2004).

[28] 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. The endogeneity of credit use is not discussed more in this paper but is discussed in detail in Puri (2006).

Using this dataset and the relationships hypothesized above, I estimate two estimation models for total village agricultural area and cultivation intensity:[29]

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

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

8.5 Results

Results are analyzed in two ways. First, I examine the effect of different crops on total agricultural area. Tables 8.5 and 8.6 discuss results from these equations. Second, I examine how policy variables affect overall agricultural area and intensity of cultivation.

I use random effects models in Tables 8.6 and 8.7, to estimate the effect of these variables on agricultural area and intensity of cultivation:

Table 8.6 shows that an *increase* in village agricultural land is associated with an *increase* in area devoted to paddy rice (coefficient = 0.46; z = 7.8) and upland rice (coefficient = 0.21; z = 2.36). 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. Speaking with agriculturalists, this is expected: Soybean is an input intensive cash crop and is usually cultivated on land that is fertilizer rich and input rich. Table 8.7 shows that an increase in *intensity of cultivation* is associated with an increase in area devoted to Soybean (0.01399; z = 3.76) and Paddy rice (0.0037; z = 1.95). Upland rice area does not contribute significantly to increasing cultivation intensity (measured by the number of crops grown on a plot of land in a year). This too is expected. Observational data and conversations with folks at the university reveal that upland rice is grown on forest frontiers, and typically on land with low fertility that is vulnerable to erosion.

[29]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}. 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.

Table 8.6 Linear random effects regression results for land devoted to agriculture, forest reserve Villages, Chiang Mai (1986–1996)

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			

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

Table 8.7 Random effects interval regression results for intensity of cultivation, 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			

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

Furthermore land devoted to upland rice does not require much preparation. On the other hand soybean and paddy rice require large amount of inputs and preparation. They are usually grown on land that is agriculturally fertile and productive. They are usually cultivated on fertile and flat river beds and in watershed areas, and this land is much more likely to have other crops grown on it, once soybean and paddy rice have been harvested.

I now discuss the effect of variables that can be affected by policy on agricultural land and intensity of cultivation. Results are presented in column 1, Table 8.8 [30,31] Results in Table 8.8 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 villages that have no secure property rights (NPR villages). On average NPR villages cultivate land less intensively than APR villages by 71 percentage points. Additionally in NPR villages, there is almost no effect of a change in travel time to market (travel time estimate for NPR villages = 0.343 (which is coefficient for log (travel time estimate) = −2.868 + coefficient (NPR = 1*Log(travel time estimate)) = 3.212) = 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 = 5.716–4.11 = 1.6; Z-statistic = 1.04; Prob > Z = 0.30).

To investigate land expansion as measured by village agricultural land, the same variables are used to explain the equation as used for agricultural intensity. This is because variables that affect intensity of cultivation should also affect land expansion. Results are presented in column 2, Table 8.8.[32]

Results in column (2) 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 these villages. A 1 % increase in travel time to the market increases the area under cultivation in APR

[30]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. 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.

[31]The different specifications and sensitivity analyses are presented in Puri 2006.

[32]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. In Table 5.16 I present only one specification. 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 not shown here.

Table 8.8 Random effects reduced form interval regression for intensity of cultivation and log (village area) in forest reserve villages, Chiang Mai, Thailand 1986–1996

	Random effects interval regression instrumental variables (intensity of cultivation)	Instrumental variables random effects (agricultural area)
	(1)	(2)
NPR dummy =1	−71.091	−0.651
	(2.15)*	(−0.35)
Year	−0.269	−0.022
	(−1.26)	(1.76)+
(NPR =1)*year	0.485	0.018
	(−1.43)	(0.86)
Log (Village Population)	0.328	0.427
	(0.2)	(5.33)**
(NPR =1)*Log (Village Popn)	0.083	0.021
	(0.04)	(0.21)
Log(Travel time to market)	−2.868	0.158
	(2.91)**	(4.04)**
(NPR =1)*Log (Tr time to mkt.)	3.212	−0.126
	(2.52)*	(2.59)**
Short run water dummy	5.716	−0.055
	(3.87)**	(−1.12)
(NPR =1)*SR water dummy	−4.11	0.005
	(1.92)+	(0.08)
LR water dummy	−3.06	−0.041
	(−1.37)	(−0.62)
(NPR =1)*LR water dummy	3.343	0.145
	(1.1)	(1.52)
Proportion of adults	−7.157	−0.056
	(−1.16)	(−0.31)
(NPR =1) *Propn of adults	28.112	0.227
	(3.25)**	(0.83)
Acidic soil dummy	−7.973	−0.28
	(3.82)**	(4.13)**
(NPR =1) *Acidic soil dummy	−0.85	0.314
	(−0.3)	(3.22)**
BAAC credit use dummy	4.93	1.11
	(1.09)	(2.41)*
(NPR =1) *BAAC credit dummy	−1.904	−0.83
	(−0.28)	(−1.32)
Constant	104.437	4.339
	(4.88)**	(3.94)**
Observations	2204	1989
Number of ID	628	622

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

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 %.

8.6 Discussion of Main Results

In this paper I explain the direction and magnitude of impacts on agricultural intensity and extensive frontier using random effects equations for village agricultural land and intensity of cultivation. I discuss findings below:

8.6.1 Effect of Population

The study 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.[33] 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 paper i.e. 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.

8.6.2 Effect of Travel Costs

I find that transportation cost has a quantitatively modest impact on agricultural decisions in the study area. For total agricultural land in a village, the effects of

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

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. This is different from 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.[34]

8.6.3 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.

An important effect in the study is that villages with no property rights are likely to 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. 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. Feder et al. (1988a, b) 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. In this study the distinction

[34] 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.

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)).

8.7 Overall Discussion

Anecdotal evidence in Thailand shows that North Thailand witnessed a large increase in deforested area during the years 1986–1996. One of main reasons for this is claimed to be agricultural expansion. ASB (2004) reports that during the same period, area devoted to upland rice area grew rapidly as well. 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 upland rice cultivation especially since it is seen as being 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 effect on the surrounding ecosystem compared to paddy rice and soybean. On the other hand, paddy rice and soybean can be intercropped and are usually grown on agriculturally important land while upland rice is usually not grown with other crops (in these contexts). Specifically speaking upland rice is grown on lands which is deserted after two or three crops have been planted and harvested.

This study suggests that a reduction in travel time to market reduces the area devoted to upland rice. It also suggests that *while not affecting forest cover*, *a reduction in travel time to market may also help to reduce the incentive to adopt and cultivate upland rice*. One policy implication from this study is to encourage crops that allow multiple rotation in the lowlands, and thus reduce pressures that push the agricultural frontier to mountain slopes that are prone to erosion. 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.

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