Land property rights and rice growing in Vietnam.

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Abstract: In most of the empirical literature on the effects of land titling, the household is regarded as unitary where land rights are considered as a household right and found to have ambiguous effects on land allocation, investment and productivity. Using data from 12 provinces in Vietnam, we diversify land rights by the household member(s) in whose name(s) the land title is issued. A household fixed effects analysis of the decision to grow rice and plot level rice yields suggests that both gender and the exclusivity of property rights are important in the choice of crop whereas the rice yield results appear to be purely gender driven. Plots where women have partial or exclusive rights have higher yields than plots where men have exclusive rights. A household rice yield function reveals that exclusive use rights are inefficiency decreasing while jointly held use rights have no efficiency effects. Our results show that the ownership structure in the land title may affect production.

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1. Introduction

Empirical research into the effects of formal land rights on farmer behaviour presents an ambiguous picture. In theory, formal land rights are shown to have beneficial effects on land productivity (Feder and Feeny, 1991; Besley, 1995; Binswanger, Deininger and Feder, 1995). In particular, when land is scarce the formalisation of land rights is considered crucial to further economic growth. The most common effects expected from secure property rights are their allocative effects on the one hand, where land is used in a more efficient way, and their land investment effects, including increased access to credit and land productivity, on the other. The allocative effects can include changing crop choices, where the tendency to grow longer cycle crops is correlated with more secure property rights, or the transfer of land from less to more dynamic farmers, resulting in more consolidated land holdings (Deininger and Jin, 2003; Ravallion and van de Walle, 2003). Increased tenure security is expected to provide farmers with incentives to invest in land improvements that may only have productive benefits in the long run (Hayes, Roth and Zepeda, 1997; Gavian and Fafchamps, 1996; Gebremedhin and Swinton, 2003; Deininger and Jin, 2006; Ali et al, 2007). Farmer's willingness and ability to invest in land may be enhanced through increased access to credit when land becomes available as collateral.

Although the beneficial effects of tenure security are clear in theory, in practice the expected effects are not always found. Positive effects of property rights on investment, land yields or credit appear limited or inexistent, or dependent on the institutional environment (Migot-Adholla et al, 1991; Place and Hazell, 1993; Binswanger, Deininger and Feder, 1995; Place and Migot-Adholla, 1998; Carter and Olinto, 2003; Van Tassel, 2004; Barslund and Tarp, 2007[1]). When the endogeneity of land property rights is controlled for, the positive investment impact of tenure security is often contested (Carter, Wiebe and Blarel, 1994; Besley, 1995; Braselle, Gaspart and Platteau, 2002). Further, it has been argued that title ownership and ownership security are not necessarily

[1] Barslund and Tarp use data collected in 2002 in four provinces in Vietnam and find significantly positive effects of land use rights on household demand for formal credit in only one province. They find positive but not significant effects in the other three provinces and a negative effect on the demand for informal credit. They find no significant effects on the amount of credit obtained by rural households.

synonymous and that informal systems are not inherently weaker than formal ones (Roth et al, 1989; Platteau, 2000). In addition, tenure security can be expressed in more or less detail yielding different results. For example, the rights to bequeath land may not yield as large an effect as the right to sell land. In the latter case the expected returns to investment are increased because it is easier to sell land and convert it into liquid assets (Besley, 1995; Platteau, 1996). In summary, even though the individualisation of land property rights is generally advocated as good policy for growth and poverty reduction (Deininger, 2003), the literature suggests that the effects of land property rights on investment, credit, crop choice or yields are not *a priori* clear and require a case specific evaluation.

In addition to the positive effect on growth and poverty reduction of household land rights, land rights for women are seen as crucial to their economic and social situation (Agarwal, 1994; Deininger, 2003; Rao, 2006). Land rights for women are associated with better nutritional and human capital outcomes for children, increased bargaining power and under certain circumstances improvements in land productivity. In most of the literature on the effects of land titles, the household is regarded as unitary and land rights are considered as a household right. However, the analysis of land rights may not yield the same results if the household is not unitary but a place of cooperation and conflict (Sen, 1989) where individual land titles can have different effects according to gender or position in the household. For example, Place and Migot-Adholla (1998) analyse the effects of registration in the name of the household head but contrast their results in some cases with the titles that include registration in the name of close relatives, finding different results. Similar to the effects of household land titles, the effects of female titling are not clear *a priori* and depend on the institutional framework, the protection and enforcement possibilities of their rights and opportunities to use them.[2]

Since 1993 land use certificates have been issued in Vietnam to formalise households' claim to the land they are tilling.[3] In addition, the 2003 Land Law states that land use

[2] The qualitative research of Rao (2006) shows that the right to land for women increases their work burden without much change in their status or decision-making authority.
[3] For an overview of the evolution of land rights in Vietnam, see Kerkvliet (2006).

certificates should bear the names of both spouses if the land belongs to both.[4] This provides an opportunity to test some of the expected effects of female versus male and single versus joint titling. If men and women have different perceptions on the security entitled by the land right, if they have different cropping preferences or responsibilities, different risk attitudes or different access to inputs, we may expect the effect of a male versus female land title to be different.[5] For example, female landholders may be more inclined to grow annual (food) crops on their plots to provide food for the household whereas male landholders may prefer grow long term crops which are more likely to generate cash income and are typically associated with higher tenure security. Grouping all land use rights under a unitary household category may hide some of these effects.

We explore the effects of the issuance of land use certificates (LUCs) in Vietnam, where we consider individual use rights rather than household use rights, on crop choice and on crop yields. Specifically, we focus on the effect of land title on the decision to grow rice and rice production as rice is still the most important crop for most of the farmers, both in terms of generating income and as the main staple food. Hence both husbands and wives may have an interest in growing the crop, even if their choice is based on different concerns. In addition to the decision to grow rice, we analyse the effect of land titles on rice production. Firstly, since we have plot specific production data for rice, we are able to use household fixed effects estimation techniques to test whether property rights accruing to different household members affect rice yields differently. Secondly, we use a stochastic frontier approach to test whether household production efficiency changes according to the title owner(s). To our knowledge this is the first empirical analysis on

[4] The issuance of land use certificates originated from the 1993 land law together with the rights to transfer, exchange, bequeath, lease and mortgage land. Originally, only one household member's name was inscribed in the land use certificate, usually the head of the household, but in 2003 the law was modified stating that for jointly owned land a second person's name should be inscribed, which would most likely be the spouse.

[5] Different agricultural techniques may also cause the result of land rights to be different dependent on the name it bears. For example, Udry (1996) found that input use on female plots is much less intensive compared to male plots. So it may be that female and male land right owners show different investment behaviour.

crop choice and yield effects of land titles diversified by the type of household member who actually holds the title for a specific plot.[6]

The data we use are taken from the Vietnam Access to Resources Household Survey 2006 (VARHS). This dataset contains detailed plot level information for rural households in 12 provinces spread over different regions of Vietnam.[7] These data allow us to conduct more detailed research on the crop choice and productivity effects of property rights than what is commonly found in the literature. We analyse the rice growing and output effects of the land use certificate in general, and by name and gender structure of the land use certificate. In particular, we test for differences in singly held (by men versus women) and jointly held land titles. We find that owning a land use certificate does not appear to matter in the production decisions and productivity levels of rice plots but where property rights are defined, intra-household differences in land tenure appear to affect production decisions and efficiency. Both gender effects and exclusivity of property rights play a role in the choice of crops. A plot level analysis of rice yields suggests that plots with a LUC with at least one female return higher yields while a household level analysis of efficiency shows that where land rights are held exclusively by males or females efficiency is increased compared to joined ownership.

The paper is organised as follows. The data are described in section 2 while section 3 presents the methodology. The results of the empirical analysis are presented in section 4 and section 5 concludes.

2. Data

In Vietnam all land is owned by the people of Vietnam and managed by the state. The laws that govern land distribution have been reformed several times since the decollectivisation of land in 1988. Under the 1993 land law, land use certificates (LUCs)

[6] The closest study to this that explores these issues is Goldstein and Udry (2005) who use information on plot cultivators' position in the social and political hierarchy as an instrument for tenure security. They find that productivity and investment intensity on plots is positively related to tenure security.

[7] The 12 provinces are Ha Tay in the Red River Delta, Lao Cai and Phu Tho in the North East, Lai Chau and Dien Bien in the North West, Nghe An in the North Central Coast, Quang Nam and Khanh Hoa in the South Central Coast, Dak Lak, Dak Nong and Lam Dong in the Central Highlands, and Long An in the Mekong River Delta.

were issued as proof of households' claim to the land they cultivated. At the same time, households were allowed to engage in land transactions such as the transfer, exchange, bequeathing, leasing and mortgaging of land (use certificates). For agricultural land, rural households reported in 2004 to hold LUCs for 76.5 percent of plots (Brandt, 2005). The most recent land law of 2003 ensures an improved land registration system and clearer administrative procedures together with the requirement for the LUC to bear the names of two persons if the plot belongs to both. In most cases this law implies that the name of both the head and the spouse should appear on the LUC. 12.3 percent of the titles in rural Vietnam bore a male and a female name in 2004 (Brandt, 2005).

We use data from the Vietnam Access to Resources Household Survey 2006 (VARHS), which was implemented in 12 provinces. The provinces were selected in order to provide a basis for monitoring the progress of farmers in provinces covered by DANIDA support programmes.[8] The households surveyed are a sub-sample of rural households interviewed by the General Statistics Office in 2002 or 2004 for the Vietnam Household Living Standards Survey (VHLSS) and as such will not be representative at a national level. Our results will thus only apply to the actual surveyed sample. The questionnaire was developed in co-operation between the University of Copenhagen and ILSSA.[9] In total 2,324 households were interviewed between July and September 2006. The households are spread over 466 communes and 161 districts. Besides general sections with information on individual household members, the survey contains detailed information on access to and use of productive resources such as land, labour, credit and other inputs. In this paper, we use the land and agricultural production section extensively. The survey is a rich source of information regarding plot level characteristics. It includes size and quality of plots, their slope and irrigation infrastructure, when and how the plot was acquired, whether the household has a LUC (commonly called a *red book*) for the plot and whose name(s) appears in the red book. Furthermore, information exists on which crops are grown on each plot and, for rice only, the amount of output during the three last agricultural seasons is available at the plot level.

[8] Five provinces are covered under DANIDA's Agricultural Sector Programme Support and seven under the Business Sector Programme Support.

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In the following tables we present an overview of the LUC situation of the plots owned by the surveyed households and the characteristics of those plots, the crops grown on plots by different land title types and the rice yields derived from the plots. We divide the plots according to (1) whether the plot has a LUC, (2) how many household member names appear in the LUC (zero, one or two) and (3) the name structure on the LUC. In Vietnam the LUC is often called the red book, derived from the colour of the cover page, and we will use LUC and red book interchangeably. With respect to the name structure, we define four different possibilities. In the first case, only one man's name appears on the red book, being either the household head in case of a single male head or the husband in case of a married head (*husband/male head*). In the second case, only one woman's name appears on the red book being either a single female head or the wife in case of a married head (*wife/female head*). In the third case, both husband's and wife's names appear on the red book (*husband and wife*). In the last case we combine all other possibilities, such as names of persons not considered part of the household, children or parents of the household head or spouse, or combinations of the head or spouse with any of their parents or children (*other*).

In Table 1 we show the red book status of plots in the surveyed households, where plots are divided according to the decomposition outlined above. In total there is information on 11,683 plots, 10,099 of which are used for cultivation of crops, either annual or perennial.[10] Focusing on crop land, households have LUCs for 82 percent of all plots, but mostly only one household name is written in the red book (87%). Most often this person is the husband or a single male head but in 16 percent of all red books only the wife or a single female head name appears. When two household members are written in the red book, these are generally husband and wife: both husband and wife names appear in 7 percent of the red books.

[INSERT TABLE 1 ABOUT HERE]

[10] Other uses are purely residential land, forestry land, grazing land, aquaculture land.

Looking at plot characteristics, plots with and without LUCs are different on the whole range of characteristics included in Table 2. Plots with a LUC appear to be smaller, closer to the house, more likely to be flat-sloped and to be irrigated, more likely to be allocated to the household by the state or commune and to have restrictions on the choice of crops. The characteristics of plots with a red book generally appear to be more favourable for growing rice.

[INSERT TABLE 2 ABOUT HERE]

Next, we look into crop growing patterns by type of plot according to the red book situation. Our main interest is in whether there is a difference between plots with or without a red book and between plots of different red book status. In Table 3a we present the percentages of crops grown on plots of different red book status for all households. In Table 3b we restrict the sample to only those households with variation over plots in having a red book or not. Seventy-five percent of all households either have zero plots with a red book (10%) or all plots with red books (65%). The plot-crop allocation percentages are different in the full and the restricted sample, with differences between the red book types more pronounced in the latter.

[INSERT TABLE 3 ABOUT HERE]

There are no strong differences between the red book types in whether annual or perennial crops are grown in the unrestricted sample.[11] Most striking is the difference in staple food choice. The staple foods considered here are rice, maize and the tuber crops potato and cassava. Around 56 percent of all plots without a red book are allocated to rice while this is 70 percent of all plots with a red book. The difference is even larger in those

[11] Although we do not find any differences in the total sample regarding the tendency to grow annual or perennial crops, in the restricted sample, plots bearing a red book with only the name of the wife or a single female head are much more likely to have perennial crops (23 percent versus 12 percent on average for other plots with a red book), especially fruit and coffee trees.

households with red book variation, at 52 versus 73 percent respectively. The fact that such a high percentage of plots are cultivated with rice is likely due to a long tradition of rice growing ensured by government national food security considerations, and more recently foreign exchange generation may also play a role considering the importance of rice in Vietnam's export. In many communes restrictions on crop choice still exist. Households report that crop choice is restricted (to growing rice) on 54 percent of all plots. Plots with a red book appear to be even more likely to have restrictions on crop choice (58 percent versus 40 on plots without red book, see Table 2) which may partly explain the large differences in plots allocated to rice according to red book ownership. There appears to be a tendency to grow less rice in favour of maize or potato and cassava on plots which do not have a red book, especially within the households where variation in red book ownership exists.

Across the plots with a red book, there are strong differences in crop growing behaviour according to whose name is in the red book, especially in the restricted sample. In the total sample, both husband or wife only plots (or single male or female head plots) are equally likely to be cultivated with rice. The percentage drops when both husband and wife appear on the red book. However, the results are quite different when looking at the restricted sample. In the latter, it appears that plots with red books bearing only the husband's name are much more likely to be cultivated with rice than plots bearing only the wife's name (75 versus 61%). This difference is puzzling but may for example suggest a female preference for food diversification given that the men already grow rice (for food and/or income generation). When both husband and wife are on the red book, they appear to settle somewhere in the middle with 67 percent of plots cultivated with rice. But it is difficult to conclude anything from these bivariate summary statistics as it may well be the case that women receive responsibility/ownership of those plots which are much less suitable for rice cultivation. This can be clarified in the empirical section where we can correct for plot characteristics.

Table 4 presents average rice yields (in kg per square metre) by red book type. In general, the average and median rice yields are around half a kilo per square metre. There are some differences between the plots with different red book situation. First, it appears that yields are slightly higher on plots with a red book compared to those without, especially

within the households where some red book variation exists. However, these differences are not significant.

[INSERT TABLE 4 ABOUT HERE]

Second, wife or female head plots appear to have higher yields than husband or male head plots and plots bearing only one name have higher yields than plots where both husband and wife's names are in the red book. The difference between wife only and husband only plots is significant in the unrestricted but not in the restricted sample, while differences between wife only or husband only plots and husband and wife plots is significant in both samples. This suggests that shared responsibility is possibly leading to lower individual responsibility thereby depressing efforts and yields. However, as before we can only draw conclusions after correcting for other plot characteristics.

In summary, it appears that the both the decision to grow rice and rice yields are correlated with the red book structure of the plot. In the next section, we present the methodology used to explore how the red book situation affects the decision to grow rice and rice yields at plot and household level.

3. Methodological Framework

The descriptive analysis presented in section 2 suggests that the decision to grow rice and rice yields are correlated with the nature of the property rights assigned to plots as indicated by their red book status. The general framework we use to empirically explore these relationships follows the approach proposed by Udry (1996) and applied by Goldstein and Udry (2005). We focus on the within household variation across plots to identify the potential impact of land rights on crop choice and crop yields using household fixed effects. Differences in plot characteristics are also controlled for. The first model we consider is the decision to grow rice. The underlying latent equation is given by

$$Y_{hi}^{*} = X_{hi}\beta + \alpha R_{hi} + \lambda_h + \varepsilon_{hi} \quad (1)$$

and the decision rule by:

$Y_{hi} = 1$ if $Y_{hi}^{*} > 0$

$Y_{hi} = 0$ otherwise

where Y_{hi} is a dummy indicator of whether plot *i* in household *h* is cultivated with rice; Y_{hi}^{*} is the underlying utility associated with choosing to grow rice on plot *i*; X_{hi} are plot characteristics; λ_h are household fixed effects and ε_{hi} is a statistical noise term assumed to have an extreme value distribution. The key variable of interest is R_{hi} which represents the red book status of the plot. We consider a number of different forms for R_{hi} which are discussed below.[12]

The second model we consider, explores the relationship between red book status and yields. Using the framework described above we explore the relationship between land rights and the within household variation in rice plot yields. The equation of interest is specified as:

$$Q_{hi} = X_{hi}\beta + \alpha R_{hi} + \lambda_h + \varepsilon_{hi} \quad (2)$$

where Q_{hi} are the rice yields of plot *i* owned by household *h*. All other variables are defined as before.[13]

Thirdly, we explore the relationship between land rights and rice yields further by considering the direct impact of red book status on household efficiency. We do this by estimating a stochastic yield function at the household level that allows us to explain heterogeneity in efficiency levels across households with household and plot characteristics. We express the production function in yield form to reduce the multicollinearity between land area and the other inputs.[14] The production technology is

[12] The model is estimated as a conditional fixed effects logit model using Maximum Likelihood Estimation.
[13] This model is estimated using the standard fixed effects approach for linear models.
[14] Expressing the function in yield form requires dividing all of the inputs by land area. This imposes homogeneity of degree one in the inputs and constant returns to scale. (See Ajibefun *et al*. (2006) for a similar application).

thus defined by expressing rice yields as a function of inputs per square metre, technical inefficiencies capturing the degree to which household yields are below the optimal level of production and a random error component:[15]

$$q_h = f\left(x_h;\beta\right)e^{v_h - u_h} \tag{3}$$

where q_h are total rice yields of household *h*; x_h is the vector of inputs into the production process expressed in per square metre terms; β is the vector of parameters of the yield function, v_h represents statistical noise and other random external events influencing the production process.[16] The technical efficiency effects are given by the set of non-negative random variables u_h. Using Kumbhakar et al.'s (1991) approach, u_h are assumed to have two components: a deterministic component explained by a vector of observed variables, z_h, assumed to affect the efficiency level of household and a random component given by τ_h.

$$u_h = z_h\delta + \tau_h \tag{4}$$

where δ are parameters to be estimated. u_h are assumed to be independently distributed as truncations at zero of $N\left(z_h\delta,\sigma_u^2\right)$. We assume that z_h includes both household and plot characteristics. Plot characteristics are included as proportions, that is the proportion of plots owned by the household that possess a certain characteristic. The yield function is specified in translog form.[17]

4. Empirical results

The full list of plot and household variables used in the analysis are presented in Table 5. The key question of interest in this paper is whether differences in property rights have an

[15] Aigner *et a*l. (1977) and Meeusen and van den Broeck (1977) were the first to propose this approach. It has since been widely applied in the literature.

[16] v_h are assumed to be i.i.d. $N\left(0,\sigma_v^2\right)$.

[17] The model is estimated using Battese and Coelli's (1996) software, Frontier version 4.1. See the Appendix for appropriate specification tests.

influence on production decisions. In order to test for this using the models presented in section 3, we assume that property rights are determined by the red book status of the plot, that is we assume that the individual(s) named in the red book is(are) responsible for all production decisions related to those plots. Various specifications of the red book variable are considered. Firstly, we consider whether a plot has a red book as an indicator of whether or not property rights are formally defined for the plot in question. For the production function model (equation (3)), the proportion of plots with a red book enters as an explanatory variable in the inefficiency component of the model (equation (4)). Secondly, we consider the impact of different types of red book status. The categories considered are: 1) the red book includes one male name only (husband/single male head); 2) the red book includes one female name only (wife/single female head); 3) the red book includes the names of both husband and wife. Other categories, such as cases where the red book includes household members other than the husband or wife or persons not considered household members, are excluded since we are specifically interested in intra-household factors that influence production decisions. As before the red book status variables are included as indicator variables in the crop choice and yield regressions (equations (1) and (2), while for the production function model they are included as the proportion of plots owned by the household of each status. Thirdly, since we are particularly interested in the effect of property rights for women we consider a specification that looks at the impact of having at least one female household member named in the red book. To isolate the intra-household variation in LUCs we also estimate the intra-household crop choice and yield regressions (models (1) and (2)) conditional on having a red book and conditional on there being some variation across plots in red book status.[18]

INSERT TABLE 5 ABOUT HERE

Table 6 presents the results for the conditional fixed effects logit model of the decision to grow rice. The results for the effects of different plot characteristics on the decision to grow rice are as expected. Plots which are restricted in terms of crop choice are much

[18] We restrict the sample in this way to ensure that we are dealing with households where a deliberate decision on property rights has been made.

more likely to be used for rice, as are plots which are irrigated. Plots which were granted by the state are also more likely to be planted with rice than plots acquired by other means. The slope of the plot also has a strong negative effect. In this model, we are interested in the extent to which property rights influence the decision to grow rice. In section 2, we saw that based on the raw data, plots with a red book are more likely to be allocated to rice, but observed that in many cases the probability that a plot has a red book is correlated with plot characteristics (such as, for example, plot restrictions). In this model, controlling for plot characteristics we find no significant effect of having a red book on the decision to grow rice. Since multicollinearity between having a red book and other plot characteristics may make it difficult to identify this relationship we restrict our analysis to plots that have a red book and consider variations in red book status as classified above. Since we are interested in identifying potential differences in production decisions across each group we estimate the model three times including each category as a single indicator variable in each case.

INSERT TABLE 6 ABOUT HERE

We find that conditional on having a red book, and excluding cases where the red book includes non-household names, plots where only the husband's name appears in the red book are less likely to produce rice. Where either the wife/female alone, or husband and wife together, have land rights, rice production is more likely, with the effect on the probability greater for the latter group.[19] This result is also present once the sample is restricted to households where red book status varies across plots. The effect of at least one female name present in the red book is also positive and significant in both of the restricted samples. These results suggest that both gender and the exclusivity of property rights may be important factors in the choice of crop. In Section 2 we hypothesised that while males and females may have separate incentives in relation to the type of crop they decide to grow, both will have an incentive to grow rice as it is an important crop for

[19] Intra-household differences are less obvious when other combinations of household members are assigned property rights to plots. For results including these observations see Table A in the Appendix. The positive effect of husband and wife both named in the red book is observed. The other results are in the same direction as that found using the restricted sample but are not statistically significant.

generating income and for food security. The results of our empirical model suggest that the incentive for females to grow rice is greater than that for men once plot and household characteristics are controlled for. It appears to be the case that men choose to diversify where they have exclusive property rights to the plot. We find that where property rights are defined, when shared between husband and wife the incentive to grow rice may be greater than when exclusively assigned to one or other.

The results for the rice yield model given by equation (2) are presented in Table 7. The variation in plot yields within households is poorly explained by plot characteristics. The key variable determining yields is the area of the plot which is included to control for economies of scale in production. The significant and negative effect provides evidence of decreasing returns to scale in rice production. The slope of the plot is also significant in explaining differences in yields with the results suggesting that the steeper the slope the lower the yields. Based on the full sample, yields on plots which are registered with a red book are not significantly different to plots with no defined land rights. As suggested previously, this may be due multicollinearity between the plot having a red book and the other plot characteristics.

INSERT TABLE 7 ABOUT HERE

As might be expected, once the sample is restricted to plots that have a red book, and cases where the red book includes different combinations of household members other than those previously defined are excluded, the explanatory power of the models decline considerably.[20] In fact, the results suggest that most of the variation in yields across plots within households can be explained by the red book status of the plot. Plots where the husband or male only is named in the red book have significantly lower yields than cases where at least one female is named. Unlike the results for crop choice this result appears to be completely gender driven since the estimated coefficients for plots where the female only is named and plots where both husband and wife together are named are insignificant. These results provide evidence to suggest that conditional on property

[20] As with the results for crop choice, the results for the sample including non-household members in the red book are less convincing (see Table B in the Appendix). The only significant result is that conditional on having a red book, plots with at least one female name in the red book have higher yields.

rights being defined, plots where women have partial or complete property rights will have higher yields than cases where males have exclusive rights. This suggests that the assignment of property rights may have a positive effect on productivity where females are given rights to the land. These results are also robust to the inclusion of a lag on rice yields.

To explore this result further we analyse the determinants of efficiency through the estimation of a household yield function. Output and input variables are described in Table 5. The results for the inefficiency equation associated with model (3) are presented in Table 8.[21] We interpret the results for each variable as the effect it has on inefficiency. The results are as we would expect for both the significant household characteristic variables and the plot characteristic variables. The proportion of plots that are irrigated has a negative effect on inefficiency (that is, increases efficiency). A similar result is found for the proportion of plots with restrictions. As also might be expected, the proportion of plots that have a slope has a positive effect on inefficiency. While few of the household characteristic variables are significant, education plays an important role in determining efficiency. There is also some evidence to suggest that older heads of household are less efficient.

INSERT TABLE 8 ABOUT HERE

The red book variable is negative and significant when both plot characteristics and household controls are included. This means that the greater the proportion of plots with a red book the higher the efficiency level of the farm. We see that when this variable is broken down into its various categories, the greater the proportion of plots where either the husband or wife is exclusively named in the red book, the higher the efficiency of the household. The magnitude of this effect is greater the greater the proportion of plots where the wife is named. Unlike the previous model, however, gender specifically does not have a significant effect on efficiency. Rather, the results suggest that where individuals have exclusive property rights for plots, households are more efficient than

[21] The yield equation results are presented in Table C of the Appendix. In all cases a Cobb-Douglas model is rejected in favour of the Translog specification. Tests of the joint significance of the inefficiency effects also lead to a rejection of the more restricted model in all cases. Likelihood ratio tests also reject deterministic models in favour of the stochastic frontier approach.

where the property rights are shared between husband and wife. This result is also evident from the summary statistics presented in Table 4. This may be due to the fact that the incentives to be efficient are greater where individuals are the sole decision maker in relation to production on that plot.

As found in much of the previous empirical literature on the effect of security of land tenure on outcomes, defining property rights themselves through owning a LUC does not appear to matter in the production decisions and productivity levels of rice plots. We do find, however, that where property rights are defined, intra-household differences in land tenure appears to affect production decisions and efficiency. On the basis of the intra-household analysis the results suggest that gender appears to matter in the decision to grow rice and in rice yields. In contrast, the household production analysis suggests that exclusivity of property rights is the driving factor in relation to intra-household differences in efficiency. Since we do not have information on the exact household members in charge of plots that do not have a red book we cannot make any definitive conclusions on the extent to which gender or exclusivity of control matters in general to production. We can conclude, however, that the way in which property rights are defined may affect production through both of these mechanisms.

6. Conclusion

We have used household data collected in 2006 in 12 provinces in Vietnam to shed some light on the effect of land titles on crop choice, rice yields and household efficiency in growing rice. The dataset provides detailed plot level information allowing us to use a household fixed effects approach to analyse crop choice and rice yields. The determinants of inefficiency are analysed by estimating a household yield function.

Similar to much of the other empirical literature on the effects of formal land titling, we do not find any effects of holding a red book, the official document of households' long-term entitlement to the use of land, on crop choice and plot yields. However, we do find that conditional upon having a red book, there are different effects according to which household member's name appears in it. The results suggest that both gender and the exclusivity of property rights may be important factors in the choice of crop whereas the rice yield results appear to be purely gender driven. Conditional on property rights being defined, plots where women have partial or complete property rights have higher yields than where males have exclusive rights.

The efficiency level of the farm is increased when a larger share of the household's plots have a LUC. When broken down into different name structures we find that the effect only exists when either husband or wife have exclusive use rights, with a larger effect for wives, but there is no inefficiency decreasing effect of jointly held red books. This may suggest that efficiency is higher in cases of sole responsibility.

Although we can not conclude whether exclusivity of land rights or gender is driving our results, it is clear that the ownership structure in the land title may affect production.

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Table 1
Land Use Certificate situation of plots

	All plots		Annual and perennial cropland[a]	
	Observations	Percentage	Observations	Percentage
Redbook				
Plots with LUC	9,418	81	8,266	82
Plots without LUC	2,265	19	1,833	18
Total plots	11,683	100	10,099	100
Number of HH members names				
No HH members	479	5	373	5
One HH member	8,182	87	7,214	87
Two HH members	757	8	679	8
Total plots	9,418	100	8,266	100
Name structure				
Husband/male head	6,420	68	5,695	69
Wife/female head	1,570	17	1,345	16
Husband and wife	670	7	603	7
Other situation	758	8	623	8
Total plots	9,418	100	8,266	100

[a] The category also includes the type “residential land + garden”.

Table 2
Characteristics of plots by Land Use Certificate

	All plots		Annual and perennial cropland[a]	
	With LUC	Without LUC	With LUC	Without LUC
Size (in sqm)	1,579	2,241	1,427	2,391
Distance from the house (in metres)	824	1484	871	1726
Slope (% flat)	73	51	73	53
Irrigation (% irrigated)	66	42	74	51
Restrictions (% restricted crop choice)	57	38	58	40
Acquirement (% state)	70	38	74	41
Number of plots	9,415	2,265	8,264	1,833

[a] The category also includes the type “residential land + garden”.

Table 3a
Crops grown in most recent agricultural season, by Land Use Certificate situation-all households

Crop	No LUC	With LUC	Husband/ Male head	Wife/ female head	Husband and wife	Other	All
Rice	56.4	69.6	70.0	70.4	63.6	69.9	67.2
Maize	14.8	5.2	5.1	4.6	9.8	3.9	6.9
Potato/cassava	6.8	4.4	4.3	3.9	6.5	4.7	4.9
Peanuts	1.2	1.6	1.8	1.2	0.9	0.7	1.5
Vegetables	3.5	3.6	3.5	4.3	4.4	2.1	3.6
Other annual	2.6	2.3	2.3	3.2	0.5	2.1	2.4
Fruit	3.6	4.8	4.4	5.6	6.7	4.9	4.6
Coffee	4.8	3.3	3.6	2.8	0.2	3.9	3.5
Tea	0.9	1.3	1.3	0.5	3.1	1.2	1.2
Cashew nuts	1.6	0.4	0.4	0.4	0.4	0.7	0.6
Sugarcane	0.4	0.6	0.3	0.7	2.2	1.2	0.5
Pepper	0.2	0.3	0.3	0.2	0.0	0.4	0.3
Other perenn.	3.3	2.7	2.7	2.2	1.8	4.4	2.8
Annual crops	85.3	86.7	87.0	87.7	85.7	83.4	86.5
Perennial crops	14.7	13.3	13.0	12.3	14.3	16.6	13.5
All crop plots	100	100	100	100	100	100	100
(Obs.)	(1632)	(7568)	(5292)	(1153)	(552)	(571)	(9200)

Table 3b
Crops grown in most recent agricultural season, by LUC situation-households with LUC variation

Crop	No LUC	With LUC	Husband/ Male head	Wife/ female head	Husband and wife	Other	All
Rice	51.5	72.8	74.8	60.5	66.9	70.7	65.4
Maize	18.2	5.1	5.0	4.0	9.7	3.2	9.7
Potato/cassava	8.2	3.4	2.8	4.0	4.1	7.6	5.1
Peanuts	0.9	1.0	1.2	0.0	0.0	0.6	1.0
Vegetables	3.2	3.0	2.7	4.8	6.9	0.6	3.1
Other annual	2.6	2.4	2.4	4.0	0.7	2.6	2.4
Annual crops							
Fruit	2.9	4.0	3.3	8.9	5.5	5.1	3.6
Coffee	4.8	4.3	4.3	8.1	0.7	3.8	4.5
Tea	1.4	0.8	0.6	0.8	3.5	0.6	1.0
Cashew nuts	1.5	0.6	0.5	2.4	0.0	0.6	0.9
Sugarcane	0.3	0.4	0.3	1.6	0.0	1.3	0.4
Pepper	0.2	0.5	0.5	0.8	0.0	0.6	0.4
Other perenn.	4.3	1.6	1.6	0.0	2.1	2.6	2.6
Annual crops	84.5	87.8	89.0	77.4	88.3	85.4	86.7
Perennial crops	15.5	12.2	11.1	22.6	11.7	14.7	13.3
All crop plots	100	100	100	100	100	100	100
(Obs.)	(975)	(1811)	(1385)	(124)	(145)	(157)	(2786)

Table 4
Average and median rice yield, by LUC situation of plot (only most recent agricultural season)

	All plots			Conditional on variation in LUC		
	Obs.	Avg. kg/sqm	Median kg/sqm	Obs.	Avg. kg/sqm	Median kg/sqm
No LUC	920	0.51	0.46	502	0.51	0.43
With LUC	5268	0.53	0.48	1319	0.56	0.49
Husband/male head only	3706	0.51	0.48	1036	0.50	0.49
Wife/female head only	812	0.56	0.50	75	0.57	0.55
Husband and wife	351	0.46	0.45	97	0.42	0.40
Other situation	399	0.67	0.48	111	1.18	0.50
All plots	6188	0.53	0.48	1821	0.54	0.49

All plots: One-sided T-test between husband and wife only plots: significantly different at 5%; One-sided T-test between husband or wife only and husband& wife plots significantly different at 10%.
Conditional on household variation in red book ownership: no significant difference between husband and wife only plots but significant difference between husband only or wife only and husband&wife plots (one sided T-test at 10% and 5% respectively).
No significant differences between redbook/no redbook plots.

Table 5: Description of Variables

Variable Name	Description
Plot Characteristics	
Log(Area)	Log of the area of the plot in square metres
Distance	Distance from home to plot in metres/100
Irrigated	Dummy indicator for whether the plot is irrigated
Restrictions	Dummy indicator for whether restrictions on the type of crop are in place
Slight slope	Dummy indicator for plot with a slight slope
Moderate Slope	Dummy indicator for plot with a moderate slope
Steep Slope	Dummy indicator for plot with a steep slope
State	Dummy indicator for plot given by the state or commune
Inherit	Dummy indicator for plot inherited
Market	Dummy indicator for plot purchased on the market
Red Book Variables:	
Redbook	Dummy indicator for plot with a red book
Husband in RB	Dummy indicator for plot with husband/single male named in red book
Wife in RB	Dummy indicator for plot with wife/single female named in red book
Husband + Wife in RB	Dummy indicator for plot with husband and wife named in red book
Female in RB	Dummy indicator for plot with at least one female named in red book
Production Function Variables:	
Total Yields	Rice kilograms per square metre produced by households
Labour	Labour units used in production of rice (per sq. metre)
Seed	Value of seeds and saplings used in production of rice (per sq. metre)
Fertilizer	Value of fertilizers used in production of rice (per sq. metre)
Pesticide & Herbicide	Value of pesticides and herbicides used in production of rice (per sq. metre)
Efficiency Variables:	
Redbook	Proportion of plots owned by the household with a red book
Husband in RB	Proportion of plots owned by the household with husband/single male named in red book
Wife in RB	Proportion of plots owned by the household with wife/single female named in red book
H&W in RB	Proportion of plots owned by the household with husband and wife named in red book
Others in RB	Proportion of plots owned by the household with other red book formulations
Female in RB	Proportion of plots owned by the household with at least one female named in red book
Plot age	Average age of plots used by household
Irrigated	Proportion of plots owned by the household that are irrigated
Restrictions	Proportion of plots owned by the household with restrictions
Slight slope	Proportion of plots owned by the household with a slight slope
Mod. Slope	Proportion of plots owned by the household with a moderate slope
Steep Slope	Proportion of plots owned by the household with a steep slope
Sex Head	Dummy indicator for gender of the head of household (=1 if male)
Age Head	Age of the head of household
Married	Dummy indicator for marital status of the head of household (=1 if married)
Ed1	Dummy indicator for head of household completed primary school
Ed2	Dummy indicator for head of household completed secondary school
Ed3	Dummy indicator for head of household has a third level educaiton
HHsize	Household size

Table 6: The Decision to Grow Rice – Within household variation – Conditional Fixed Effects Logit Model with Robust Standard Errors

	Full sample			Conditional on Red Book			Conditional on Red Book and Variation in Red Book Status within Households			
Log(Area)	0.012	0.013	0.057	0.056	0.058	0.056	-0.033	-0.034	-0.033	-0.036
	(0.072)	(0.072)	(0.082)	(0.082)	(0.082)	(0.082)	(0.163)	(0.164)	(0.163)	(0.163)
Distance	0.011	0.010	0.006	0.006	0.006	0.006	0.081***	0.082***	0.083***	0.081***
	(0.009)	(0.009)	(0.004)	(0.004)	(0.004)	(0.004)	(0.024)	(0.025)	(0.025)	(0.024)
Irrigated	2.665***	2.672***	2.542***	2.544***	2.548***	2.542***	2.586***	2.594***	2.614***	2.586***
	(0.180)	(0.180)	(0.208)	(0.208)	(0.207)	(0.208)	(0.506)	(0.507)	(0.501)	(0.506)
Restrictions	3.875***	3.885***	4.096***	4.104***	4.085***	4.095***	3.881***	3.928***	3.871***	3.879***
	(0.276)	(0.277)	(0.347)	(0.349)	(0.346)	(0.347)	(0.929)	(0.943)	(0.935)	(0.928)
Slight slope	-1.575***	-1.577***	-2.081***	-2.082***	-2.082***	-2.081***	-1.614**	-1.618**	-1.623**	-1.612**
	(0.258)	(0.257)	(0.346)	(0.347)	(0.346)	(0.346)	(0.783)	(0.787)	(0.790)	(0.782)
Moderate	-2.460***	-2.475***	-2.756***	-2.757***	-2.756***	-2.755***	-2.541***	-2.550***	-2.552***	-2.538***
Slope	(0.325)	(0.325)	(0.457)	(0.457)	(0.457)	(0.457)	(0.929)	(0.933)	(0.938)	(0.927)
Steep Slope	-3.608***	-3.601***	-3.209***	-3.209***	-3.209***	-3.208***	-13.670***	-14.150***	-15.013***	-13.673***
	(0.647)	(0.639)	(0.783)	(0.783)	(0.783)	(0.783)	(1.323)	(1.331)	(1.330)	(1.322)
State	0.948***	1.033***	1.500***	1.501***	1.502***	1.500***	3.194***	3.207***	3.203***	3.192***
	(0.318)	(0.311)	(0.504)	(0.505)	(0.505)	(0.504)	(0.577)	(0.577)	(0.572)	(0.577)
Inherit	-0.694**	-0.617*	-0.448	-0.448	-0.450	-0.448	-0.438	-0.430	-0.426	-0.440
	(0.361)	(0.356)	(0.595)	(0.595)	(0.593)	(0.595)	(0.764)	(0.759)	(0.732)	(0.764)
Market	-0.350	-0.302	-0.336	-0.335	-0.331	-0.336	0.917	0.922	0.906	0.916
	(0.382)	(0.372)	(0.571)	(0.571)	(0.567)	(0.571)	(1.041)	(1.028)	(0.976)	(1.042)
Redbook		-0.247								
		(0.324)								
Husband in RB			-2.359***				-3.362***			
			(0.691)				(0.824)			
Wife in RB				1.411**				1.497**		
				(0.660)				(0.771)		
Husband + Wife in RB					10.431***				13.636***	
					(1.031)				(1.365)	
Female in RB						2.359***				3.362***
						(0.691)				(0.824)
LL	-1,159	-1,159	-816	-816	-817	-817	-133	-133	-134	-133
Pseudo R^2	0.5303	0.5304	0.5308	0.5306	0.5301	0.5305	0.5997	0.5991	0.5970	0.5985
n	6,228	6,228	4,453	4,453	4,455	4,455	885	885	887	887

*Standard errors are given in parenthesis. *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level*

Table 7: Rice Yields – Within household variation – Linear Fixed Effects Model with Robust Standard Errors

	Full sample			Conditional on Red Book			Conditional on Red Book and Variation in Red Book Status within Households			
Constant	1.593***	1.595***	2.051***	1.749***	1.765***	1.691***	1.616***	1.406***	1.403***	1.383***
	(0.314)	(0.305)	(0.471)	(0.388)	(0.392)	(0.374)	(0.604)	(0.509)	(0.507)	(0.499)
Log(Area)	-0.164***	-0.164***	-0.198***	-0.197***	-0.197***	-0.198***	-0.152**	-0.150*	-0.150*	-0.152**
	(0.043)	(0.043)	(0.054)	(0.054)	(0.054)	(0.054)	(0.079)	(0.078)	(0.078)	(0.079)
Distance	0.000	0.000	-0.001	-0.001	-0.001	-0.001	0.001	0.001	0.002	0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Irrigated	-0.095	-0.095	-0.120	-0.120	-0.120	-0.120	-0.042	-0.041	-0.040	-0.042
	(0.089)	(0.091)	(0.117)	(0.117)	(0.117)	(0.117)	(0.053)	(0.052)	(0.052)	(0.053)
Restrictions	0.008	0.009	0.076*	0.076*	0.076*	0.076*	0.034	0.035	0.036	0.034
	(0.038)	(0.039)	(0.045)	(0.045)	(0.045)	(0.046)	(0.034)	(0.034)	(0.034)	(0.034)
Slight slope	-0.051**	-0.051**	-0.029	-0.029	-0.039	-0.029	-0.027	-0.027	-0.027	-0.027
	(0.024)	(0.025)	(0.033)	(0.033)	(0.033)	(0.033)	(0.095)	(0.095)	(0.095)	(0.095)
Moderate	-0.077*	-0.078*	-0.086	-0.086	-0.086	-0.086	-0.102	-0.104	-0.105	-0.104
Slope	(0.044)	(0.044)	(0.056)	(0.056)	(0.056)	(0.056)	(0.092)	(0.092)	(0.092)	(0.092)
Steep Slope	-0.055	-0.055	0.019	0.019	0.018	0.019	…	…	…	…
	(0.056)	(0.056)	(0.075)	(0.074)	(0.074)	(0.075)				
Redbook		-0.003								
		(0.056)								
Husband in RB			-0.360***				-0.232*			
			(0.127)				(0.126)			
Wife in RB				0.136				0.064		
				(0.108)				(0.084)		
Husband + Wife in RB					0.086				0.100	
					(0.114)				(0.105)	
Female in RB						0.360***				0.232*
						(0.127)				(0.126)
Within R^2	0.0345	0.0345	0.0406	0.0404	0.0403	0.0406	0.0388	0.0384	0.0384	0.0388
n	6,154	6,154	4,846	4,846	4,847	4,847	1,401	1,401	1,402	1,402

*Standard errors are given in parenthesis. *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level*

Table 8: Efficiency estimates from Translog household yield functions – rice yields

	Model Ia	Model Ib	Model IIa	Model IIb	Model IIIa	Model IIIb
Constant	-0.5869 (1.0912)	0.0623 (0.4569)	-0.3974 (0.4635)	0.0957 (0.3980)	-0.8047 (0.6635)	-0.1897 (0.5984)
Redbook	-0.5185 (0.3308)	-0.4068** (0.1913)				
Husband in RB			-0.5005* (0.2830)	-0.2657* (0.1552)		
Wife in RB			-0.8793* (0.5042)	-0.9833* (0.5702)		
H&W in RB			0.0392 (0.2518)	0.0863 (0.1013)		
Others in RB			-0.2828 (0.3452)	-0.3287 (0.2184)		
Female in RB					-0.1444 (0.2776)	-0.3129 (0.2859)
Plot age	-0.0115 (0.0385)	-0.0028 (0.0151)	-0.0090 (0.0314)	-0.0053 (0.3980)	-0.0215 (0.0423)	-0.0138 (0.0160)
Irrigated	-1.3417 (0.8657)	-0.8258** (0.3295)	-1.2348* (0.6365)	-0.7647** (0.3400)	-1.3989** (0.6387)	-0.8874* (0.4738)
Restrictions	-1.1988 (0.8416)	-0.7144** (0.2885)	-0.9778* (0.5528)	-0.5561* (0.3190)	-1.2711* (0.6628)	-0.8123* (0.4893)
Slight slope	0.7657 (0.4993)	0.4389** (0.1976)	0.6448** (0.2736)	0.3829** (0.1874)	0.7606** (0.3404)	0.4509** (0.2293)
Mod. Slope	1.5894 (1.1492)	0.8460*** (0.3200)	1.3728* (0.7189)	0.7715** (0.3889)	1.6690** (0.7560)	0.9726* (0.5606)
Steep Slope	1.1116 (1.0997)	0.6565* (0.3633)	0.7972* (0.4422)	0.4856 (0.3546)	1.0143** (0.4843)	0.6931 (0.4629)
Sex Head		-0.1306 (0.1221)		0.2655 (0.2332)		0.0904 (0.1892)
Age Head		0.0073** (0.0031)		0.0072* (0.0043)		0.0075 (0.0050)
Married		-0.1774 (0.1645)		-0.1765 (0.1192)		-0.1413 (0.1316)
Ed1		-0.6688** (0.2857)		-0.5493* (0.3026)		-0.6593 (0.4093)
Ed2		-0.2124 (0.1547)		-0.1658* (0.0906)		-0.1783 (0.1180)
Ed3		-2.1150** (1.0188)		-1.6477 (1.3458)		-2.2642 (0.1412)
HHsize		-0.0137 (0.0291)		-0.0133 (0.0178)		-0.0145 (0.0240)
n	1,524	1,523	1,524	1,523	1,524	1,523

**** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level*

Appendix

Table A: The Decision to Grow Rice –Including plots where non-household members named in the red book

	Conditional on Red Book				Conditional on Red Book and Variation in Red Book Status within Households			
Log(Area)	0.041 (0.079)	0.040 (0.079)	0.040 (0.079)	0.044 (0.082)	-0.021 (0.152)	-0.023 (0.152)	-0.023 (0.154)	-0.065 (0.164)
Distance	0.006 (0.004)	0.006 (0.004)	0.006 (0.004)	0.006 (0.004)	0.059** (0.025)	0.059** (0.026)	0.059** (0.026)	0.088*** (0.025)
Irrigated	2.601*** (0.199)	2.601*** (0.199)	2.602*** (0.199)	2.575*** (0.205)	2.915*** (0.506)	2.914*** (0.505)	2.915*** (0.505)	2.639*** (0.504)
Restrictions	4.159*** (0.330)	4.160*** (0.330)	4.161*** (0.330)	4.111*** (0.346)	3.797*** (0.725)	3.801*** (0.728)	3.811*** (0.732)	3.886*** (0.910)
Slight slope	-2.093*** (0.340)	-2.093*** (0.340)	-2.095*** (0.339)	-2.064*** (0.345)	-1.281* (0.723)	-1.279* (0.722)	-1.288* (0.723)	-1.405* (0.756)
Moderate Slope	-2.840*** (0.433)	-2.841*** (0.434)	-2.841*** (0.433)	-2.766*** (0.449)	-2.188*** (0.807)	-2.188*** (0.807)	-2.193*** (0.805)	-2.459*** (0.899)
Steep Slope	-3.355*** (0.738)	-3.355*** (0.739)	-3.356*** (0.738)	-3.195*** (0.778)	-14.148*** (0.915)	-15.109*** (0.912)	-13.881*** (0.931)	-13.221*** (1.325)
State	1.439*** (0.468)	1.436*** (0.468)	1.432*** (0.469)	1.528*** (0.479)	2.471*** (0.561)	2.470*** (0.563)	2.459*** (0.563)	3.063*** (0.514)
Inherit	-0.322 (0.553)	-0.328 (0.552)	-0.310 (0.553)	-0.291 (0.574)	0.212 (0.609)	0.202 (0.599)	0.231 (0.604)	-0.111 (0.705)
Market	-0.191 (0.566)	-0.205 (.563)	-0.200 (0.553)	-0.113 (0.555)	0.948 (1.044)	0.923 (1.041)	0.930 (0.930)	1.622* (0.947)
Hus. in RB	-0.155 (0.759)				-0.095 (0.994)			
Wife in RB		-0.059 (0.747)				-0.027 (0.995)		
Hus./Wife in RB			1.827** (0.894)				0.690 (0.990)	
Female in RB				1.049 (0.695)				0.725 (0.746)
Others in RB	0.749 (0.765)	0.824* (0.496)	0.910* (0.513)	0.095 (0.821)	0.797 (1.002)	0.852 (0.657)	0.884 (0.660)	-0.923 (0.825)
Log-L	-868	-868	-869	-830	-164	-164	-164	-140
Pseudo R^2	0.5405	0.5405	0.5404	0.5353	0.5951	0.5951	0.5942	0.6023
n	4,865	4,865	4,867	4,599	1,087	1,087	1,089	946

*Standard errors are given in parenthesis. *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level*

Table B: Rice Yields – Including plots where non-household members named in the red book

	Conditional on Red Book				Conditional on Red Book and Variation in Red Book Status within Households			
Constant	1.803*** (0.388)	1.722*** (0.370)	1.724*** (0.370)	1.692*** (0.373)	1.465*** (0.469)	1.406*** (0.452)	1.403*** (0.449)	1.331*** (0.470)
Log(Area)	-0.191*** (0.050)	-0.191*** (0.050)	-0.191*** (0.050)	-0.191*** (0.052)	-0.151** (0.069)	-0.151** (0.069)	-0.152** (0.069)	-0.141** (0.073)
Distance	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.002)	0.002* (0.001)	0.002* (0.001)	0.002* (0.001)	0.002 (0.001)
Irrigated	-0.109 (0.108)	-0.109 (0.108)	-0.109 (0.109)	-0.119 (0.114)	-0.030 (0.044)	-0.030 (0.043)	-0.030 (0.043)	-0.034 (0.047)
Restrictions	0.064* (0.039)	0.064* (0.039)	0.064* (0.039)	0.076* (0.0440	0.028 (0.037)	0.029 (0.037)	0.029 (0.037)	0.036 (0.032)
Slight slope	-0.030 (0.031)	-0.030 (0.031)	-0.030 (0.031)	-0.028 (0.032)	-0.031 (0.086)	-0.031 (0.086)	-0.031 (0.086)	-0.023 (0.094)
Mod Slope	-0.085 (0.054)	-0.085 (0.054)	-0.085 (0.054)	-0.086 (0.055)	-0.103 (0.083)	-0.104 (0.083)	-0.105 (0.083)	-0.101 (0.089)
Steep Slope	0.013 (0.071)	0.013 (0.071)	0.013 (0.071)	0.014 (0.072)	…	…	…	…
Hus. in RB	-0.095 (0.064)				-0.067 (0.048)			
Wife in RB		0.046 (0.059)				0.019 (0.045)		
Husband + Wife in RB			0.086 (0.096)				0.106 (0.092)	
Female in RB				0.153* (0.082)				0.093 (0.064)
Others in RB	-0.045 (0.056)	0.035 (0.029)	0.025 (0.026)	0.035 (0.053)	-0.034 (0.042)	0.020 (0.021)	0.016 (0.020)	-0.004 (0.033)
Within R^2	0.0398	0.0397	0.0398	0.0391	0.0409	0.0408	0.0409	0.0363
n	5,241	5,241	5,242	5,036	1,611	1,611	1,612	1,502

*Standard errors are given in parenthesis. *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level*

Table C: Stochastic yield function estimates

	Model Ia	Model Ib	Model IIa	Model IIb	Model IIIa	Model IIIb
Constant	0.2230*** (0.0227)	0.2370*** (0.0200)	0.2264*** (0.0215)	0.2351*** (0.0267)	0.2232*** (0.0198)	0.2282*** (0.0222)
$\ln x_1$	0.1687*** (0.0173)	0.1682*** (0.0171)	0.1672*** (0.0173)	0.1657*** (0.0173)	0.1697*** (0.0166)	0.1693*** (0.0174)
$\ln x_2$	0.1444*** (0.0173)	0.1439*** (0.0176)	0.1477*** (0.0177)	0.1458*** (0.0174)	0.1437*** (0.0167)	0.1421*** (0.0178)
$\ln x_3$	0.3146*** (0.0236)	0.3143*** (0.0233)	0.3144*** (0.0235)	0.3172*** (0.0235)	0.3152*** (0.0237)	0.3173*** (0.0224)
$\ln x_4$	0.1562*** (0.0161)	0.1549*** (0.0158)	0.1540*** (0.0163)	0.1494*** (0.0160)	0.1575*** (0.0163)	0.1562*** (0.0156)
$\ln x_1 * \ln x_1$	0.0292*** (0.0089)	0.0273*** (0.0088)	0.0287*** (0.0089)	0.0270*** (0.0087)	0.0294*** (0.0089)	0.0279*** (0.0089)
$\ln x_2 * \ln x_2$	-0.0063 (0.0068)	-0.0063 (0.0066)	-0.0063 (0.0068)	-0.0064 (0.0067)	-0.0057 (0.0065)	-0.0056 (0.0067)
$\ln x_3 * \ln x_3$	0.0800*** (0.0149)	0.0811*** (0.0140)	0.0802*** (0.0147)	0.0828*** (0.0142)	0.0784*** (0.0153)	0.0812*** (0.0144)
$\ln x_4 * \ln x_4$	0.0222*** (0.0084)	0.0215** (0.0083)	0.0223*** (0.0084)	0.0209** (0.0092)	0.0226*** (0.0080)	0.0222*** (0.0083)
$\ln x_1 * \ln x_2$	0.0188 (0.0190)	0.0237 (0.0186)	0.0182 (0.0189)	0.0216 (0.0187)	0.0194 (0.0185)	0.0241 (0.0187)
$\ln x_1 * \ln x_3$	-0.0443** (0.0224)	-0.0447** (0.0219)	-0.0427* (0.0225)	-0.0430* (0.0221)	-0.0446** (0.0224)	-0.0467** (0.0222)
$\ln x_1 * \ln x_4$	0.0087 (0.0144)	0.0097 (0.0145)	0.0086 (0.0146)	0.0090 (0.0144)	0.0081 (0.0145)	0.0089 (0.0146)
$\ln x_2 * \ln x_3$	-0.0505*** (0.0190)	-0.0518*** (0.0190)	-0.0513*** (0.0191)	-0.0499*** (0.0190)	-0.0506*** (0.0193)	-0.0501*** (0.0183)
$\ln x_2 * \ln x_4$	0.0650*** (0.0161)	0.0630*** (0.0156)	0.0646*** (0.0164)	0.0608*** (0.0161)	0.0653*** (0.0164)	0.0638*** (0.0159)
$\ln x_3 * \ln x_4$	-0.0567*** (0.0190)	-0.0554*** (0.0197)	-0.0553*** (0.0202)	-0.0537*** (0.0201)	-0.0563*** (0.0203)	-0.0568*** (0.0201)
$\hat{\sigma}^2$	0.6420 (0.4145)	0.4309*** (0.1585)	0.5760** (0.2871)	0.3743** (0.1660)	0.6460** (0.2955)	0.4406** (0.2278)
$\hat{\gamma}$	0.8698*** (0.0833)	0.8062*** (0.0764)	0.8565*** (0.0740)	0.7861*** (0.0947)	0.8701*** (0.0627)	0.8137*** (0.0966)
Log-L	-511.15	-499.97	-509.69	-495.94	-512.49	-501.61
LR Test Stats:						
TL v. CD	107.55	109.61	107.28	111.14	105.01	106.88
$\hat{\delta}_1 = ... = \hat{\delta}_p = 0$	75.16	97.51	78.06	105.56	72.46	94.23
$\hat{\gamma} = 0$	102.66	125.01	105.56	133.06	99.96	121.73

**** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level*

$\ln x_1$ *is the log of labour,* $\ln x_2$ *is the log of seed,* $\ln x_3$ *is the log of fertilizer,* $\ln x_4$ *is the log of pesticide and herbicide,* $\hat{\sigma}^2$ *is an estimate of the variance of the composite error term,* $\hat{\gamma}$ *is an estimate of the share of technical efficiency in total variance, TL and CD stand for the Translog and Cobb-Douglas models respectively, and p is the number of variables in the inefficiency equation.*