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Have the Key Priority Forestry Programs Really Impacted on China's Rural Household Income

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Abstract

We use a large unique household panel data set spanning 16 years to estimate the impacts of three major Chinese forest conservation and reforestation programs on household incomes. The programs are the most significant of China’s Key Priority Forestry Programs, namely the Sloping Land Conversion Program (the SLCP), the Natural Forest Protection Program (the NFPP), and the Desertification Combating Program around Beijing and Tianjin (the DCBT). Cluster effects with county and environment factors have been estimated by using year dummy variables. Fixed model with cluster effects has been used. In addition to estimating the total impacts of the programs, individually and in combination, we disaggregate the effects by income source, stage of policy implementation, and duration of participation. We find minimal effects on total incomes from the programs overall, which are quiet different with other research empirical results, .but the more detailed results show that the initial stages of the programs, and the early years of participation had negative or neutral effects on land-based incomes, while in more recent years, impacts have improved, and in some cases become positive.

Key words: Priority Forest Programs, rural household income, rural development, forest economics, ecological restoration.

JEL classification: Q23, I38, R14, R29.

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I. Introduction

Over the past three decades, by any standard, China's economic performance has been impressive, with annual GDP growth averaging 10% (Zheng, Bigsten and Hu 2008; World Bank 2012). Chinese rural households' income per capital has increased 8.5 times from 1978 to 2010 (China National Statistics Bureau 2011). Despite these great achievements, China still has large number of poor people (Chen and Ravallion 2004). China's current pattern of development has also placed considerable stress on the ecosystems, and has imposed increased pressure on the availability of natural resources, which has led to concerns that past and current economic growth patterns are environmentally unsustainable (World Bank 2012). China suffered serious natural disasters in late 1990s, such as flooding (Xu and Cao 2001), serious soil erosion and sandstorms (Liu and Zhang 2006), which led the Chinese authorities to propose a new environmental strategy emphasizing continued rapid growth together with ambitious targets for natural resource management and ecological sustainability, which can be viewed in the framework of a crisis-response model (Mather, Fairbain and Needle 1999; Hirsch and Lohmann 1989). Specifically, the government of China launched six Priority Forest Programs (PFPs) since 1998 with objectives of environmental restoration and increasing rural households' income, which include the Sloping Land Conversion Program (the SLCP); the Natural Forest Protection Program(the NFPP); the Desertification Combating Program around Beijing and Tianjin (the DCBT); and three smaller programs: the Shelterbelt Development Program (the SBDP), the Wildlife Conservation and Nature Reserve Program (the WCNR), and the Industrial Timber Plantation Program (the ITPP).The six PFPs differ in when they were introduced, and in their characteristics and specific objectives. Broadly, they involve government subsidies for conversion of cropland to forest land under the SLCP and the DCBT; government restrictions on use of natural forest land under the NFPP and the WCNR; and the government incentives for timber plantations under the ITPP and the SBDP. These PFPs will be ongoing in the China. Large-scale and effective land conversion and forest ecological restoration programs have mainly taken place in developed countries, notably the Conservation Reserve Program in America (Cowan and Johnson 2008), the Permanent Cover Environmental Program in Canada, and a variety of short-term set aside programs and long-term forest programs in the European Union (OECD 1997). Many developing countries have also paid attention to forest ecological restoration (FAO 2009). Thailand, Indonesia and other countries have launched Logging Ban programs similar to the NFPP (FAO 2001). Given China's significant experience in this respect, an assessment of the impact of the PFPs on rural households' total income and their sources is not only useful for China, but also insightful for other countries.

The impacts of the PFPs on farmers' income and livelihood during their initial period of implementation have received a great deal of attention in the literature, particularly the SLCP. A number of studies from different regions have found largely positive effects of the SLCP on households' income (Zhi and Shao 2001, Yao, Guo and Huo 2010, Xie, Zhao and et al 2006, Liu, Lu and Yin 2010), or little effects of the SLCP on rural household (Xu and Qin 2004), and on eradicting poverty in the countryside (Uchida, ,Xu and Rozelle 2005; Uchida, Xu and et al. 2007), and the SLCP has indeed induced a restructuring of agricultural production (Xu, Tao and et al 2010). However, the SLCP does not provide them with ability to find a new way of life after the compensation ends (Wang and Maclaren 2011). Compared to the SLCP, there have been fewer studies of the income impacts of other programs. Using case study data, some researchers found that the NFPP caused income losses for households dependent on the state and collective forest sectors (Xu, Katsigris and White 2002, Ni, Wang and Yang, 2002, Liu, Meng and et al. 2005, Xu, Yin and et al 2006, Weyerhaeuser, Wilkes and Kahrl 2005). However, others have found different impacts of NFPP on rural households (Mullan, Kontonleon and et al 2010; Liu, Lu and Yin 2010). Shen, Liao and Yin (2006) used input-output analysis to show that the combined impacts of the logging ban and the afforestation activities would likely increase output and employment in the economy as a whole. With data from 18 counties in Shanxi, Inner Mongolia and Hebei, Liu and Zhang (2006) show that the DCBT had a positive or negative effect on farmers' income, but the effect varied by the case study county. However, there are some key research gaps that our study aims to address. 1) Unlike most previous researchers, who used the data from the early implementation period of the PFPs, we plan to use a unique large and long-term panel to dataset of 1458 sample households over 16 years from 1995 to 2010 in 15 counties of 6 provinces to analyze the longer term impacts of the programs. 2) To our knowledge, little work has been conducted so far to make an integrated assessment of the impacts of the PFPs (Liu, Lu and Yin 2010; Weyerhaeuser, Wilkes and Kahrl 2005). We examine the combined impacts of the SLCP and the NFPP. 3) In the presence of cluster effects, ordinary least square estimates are still unbiased, but standard errors may be quite wrong leading to incorrect inference (Moulton 1990, 1986; Kloek 1981), almost no researchers have considered the cluster effects within a cluster (such as county or province) to estimate the effects of the PFPs on rural households' income. We used a fixed-effect model with clustered standard errors to accurately estimate the impacts of the program, while controlling for heterogeneity at the household and county level. 4) There have been changes in the details of the PFPs policy implementation and policy environment since the early period of the PFPs, which could affect rural households' income and its sources, the impacts of policy environment on rural households' income should be excluded to estimate the true effects of these PFPs on rural households' income. Due to the limitation of sample households, almost previous researchers have not paid attention to the effects of these PFPs on rural household by the year enrolled in the PFPs and by the PFPs implementation policy stage. By using more recent large and long-term panel dataset, we can consider the impacts of these changes by enrolled years in these PFPs and the policy stages of these PFPs, as well as wider changes in the institutional and policy environment of rural China. As the SBDP, the ITPP and the WCNR operate on a much smaller scale than the NFPP, the SLCP and the DCBT, and involve little activity at the household level[1], our paper focus on the latter three key PFPs (the KPFPs).

The following sections of the paper are as follows: the characteristics of the KPFPs' and how they have changed over time and the mechanisms through which they affect rural household incomes are presented in section 2. Methodology and data are presented in section 3 and 4 Section 5 contains the empirical results, and the final section contains conclusions and discussion.

II. Characteristics and impact mechanisms of the KPFPs

The SLCP was piloted in 1999 and 2000. It was formally implemented in 2001. The primary goal was to convert 14.6 million hectares of sloping or desertified cropland into forest and grass coverage from 2001 to 2010. When it was formally launched, the SLCP extended to and covered 25 provinces or autonomous regions with a budget of 225 billion Yuan. The central government subsidizes rural households enrolled in the SLCP in the form of seeds or seedlings, grain, and cash. Subsidies last 8 years for ecological forest, 5 years for economic forest, and 2 years for grassland. There have been two subsidy periods: from 1997 to 2007, households received 2400 Yuan/ha in the Yellow River Basin and 3450 Yuan/ha in the Yangtze River Basin. From 2007 onwards, the subsidies were 1350 Yuan/ha in the Yellow River Basin and 1875 Yuan/ha in the Yangtze River Basind. In light of the policy changes, we consider three stages of potential participation in the SLCP. The first is the initial subsidy period prior to 2007; the second is the period of discontinuity experienced by some households between the end of the initial subsidies and the start of the later subsidies; and the third is the post-2007 period in which households could re-enroll in the SLCP. The DCBT has a total projected investment of 57.7 billion Yuan. It includes subsidies for cropland conversion that are equivalent to those for the SLCP in the Yellow River Basin. Other elements of the program include irrigation projects; resettlement of people away from fragile areas; and changing herding and animal husbandry practices to control overgrazing and rehabilitate degraded grassland. The program was launched in 2001 with the first subsidy payments in 2002, therefore, rural households could experience the first stage of the SLCP subsidies, and the third stage (the later subsidies), but none of those in DCBT areas experienced a period of discontinuity in subsidies. In both the SLCP and the DCBT areas, households enrolled in the subsidy elements of the program are required to plant trees on barren forestland of at least the area of their converted cropland. The central government prepared the plan for the SLCP and the DCBT, and township governments and village committees informed rural households the locations of these two KPFPs, rural households made their decisions to participate in these two KPFPs. Following pilot implementation during 1998-

[1] Our survey indicates that 0.77% and 4.15% of sample rural households have been enrolled in the ITPP and the SBDP in 2008, respectively. Meanwhile, the investment weight of the SBDP, the ITPP and the WCNR was 8.02%, 0.20% and 1.66% of the total investment of the PFPs in 2008 (State Forestry Administration 2009). These PFPs are managed by villages or sub-villages or companies, and state forest farms.

1999, the NFPP was formally launched in 2000 with an initial investment of 96.4 billion Yuan for the decade. A key component of the NFPP was commercial logging bans over 30 million hectares of natural forests in the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River. In the Northeast, Northwest of China and Hainan Province, harvest restrictions were tightly imposed. Rural households who have natural forests and some forest plantation in the NFPP areas are required to participate in the NFPP.

The KPFPs may have direct or indirect effects on rural households' income. From the perspective of rural households, the most likely direct effects are: (1) the government subsidies they receive for converting the sloping and decertified cropland or rehabilitating grassland under the SLCP or the DCBT. These may be higher or lower than the opportunity cost of the land taken out of production, but to the extent that participation is voluntary, we would only expect households to enroll if they expected their income to rise. We would also expect the higher subsidies in the first stage of the SLCP and DCBT to have larger positive effects on incomes than the lower subsidies paid in the third stage. (2) The government restrictions imposed on logging, forest product collection, and forest management practices under the NFPP. We would expect incomes to fall as a result of these restrictions.

Indirect effects on income may occur through changes in land or labor allocation or changes in production technologies. Induced by the land reallocation and production shift, farmers may intensify farming and commercial forestry activities on their remaining lands, switch animal husbandry from open gazing to pen raising, or search for off-farm jobs in order to sustain their income. Therefore, it is expected that following their participation in the KPFPs, rural households' income sources, employment structure and production technology will undergo major transformation. In addition to farmers' own initiatives, efforts, and inputs, the size and direction of their income and employment changes will depend critically on the availability and effectiveness of technical, financial, and personnel assistances provided by the central and local public agencies. Finally, after the implementation of the KPFPs, changes in local ecological conditions may benefit local production, and further affect rural households' income.

III. Methodology

The objective of this paper is to quantify the impact of the KPFPs on rural households' income in affected areas. In order to this, we need to deal with an identification problem: if there are two potential outcomes, Y_1, the outcome when the rural household participates in programs; and Y_0, the outcome when the rural household does not participate, then the impact of participating in the programs is given by:

$$\Delta = Y_1 - Y_0 \qquad (1)$$

However, estimating this requires information on both Y_1, and Y_0 for each rural household, which is not obtainable because we cannot observe the outcome of participation for non-participants or the outcome of non-participation for participants. Therefore, estimation of the causal effect of the program is equivalent to solving a missing data problem (Heckman, Smith and Clements 1997), and requires the use of techniques that allow the identification of the relevant impacts in the absence of the data. In the case of the KPFPs, we want to know the difference between the level of household income when a household is in the program and when they are not, but we only have data on one situation or the other.

There are various methods to estimate a counterfactual outcome against which the outcome for treated individuals can be compared (Heckman and Robb 1985; Ashenfelter and Card 1985; Heckman, Smith and Clements 1997). The availability of panel data allows us to use a fixed-effect model to control for individual-specific heterogeneity that could affect the outcomes of participation as discussed above. We can consistently estimate average treatment effects on the treated as long as the treatment varies over time and is uncorrelated with time-varying unobservable variables that affect the outcome of interest. It is also necessary to assume that time trends in the outcome variable among program participants and non-participants are the same. For any individual, the observed outcome (Y), following Imbens and Wooldrige (2009), Roy (1951), Quandt (1972) and Rubin (1978), is defined as:

$$Y_{ist} = D_{ist} Y_{ist1} + (1 - D_{ist}) Y_{ist0} \qquad (2)$$

Where:Y is the total income(R) or land-based income (RL) or off-farm income(RO); *D* denotes participation in the program(s), and takes the values 1 if the individual participates/is treated or 0 if the individual does not participate or is not treated; s indexes the cluster/county($s = 1,2, \dots, 15$); i indexes sample rural household within s cluster; and t indexes the year($t = 1, 2, \dots, 15, 16$).

In addition to the KPFP participation, we include factors anticipated to influence rural households' income, namely production inputs and other biophysical and socioeconomic factors, as additional explanatory variables. The model can therefore be written as a function of observable characteristics of the individual and village (X_{it}), and the year effect variable Z_{ist}, the key program dummy variables$KPFP_{istk}$and unobservable, time-invariant individual-specific effects$\theta_{is}$and individual-specific disturbance terms($u_{ist1}, u_{ist0},$).

$$\begin{aligned} Y_{ist1} &= \alpha_0 + \sum \alpha_m X_{ist} + \sum_{s=1}^{15} \beta_n Z_{ist} + \sum_{k=1}^{4} \gamma_k KPFP_{istk} + \theta_{i_s} + u_{ist1} \\ Y_{ist0} &= \alpha_0 + \sum \alpha_m X_{ist} + \sum_{s=1}^{15} \beta_n Z_{ist} + \theta_{i_s} + u_{ist0} \end{aligned} \qquad (3)$$

Y_{ist1} has been decomposed into a linear function of observed variables X_{ist}, Z_{ist}, $KPFP_{istk}$and residualsunobservable, time-invariant individual-specific effectθ_i and $u_{ist1}$by construction.

The full model to be estimated becomes:

$$Y_{ist} = \alpha_0 + \sum \alpha_m X_{ist} + \sum_{n=1}^{15} \beta_n Z_{ist} + \sum_{k=1}^{4} \gamma_k PFP_{istk} + \theta_i + \varepsilon_{ist} \quad (4)$$

Where: $\varepsilon_{ist} = u_{ist0} + D(u_{ist1} - u_{it0})$ (5)

Specifically, a potential concern with this model is that the estimated treatment effects may be biased if the individual-specific effect or the disturbance term is correlated with participation in the program. The former may occur if unobserved characteristics of the individual affect the probability that they will participate in one KPFP, i.e. endogeneity or self-selection bias. This is likely in the case of voluntary (or semi-voluntary) programs such as the SLCP. If households have the freedom to select for participation, then their participation becomes an endogenous choice and assessment of the program impact must account for this to avoid biased estimates (Woodridge 1999; Uchida, Xu and et al 2007). The latter would be an example of what is referred to as 'Ashenfelter's dip' – if individuals experience unusually low or high incomes immediately prior to entering a program, the estimated returns to treatment will be biased in a context of mean reversion. We test for both endogeneity of selection into the PFPs and Ashenfelter's dip, in addition to Hausman tests to compare the fixed- and random-effect specifications of our model in Section 5.

Fixed effect is an example of modelling error components, where the structure is very special, i.e. each sampling within the cluster is equally-well correlated with every other samples. Partial out the fixed effect and we are left with a homoskedastic idiosyncratic error. We keep the assumption of zero correlation across clusters as with fixed effects, but allow the intra-cluster correlation to be anything at all. The usual assumption is that ε_{ist} is independently and identically distributed, but this is clearly violated in many cases. A natural generalization is to assume clustered error, i.e. that samples with cluster are correlated in some unobserved way, inducing correlation in u_{it} with cluster, but inter-cluster do not have correlated error. An intra-cluster correlation tells us the average correlation of sampling rural households within a sample county. Higher intra-cluster correlation, the less unique information each additional rural household provides. In the presence of the clustered errors, Ordinary Least Square (OLS) estimates are still unbiased, but standard errors may be quite wrong leading to incorrect inference in a surprisingly high proportion of finite samples (Moulton 1990,1986; Kloek 1981, Scott and Holt 1982; Greenwald 1983), they have shown that the magnitude of the downward bias for the standard errors increases with the average cluster size, the intra-cluster correlation of disturbances and the intra-cluster correlations of the estimators. We have the option of using clustered robust standard errors or using a multilevel model. Using clustered robust standard errors is the method of inflating the standard errors, as the most commonly; Huber-White standard errors are used. When we use a multilevel modelling technique to account for the intra-cluster correlation, we need to make sure that we have random intercepts, this is necessary because our cluster variable is random variable. In this paper, the cluster variable is not random variable, therefore, we use clustered robust standard errors method (Wooldrige 2003, 2002). First of all, we should test whether cluster effect exists or not before we get these empirical results.

IV. Data

A stratified random sample was used to collect household, village and county level data for this study. Based on the distributions of the rural households' income, the geographical distribution of the KPFPs, and our discussions with officials of provincial forestry and other departments and local experts, we first selected 15 counties for our surveys (see Fig. 1). Each of these counties has participated in at least one of the KPFPs with the exception of Pingyi County in Shandong Province. In the meanwhile, the average total income of sampling households is 74.28%~97.67% of national average rural households' total income surveyed by China National Statistics Bureau from 1995~2010, and average total income of some counties' sampling households are higher than that of the national average, and some are lower than that of the national average. The sample counties are representative of the KPFP areas of rural China, geographically and in terms of income level (see Fig. 1).

[Fig. 1 – page 31]

Sample villages and households were chosen randomly. Specifically, we chose the villages from the village list of a county and households from the household list of a village. In general, 15 households were chosen in each sample village. Altogether, we interviewed 3375 households in 216 villages of 72 townships. Our initial survey was conducted in 2004 as part of our program. To understand the microeconomic shifts over time, we asked interviewees to recall their production activities and other relevant information back to 1995. Then, every one or two years from 2005 to 2011, we repeated our surveys to collect data for both the treatment and control groups from the same households to qualify as panel data over the period 1995-2010, which has a longer and more continuous coverage than any other dataset used to assess the impacts of the KPFPs.

In order to help interviewees to describe their production and consumption behaviors, we designed the questionnaires in terms of specific production and consumption activities, asked multiple family members to recall their household activities in each year, and cross-checked the responses by consulting with village resource persons and statistical data and information for the case study counties, townships and villages. All these steps served to ensure high quality of the data collected. For this analysis, we have removed those observations with incomplete information and/or incomplete interviews for one or more years, resulting in a balanced panel of 1458 households[2] over 16 years from 1995 to 2010 for the study. Some of the missing observations were due to households moving away from the sample villages, being absent when the interview(s) occurred, errors occurring in some interviews, or certain families failing to clearly and exactly recall what had happened to them in the previous year(s).

Within the sample, there is variation in the years in which case study counties were enrolled in the SLCP, and the years in which households within a given county or village were enrolled in the SLCP and the DCBT (see Table 1). Increasing numbers of households enrolled in each of the KPFPs over time. While some participated in the two KPFPs, others did not participate in any of them. In addition to the overall impacts of program participation, we are interested in how the program impacts differ with the varying stages of implementation. In 2007, 191 households enrolled in the new version of the SLCP (what we refer to as the 'third stage' of participation), and 14 households in the DCBT. By 2010, these numbers had increased to 473 in the SLCP and 106 in the DCBT. Only a small number of households experienced a gap in the SLCP subsidies between the two iterations of the program for example, 5 in 2004, 26 in 2005 and 37 in 2006(see Table 2).

[Tables 1 and 2 – page 21]

Also included in the dataset are the following variables: (1) household demographics (household size, the educational years of the household head received, and the like); (2) monetary outputs and production inputs for land-based and off-farm activities; (3) natural and socioeconomic conditions.

Total income and cash outlay of sample households were deflated and converted to the 1994 constant Yuan, using the rural consumer price index and rural industrial product price index from the Chinese Statistical Yearbooks, published by China National Statistical Bureau (2011). Average annual household total income has been steadily increasing from 4400 Yuan in 1995 to 13300 Yuan in 2010 (see Table 3). We also examine income from different sources. Land-based income (which includes crop production income, forest income and animal husbandry income) rose in absolute terms over the period. Average off-farm income has risen from about1400 Yuan in 1995 to 8000 Yuan in 2010, which constitutes an increasing share of total income. These data indicate that rural household income sources have changed substantially since 1995, with cropland being replaced by off-farm activities as the main source of income.

[Table 3 – page 22]

[2] We test the estimation difference of total income, land-based income and off-farm income between these 1458 sampling households and 3375 sampling households by use of dataset from 1995 to 2004, the empirical results indicated that there were significant differences.

With the implementation of the PFPs, rural household land structure has been changing. Cropland area per household decreased from 7.7 mu[3] in 1995 down to 5.1mu in 2010; meanwhile average forestland area per household is10.6 mu, 10.7 mu, 14.6 mu, 18.8 mu and 22.4 mu in 1995, 1998, 2003, 2008 and 2010. Area of grassland per household fluctuated during the study period. The household's forestland area expansion is due to the KPFPs and the reform of the collective forest tenure [4] in China.

The empirical analysis includes additional observable characteristics that could affect household incomes. For example, production inputs constitute labor, capital and land. Included in land are cropland, forestland and grassland for growing vegetables and fruits. In addition, land-based production activities entail cash outlays for commercial seeds, fertilizers, plastic sheets, and the like, production expenditure for land-based activities was 552.67 Yuan, 598.04 Yuan, 773.87 Yuan,1382.39 Yuan and 1354.67 Yuan in 1995, 1998, 2003, 2008 and 2010, respectively; labor for off-farm employment has been increasing since 1995 (see Table 3). Moreover, household and village characteristics affect rural households' income. For example, as part of the human capital, educational attainment is commonly viewed as an important household feature (Schultz 1964), and biophysical and socioeconomic variables at the village level, like road condition, are also relevant to income determination. Road condition has been improving since 1995 (see Table 3)

V. Model specification and empirical results

A number of technical issues must be addressed relating to the specification of the empirical model. These include the choice of random-effect vs. fixed-effect estimation; potential endogeneity bias from selection into the programs; potential correlation between the disturbance term and the treatment effect (Ashenfelter's dip); and potential correlation between households within the same county (cluster effects). The following section focuses on these issues, while section 5.2 presents the empirical results based on the selected specification.

5.1 Model specification

First, note that equation (2) can be estimated as a fixed-effect or random-effect model. Whether we adopt the random-effects or fixed-effects estimation technique hinges on the outcome of a Hausman test (Woodridge 1999). To that end, we ran the corresponding regressions of the total income of sample households against the KPFP dummies. It is found that in both cases the χ^2 values are greater than the critical values at the 1% confidence level. These results indicate that we should estimate a fixed-effects model, rather than a random-effects one. One advantage of the fixed-effects

[3] 1 hectare=15mu.
[4] The reform of collective forestland tenure has been taken since 2003, the key objective of the reform is to allocate forestland to households in accordance with family size, therefore, the reform has also contributed to larger forestland area that are managed by these sample households.

estimation is its control over unobserved fixed factors that could confound the estimation (Pender 2005).

Following Liu, Lu and Yin (2010), in order to test for endogenous selection into the SLCP, we first estimate a model, in which the likelihood of participation is determined by a set of exogenous variables (see Table 4). From this, we derive the predicted probabilities of participation by individual households. These were used to identify the income effect of the SLCP participation. A Hausman test indicates χ^2 values are much lower than the critical value, so, we reject the hypothesis that there is a significant endogeneity bias in households' participation in the SLCP (results available from the authors on request). Therefore, it seems that voluntarism of the SLCP participation is questionable. That is, rural households can choose to participate in the ''take-it-or-leave-it'' program only when their croplands are eligible for it. They will not have the option if their land is considered ''ineligible.'' Since the late 1980s, croplands have been allocated to rural households in term of household responsibility system in accordance with the household size, each rural household have got several plots of croplands of different land productivity, if a village is eligible, almost each household would have similar desire to participate in the SLCP because the SLCP subsidy is generally higher than the net return generated from the converted cropland. As a result, almost all households wish to participate and then a subset of these is selected. A similar result was reported by Uchida, Xu and et al (2007), Mullan and Kontoleon (2012), and Liu and Zhang (2006).

[Table 4 – page 23]

The DCBT are composed of the SLCP, ecological resettlement and watershed management in accordance to ecological conditions. These are determined by the village or township, therefore unobserved characteristics of the individual are unlikely to affect the probability that they participate in the DCBT. The NFPP is imposed at the regional level, so households themselves cannot select themselves in or out. The county-level clustering controls for factors that influence the likelihood of participation for a specific region.

We test the assumption that the time trends in income would be equivalent in the absence of the KPFPs through comparison of trends in the treatment and control groups prior to the introduction of the KPFPs by analysis of variance. The empirical results indicate that the differences of the total income between the treatment and the control groups prior to the implementation of these KPFPs are not significant at 0.10 level, and we don't observe evidence of a change in income prior to participation for either group, as would be predicted by the Ashenfelter's dip hypothesis. We also calculate the probabilities of rural households enrolling in the KPFPs by income cluster. Sample households in each of the income classes have statistically equivalent chances of being enrolled in the KPFPs.

Lastly, we test for clustered standard errors at the county level. There are several definitions of intra-cluster correlation. We base ours on standard analysis of variance methods. The range of the intra-cluster correlation of the total income, off-farm income and land-based income is 0.02-0.13, 0.07-0.21 and 0.06-0.14 respectively. With regard to production factors, the ranges of the intra-cluster correlation of off-farm employment, labor for off-farm land-based activities, cropland area, forestland area and production expenditure for land-based activities are lie between 0.01 and 0.3.We estimate the impacts of the KPFPs on sample households' total income with and without clustered standard errors. We find that our empirical results display the same downward bias for the standard errors as Moulton (1990, 1986), Kloek (1981), Scott and Holt (1982) and Greenwald (1983) reported. standard errors of the NFPP dummy variable, SLCP dummy variable is 0.02 and 0.02 without considering the cluster effect, which is smaller than that 0.03 and 0.07 after we consider the cluster effect (see Table 5). The empirical results of the impacts of the KPFPs on sample households' income indicate that there is the cluster effect. The differences in the empirical results on the impacts of the KPFPs support the conclusion that there is the cluster effect, so we present all results with clustered standard errors in the following section.

[Table 5 – page 24]

5.2 Empirical results

Based on the results of our specification tests, we use a cluster-specific fixed effect model to estimate the effects of the KPFPs on rural households' total income, land-based income, and off-farm income. We also estimate these effects of the KPFPs on each of the income sources by the year of participation and the policy stage. The empirical results are presented in Table 5, Table 6 and Table 7.

[Table 6 – page 26]

[Table 7 – page 28]

We estimate the impact of the KPFPs on rural households' total income, land-based income and off-farm income in general. Participation in the SLCP did not cause rural households' total income, land-based income or off-farm income to significantly change, suggesting that the subsidy payments have compensated for the foregone crop production on average over the period studied. Launching the DCBT reduced rural households' total income significantly, which indicates that the reductions in income from changes in production were not fully compensated by subsidy payments in the DCBT counties. The NFPP significantly reduced the land-based component of income, although this was not translated into an observable impact on total incomes. In addition to finding minimal overall impact of the SLCP and the NFPP individually, we also find that where the two programs were implemented simultaneously, the program interactions did not significantly affect rural households' total income or its sources (see Table 5).

As the programs have varied considerably in the details of their implementation, we disaggregate the analysis by policy stage. We anticipate that as the characteristics of the policies have changed over time, the impacts on participating households may also vary. We find that the impact of the DCBT on sample households' total income was negative and significant in the first stage, but insignificant in the third stage. However, while the contributions of the SLCP and the DCBT to sample households' land-based income were insignificant in the first stage, they are positive in the third stage (see Table 6). In some ways this is surprising because the subsidy levels were reduced over time. It suggests that returns to land-based activities have fallen, either because of broader economic trends, or because of production changes that occurred in response to the earlier subsidies. The outcome is that the subsidies now more than compensate for lost crop production. Once we disaggregate by policy stage, we also find that the interaction of the SLCP and the NFPP is positive and significant for land-based income (see Table 6).

We also disaggregate the impacts of the PFPs on sample households' total income, land-based income and off-farm income by the duration of participation. The results are presented in Table 6. The results for the SLCP are particularly interesting: we observe positive impacts on land-based incomes in the first two years (and positive, but not significant impacts on total income). In the third and fourth years of participation, the program has a negative impact on total incomes, but those who remain in the program for six to twelve years appear to experience positive impacts on land-based income and no losses in total income. The positive impacts for those who remain in the program for long periods may suggest that households are able to adjust their overall production patterns, but that this takes time. Alternatively, some households would expect to benefit from the trees planted on the SLCP land as those mature over time.

Table 7 shows that there was initially no effect on land-based income or total income from the DCBT. In other words, in the DCBT regions, the subsidies compensate for foregone crop production. However, as with the SLCP, land-based incomes are positively affected for those who remain in the program, even though more recent subsidy levels have been lower. This again may be because households are adjusting their overall patterns of production, and are therefore less reliant on the land taken out of production, or alternatively, it may be related to overall reductions in returns to crop production in the program areas.

The NFPP has not significantly affected sample households' total income or off-farm income. However, during the initial years of the program, it had a negative effect on land-based income. This is unsurprising, given the restrictions on timber harvests. What is interesting is that the negative impact has been reduced over time, and even became positive by the 10^{th} year of participation. This is likely to reflect easing of the harvest restrictions in many areas, as well as improvement in forest conditions.

Besides the KPFPs, we consider how the characteristics of the individual and village, and the broader market and environmental conditions have impacted rural households' income. Our results indicate that acting as headman of the village or sub-village, household size, production expenditure for land-based activities, off-farm employment, labor for land-based activities, cropland area, and forestland area have contributed to rural households' total income. Some these variables have also impacted rural households' land-based income and off-farm income. We also include year dummy variables in all models. The coefficients on these variables indicate that the wider market and environmental conditions were such that total incomes and off-farm incomes have been steadily increasing over time, while land-based incomes have been declining overall.

VI. Conclusions and discussions

Measuring the impact of the key PFPs on rural household total income and different source incomes is not a straightforward matter, mainly because Chinese economy has undergone huge changes since the programs have been in place. With introduction of the KPFPs, as we discussed above, rural household production endowments have been changing, especially for their land resource allocation. Rural households participating in the SLCP converted their cropland to forest or grass coverage. Therefore, their crop area has decreased, while their forest area has increased. Under the new context, as rational economic stakeholders, rural households allocate their production endowments to maximize their benefits.

We use a unique balanced 1458 household panel dataset spanning 16 years, with a cluster-specific fixed effect model. Overall, because the cluster effects have been considered, we do not find significant impacts of the SLCP or NFPP on sample households' total income, which are quiet different with other research empirical results. The initial stages of the DCBT reduced sample households' total incomes, but the later stages again show no significant impact. If we disaggregate total income by source however, we find that the KPFPs have influenced the composition of total household income in some time periods.

The observed negative impacts expected in the case of the DCBT, overall and in the early years of participation. For those households that were enrolled in the program, some of their cropland or grazing land was converted to forestland. This reduced annual crop harvests and livestock production in the short term, while any potential returns from forest resource management would only be apparent on a longer time horizon. Animal husbandry is one of the leading industries in the DCBT areas; the switch in animal husbandry from open gazing to pen raising has reduced sample households' animal husbandry outputs. At the same time, the SLCP policies of the DCBT stipulated that sample households should plant trees on the waste land after they converted cropland to forest or grass coverage, at a minimum ratio of 1:1. Sample households have to use their cropland as the waste land for planting trees. After several years of enrollment, some economic returns have been generated for sample households from their converted forestland and their economic behaviors have been changed, for more intensive management of their unconverted cropland (Liu, Lu and Yin 2010)

We find that the effects of the SLCP on sample households' land-based income are significantly positive in most of their participating years, and the DCBT has positively contributed to sample households' land-based income in the 8th and 9th year. This suggests that, on average, the subsidies are higher than the opportunity cost of the land taken out of production in at least some time periods.

In the early years, the NFPP significantly reduced participating sample households' land-based income. After the launch of the NFPP, sample households lost their opportunities to collect non-timber forest products and harvest timbers. However, in more recent years, the NFPP has not significantly impacted sample households' land-based income, in the latter years, the NFPP has even become positive and significant, which is in line with conclusions reported by (Liu and Lu 2008; Mullan, Kontoleon and et al 2010).

One explanation for the lack of significant changes in total household income, and even in land-based income in more recent periods is that after sample households were enrolled in the KPFPs, their economic behaviors have changed with time. For example, their average production expenditure for land-based activities has increased, and their production model has shifted from extensive to more intensive, which has helped to reduce the negative effects of the KPFPs on land-based income and total income (Liu and Lu 2008; Liu, Lu and Yin 2010). In the meantime, the contribution of land-based income to total income has fallen substantially between 1995 (69%) and 2010 (40%) for sample households, while off-farm income has increased in importance. This is an explanation for why the positive contribution of the SLCP to sample households' land-based income is insignificant when considering total income.

Other important factors to consider when interpreting the empirical results are changes in grain prices, and taxes, fees and subsidies for crop production. Annual variation in corn prices in particular (a key crop for households in the SLCP and the DCBT areas) have affected the returns from farming in general. More specifically, Chinese government has been gradually reducing taxes and fees on cropland since 2003, while subsidies for crop production have been increasing since 2000 (See Fig. 2). These government policies have reduced the relative net economic returns for sample households enrolled in the SLCP and the DCBT as they are no longer producing crops on a portion of their land.

[Figure 2 – page 31]

The impact of the interaction between the NFPP and the SLCP on total income and land-based income has shifted from insignificant to significant and positive. The overlap of the SLCP and the NFPP occurs in Muchuan, Nanbu, Nanjing, Mabian, Yanchang and Zhen'an counties. The government of China decided to permit rural households to cut their trees in the NFPP area in the pilot counties since 2007, allowing them to generate some cash income from natural forests. As we discuss above, rural households input their labors and cash for land-based activities (Liu and Lu 2008).

Overall, we observe that the KPFPs in their initial stages of implementation, and for the early years of household participation, had negative, or at best, neutral impacts on household incomes, in particular incomes from land. However, the later stages of the SLCP and the DCBT have tended to raise land-based incomes, and the NFPP has ceased to have a negative effect. This is likely to be in part the result of adjustments made by farmers over time in response to the programs, in order to maximize the benefits from them, or minimize their losses. Another key factor is changes made to the program characteristics and to wider rural policy. These changes include specific investments in improving farmland productivity and resettlements in the SLCP and the DCBT regions and easing of restrictions on timber harvests and forest product use under the NFPP, as well as more general changes in taxes and subsidies for agricultural activities. Lastly, macroeconomic trends away from land-based production have reduced the relative importance of income from crops, animal husbandry and forestry for rural households in total income, which influences the size of the overall effect that land-based programs can have.

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Tables and figures

Table 1: Evolution of sample households' enrollment in the KPFPs

Year	the NFPP	the SLCP	the DCBT	both the SLCP and the NFPP	NONE
1998	447	0	0	0	1011
1999	422	113	0	25	898
2000	346	18	0	246	848
2001	312	27	0	280	839
2002	255	111	95	337	660
2003	182	189	163	410	514
2004	178	208	171	414	487
2005	163	226	171	429	469
2006	162	228	171	430	467
2007	152	266	171	440	429
2008	151	270	171	441	425
2009	151	270	171	441	425
2010	151	270	171	441	425

Note:
NFPP: Natural Forest Protection Program
SLCP: Sloping Land Conversion Program
DCB: Desertification Combating Program, around Beijing and Tianjin

Table 2: Number of sample households enrolled in the SLCP and the DCBP by stage

Year	the SLCP			the DCBT	
	the first stage	the second stage	the third stage	the first stage	the third stage
1999	138				
2000	264				
2001	307				
2002	448			95	
2003	599			163	
2004	617	5		171	
2005	629	26		171	
2006	621	37		171	
2007	515	0	191	157	14
2008	397	0	314	146	25
2009	361	0	350	146	25
2010	238	0	473	65	106

Note:
SLCP: Sloping Land Conversion Program
DCB: Desertification Combating Program, around Beijing and Tianjin

Table 3: Summary statistics of the household data in 1995, 1999, 2003, 2008and 2010

	Year	1995	1998	2003	2008	2010
Variable	**Parameter**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**	**Mean(SD)**
Total income (Yuan)	R_0	4440.05 (3214.54)	4788.60 (3381.11)	7527.77 (5321.23)	12281.16 (10163.08)	13305.25 (12190.23)
Land-based income (Yuan)	R_1	3061.46 (1977.43)	3112.59 (2077.43)	4292.25 (2892.22)	5395.19 (6961.76)	5349.35 (8888.89)
Off-farm income (Yuan)	R_2	1378.59 (2590.41)	1676.02 (2679.28)	3235.52 (4595.11)	6885.98 (8303.90)	7955.91 (8896.87)
Headman of village or sub-village (if yes=1; otherwise =0)	X_1	0.10(0.30)	0.10(0.30)	0.10(0.30)	0.08(0.28)	0.09(0.28)
Household size (person)	X_2	3.63(1.20)	3.77(1.22)	3.97(1.32)	4.22(1.53)	4.14 (1.59)
The education years the household head received (year)	X_3	6.43(2.75)	6.43(2.75)	6.43(2.75)	7.20(3.56)	6.12(2.78)
Road condition (if hard surface=1; otherwise=0)	X_4	0.41(0.49)	0.41(0.49)	0.41(0.49)	0.54(0.50)	0.54()0.50
Production expenditure for land-based activities (Yuan)	X_5	552.67 (482.06)	598.04 (525.95)	773.87 (721.56)	1382.39 (4375.80)	1354.67 (2878.00)
Off-farm employment (person-days)	X_6	94.61 (142.91)	117.29 (167.11)	194.92 (226.75)	278.00 (283.92)	247.91 (269.30)
Labor for land-based activities (person-days)	X_7	255.86 (176.75)	259.25 (174.72)	246.42 (175.35)	197.59 (148.52)	216.78 (201.72)
Cropland area (mu)	X_8	7.65(9.11)	7.71(9.05)	5.48(6.10)	5.25(6.30)	5.14(4.72)
Forestland area (mu)	X_9	10.62(26.58)	10.66 (26.57)	14.63 (28.11)	18.81(31.86)	22.38(50.00)
Grassland area (mu)	X_{10}	0.13(1.06)	0.14(1.10)	0.86(5.77)	0.72(5.80)	0.72(5.80)
The NFPP dummy (if yes=1; otherwise 0)	Y_1	0.00(0.00)	0.31(0.46)	0.41(0.49)	0.41(0.49)	0.41(0.49)
The DCBT dummy (if yes=1; otherwise 0)	Y_2	0.00(0.00)	0.00(0.00)	0.11(0.32)	0.12(0.32)	0.12(0.32)
The SLCP dummy (if yes=1; otherwise 0)	Y_3	0.00(0.00)	0.00(0.00)	0.41(0.49)	0.49(0.50)	0.49(0.50)
Both the SLCP and the NFPP dummy (if yes=1; otherwise=0)	Y_{NS}	0.00(0.00)	0.00(0.00)	0.28(0.45)	0.30(0.46)	0.30(0.46)

1. Standard errors are in parentheses, and figures were rounded.
2. Source: Authors' survey.

Table 4: Regression results of the SLCP participation determinants

Variable	parameter	coefficient
The distance to the township (kilometers)	X_0	0.02**(0.01)
Headman of village or sub-village (if yes=1; otherwise =0)	X_1	0.08**(0.03)
Household size(person)	X_2	0.02 (0.03)
The education years the household head received (year)	X_3	0.00(0.00)
Production expenditure for land-based activities (Yuan)	X_5	-0.00(0.00)
Off-farm employment (person-days)	X_6	0.01***(0.00)
Labor for land-based activity(person-days)	X_7	0.00(0.00)
Cropland area (mu)	X_8	0.00(0.00)
Forestland area (mu)	X_9	0.00(0.00)
Grassland area (mu)	X_{10}	-0.02***(0.00)
The county dummy of Nanbu County (if yes=1; otherwise=0)	C_1	0.74***(0.04)
The county dummy of Nanjiang County (if yes=1; otherwise=0)	C_2	0.53***(0.04)
The county dummy of Mabian County (if yes=1; otherwise=0)	C_3	0.44***(0.04)
The county dummy of Muchuan County (if yes=1; otherwise=0)	C_4	0.85***(0.06)
The county dummy of Xushui County (if yes=1; otherwise=0)	C_5	0.10(0.06)
The county dummy of Xingguo County (if yes=1; otherwise=0)	C_6	0.13***(0.05)
The county dummy of Suichuan County (if yes=1; otherwise=0)	C_7	0.39***(0.05)
The county dummy of Yixian County (if yes=1; otherwise=0)	C_8	0.48***(0.05)
The county dummy of Zhenan County (if yes=1; otherwise=0)	C_9	0.86***(0.06)
The county dummy of Yanchang County (if yes=1; otherwise=0)	C_{10}	0.91***(0.04)
The county dummy of Huanjiang County (if yes=1; otherwise=0)	C_{11}	0.22***(0.05)
Inception	α_0	-0.13(0.08)
R^2		0.40

1. Standard errors are in parentheses, and figures were rounded.
2. *** Means significant at the 0.01, level, ** at 0.05 level, and * at 0.10 level.

Table 5 : Empirical results of impacts of the KPFPs on sample households' total income, land-based income and off-farm income

Variable	Para-meter	Total income (R) without cluster	Total income (R)	Land-based income (RL)	Off-farm income RO)
Headman of village or sub-village (if yes=1; otherwise =0)	$\mathrm{X_1}$	0.01***(0.00)	0.01***(0.00)	0.03(0.02)	0.10***(0.04)
Household size(person)	$\mathrm{X_2}$	0.01***(0.00)	0.01***(0.00)	-0.00(0.01)	0.02(0.03)
The education years the household head received (year)	$\mathrm{X_3}$	0.00(0.00)	0.00(0.00)	0.01(0.01)	-0.04(0.05)
Road condition (if hard road surface =1; otherwise=0)	$\mathrm{X_4}$	-0.01***(0.00)	-0.01(0.01)	0.13**(0.05)	-0.03(0.06)
Production expenditure for land-based activities (Yuan)	$\mathrm{X_5}$	0.03***(0.00)	0.027***(0.00)	-0.01***(0.00)	0.56***(0.03)
Off-farm employment (person-days)	$\mathrm{X_6}$	0.02***(0.00)	0.02***(0.01)	0.51***(0.06)	-0.04(0.04)
Labor for land-based activity (person-days)	$\mathrm{X_7}$	0.34***(0.02)	0.37***(0.03)	0.39***(0.11)	-0.12(0.33)
Cropland area (mu)	$\mathrm{X_8}$	0.01***(0.00)	0.01***(0.00)	0.01(0.01)	0.07(0.04)
Forestland area (mu)	$\mathrm{X_9}$	0.10***(0.02)	0.12***(0.03)	0.09(0.15)	1.54***(0.45)
Grassland area (mu)	$\mathrm{X_{10}}$	0.09***(0.01)	0.08(0.05)	-0.31**(0.14)	1.09***(0.33)
the SLCP (if yes=1; otherwise=0)	$\mathrm{Y_3}$	-0.01(0.02)	-0.02(0.03)	-0.02(0.09)	-0.47(0.33)
the DCBT (if yes=1; otherwise=0)	$\mathrm{Y_2}$	-0.08***(0.02)	-0.09***(0.03)	-0.11(0.13)	0.12(0.44)
the NFPP (if yes=1; otherwise=0)	$\mathrm{Y_1}$	0.07***(0.02)	0.05(0.07)	-0.19***(0.07)	-0.18(0.54)
the SLCP and the NFPP dummy (if yes=1; otherwise=0)	$\mathrm{Y_{NS}}$	0.08***(0.02)	0.06(0.08)	-0.07(0.17)	0.64(0.66)
the Year dummy of 1996 (if yes=1; otherwise=0)	$\mathrm{Year_1}$	-0.03*(0.02)	-0.03***(0.01)	0.00(0.02)	-0.02(0.04)
the Year dummy of 1997 (if yes=1; otherwise=0)	$\mathrm{Year_2}$	-0.01(0.02)	-0.01(0.01)	-0.03*(0.02)	0.16*(0.09)
the Year dummy of 1998 (if yes=1; otherwise=0)	$\mathrm{Year_3}$	0.03(0.02)	0.03(0.03)	0.01(0.05)	0.33**(0.16)
the Year dummy of 1999 (if yes=1; otherwise=0)	$\mathrm{Year_4}$	0.09***(0.02)	0.09**(0.04)	0.02(0.06)	0.69***(0.17)
the Year dummy of 2000 (if yes=1; otherwise=0)	$\mathrm{Year_5}$	0.15***(0.02)	0.16***(0.05)	0.05(0.09)	0.90***(0.21)
the Year dummy of 2001 (if yes=1; otherwise=0)	$\mathrm{Year_6}$	0.21***(0.02)	0.22***(0.05)	0.09(0.10)	1.23***(0.22)
the Year dummy of 2002 (if yes=1; otherwise=0)	$\mathrm{Year_7}$	0.30***(0.02)	0.32***(0.05)	0.16*(0.09)	1.47***(0.21)
the Year dummy of 2003 (if yes=1; otherwise=0)	$\mathrm{Year_8}$	0.37***(0.02)	0.39***(0.05)	0.18**(0.09)	1.74***(0.22)
the Year dummy of 2004 (if yes=1; otherwise=0)	$\mathrm{Year_9}$	0.45***(0.02)	0.46***(0.05)	0.20**(0.09)	2.31***(0.33)
the Year dummy of 2005 (if yes=1; otherwise=0)	$\mathrm{Year_{10}}$	0.51***(0.02)	0.53***(0.06)	-0.11(0.15)	3.13***(0.61)
the Year dummy of 2006 (if yes=1; otherwise=0)	$\mathrm{Year_{11}}$	0.61***(0.02)	0.62***(0.06)	-0.09(0.14)	3.32***(0.63)
the Year dummy of 2007 (if yes=1; otherwise=0)	$\mathrm{Year_{12}}$	0.69***(0.02)	0.70***(0.05)	-0.35**(0.16)	4.39***(0.66)

the Year dummy of 2008 (if yes=1; otherwise=0)	Year_{13}	0.74***(0.02)	0.75***(0.06)	-0.69***(0.23)	4.28***(0.72)
the Year dummy of 2009 (if yes=1; otherwise=0)	Year_{14}	0.70***(0.02)	0.72***(0.06)	-0.96***(0.19)	6.15***(0.64)
the Year dummy of 2010 (if yes=1; otherwise=0)	Year_{15}	0.80***(0.02)	0.82***(0.06)	-0.87***(0.19)	6.26***(0.62)
Inception	α_0	7.73***(0.04)	7.68***(0.09)	3.88***(0.37)	-0.48(0.93)
R^2		0.43	0.43	0.41	0.40

1. Standard errors are in parentheses, and figures were rounded.
2. *** Means significant at the 0.01, level, ** at 0.05 level, and * at 0.10 level.
3. Year dummy variables included in model.

Table 6: Empirical results of the impacts of the KPFPs on sample households' different income sources by the policy arrangement stage with cluster

Variable		Total income $(\mathbf{R})$	Land-based income $(\mathbf{RL})$	Off-farm income $\mathbf{RO})$
Headman of village or sub-village (if yes=1; otherwise =0)	X_1	0.01***(0.00)	0.08(0.16)	0.10***(0.04)
Household size(person)	X_2	0.01***(0.00)	0.39***(0.09)	0.02(0.03)
The education years the household head received (year)	X_3	0.00(0.00)	0.01(0.01)	-0.04(0.05)
Road condition (if hard road surface =1; otherwise=0)	X_4	-0.00(0.01)	-0.12(0.09)	-0.03(0.06)
Production expenditure for land-based activities (Yuan)	X_5	0.03***(0.00)	0.21***(0.03)	0.56***(0.03)
Off-farm employment (person-days)	X_6	0.02***(0.01)	-0.01(0.00)	-0.04(0.04)
Labor for land-based activity(person-days)	X_7	0.37***(0.03)	0.08**(0.04)	-0.12(0.32)
Cropland area (mu)	X_8	0.01***(0.00)	0.02***(0.01)	0.07(0.04)
Forestland area (mu)	X_9	0.11***(0.03)	0.02*(0.01)	1.54***(0.45)
Grassland area (mu)	X_{10}	0.08(0.05)	0.01(0.01)	1.10***(0.32)
the SLCP-the first stage (if yes=1; otherwise=0)	Y_3^F	-0.02(0.03)	0.09(0.11)	-0.47(0.33)
the SLCP-the second stage (if yes=1; otherwise=0)	Y_3^S	-0.03(0.08)	0.12(0.15)	0.28(1.05)
the SLCP-the third stage (if yes=1; otherwise=0)	Y_3^T	0.04(0.05)	0.42*(0.23)	-0.62(0.59)
the DCBT-the first stage (if yes=1; otherwise=0)	Y_2^F	-0.11***(0.03)	-0.07(0.09)	0.01(0.41)
the DCBT-the third stage (if yes=1; otherwise=0)	Y_2^T	0.05(0.09)	0.42**(0.18)	0.87(0.92)
the NFPP (if yes=1; otherwise=0)	Y_1	0.05(0.07)	-0.05(0.06)	-0.18(0.52)
the SLCP and the NFPP dummy (if yes=1; otherwise=0)	Y_{NS}	0.06(0.09)	0.32**(0.14)	0.65(0.66)
the Year dummy of 1996 (if yes=1; otherwise=0)	$Year_1$	-0.03***(0.01)	-0.02(0.02)	-0.02(0.04)
the Year dummy of 1997 (if yes=1; otherwise=0)	$Year_2$	-0.01(0.01)	-0.04**(0.02)	0.16*(0.09)
the Year dummy of 1998 (if yes=1; otherwise=0)	$Year_3$	0.03(0.03)	-0.00(0.04)	0.33**(0.16)
the Year dummy of 1999 (if yes=1; otherwise=0)	$Year_4$	0.09**(0.04)	0.02(0.06)	0.69***(0.17)
the Year dummy of 2000 (if yes=1; otherwise=0)	$Year_5$	0.16***(0.05)	0.03(0.07)	0.90***(0.22)
the Year dummy of 2001 (if yes=1; otherwise=0)	$Year_6$	0.22***(0.05)	0.06(0.07)	1.22***(0.22)
the Year dummy of 2002 (if yes=1; otherwise=0)	$Year_7$	0.32***(0.05)	0.13*(0.08)	1.47***(0.21)
the Year dummy of 2003 (if yes=1; otherwise=0)	$Year_8$	0.39***(0.05)	0.18**(0.08)	1.74***(0.22)
the Year dummy of 2004	$Year_9$	0.47***(0.05)	0.20**(0.08)	2.31***(0.33)

(if yes=1; otherwise=0)				
the Year dummy of 2005 (if yes=1; otherwise=0)	$\mathbf{Year_{10}}$	0.53***(0.06)	0.18(0.12)	3.12***(0.60)
the Year dummy of 2006 (if yes=1; otherwise=0)	$\mathbf{Year_{11}}$	0.63***(0.06)	0.24**(0.11)	3.30***(0.63)
the Year dummy of 2007 (if yes=1; otherwise=0)	$\mathbf{Year_{12}}$	0.70***(0.05)	0.11(0.12)	4.40***(0.68)
the Year dummy of 2008 (if yes=1; otherwise=0)	$\mathbf{Year_{13}}$	0.74***(0.06)	0.00(0.14)	4.30***(0.78)
the Year dummy of 2009 (if yes=1; otherwise=0)	$\mathbf{Year_{14}}$	0.70***(0.06)	-0.53***(0.18)	6.18***(0.68)
the Year dummy of 2010 (if yes=1; otherwise=0)	$\mathbf{Year_{15}}$	0.79***(0.07)	-0.52***(0.19)	6.25***(0.69)
Inception	α_0	7.69***(0.09)	5.78***(0.26)	-0.48(0.94)
R^2		0.43	0.24	0.40

1. Standard errors are in parentheses, and figures were rounded.
2. *** Means significant at the 0.01, level, ** at 0.05 level, and * at 0.10 level.
3. Year dummy variables included in model.

Table 7 : Empirical results of the impacts of the three key PFPs on sample households' different income sources by the years of household participating in the programs

Variable	Para-meter	Total income ($\mathbf{R}$)	Land-based income ($\mathbf{RL}$)	Off-farm income $\mathbf{RO}$)
Headman of village or sub-village (if yes=1; otherwise =0)	X_1	0.11***(0.03)	0.07(0.16)	1.51***(0.45)
Household size(person)	X_2	0.37***(0.03)	0.38***(0.09)	-0.14(0.30)
The education years the household head received (year)	X_3	0.01***(0.00)	0.01(0.01)	0.06(0.04)
Road condition (if hard road surface =1; otherwise=0)	X_4	0.08(0.05)	-0.12(0.09)	1.10***(0.33)
Production expenditure for land-based activities (Yuan)	X_5	0.02***(0.00)	0.21***(0.03)	-0.04(0.04)
Off-farm employment (person-days)	X_6	0.03***(0.00)	-0.01(0.00)	0.56***(0.03)
Labor for land-based activity(person-days)	X_7	-0.01(0.01)	0.08**(0.04)	-0.03(0.06)
Cropland area (mu)	X_8	0.01***(0.00)	0.02***(0.01)	0.10***(0.04)
Forestland area (mu)	X_9	0.01***(0.00)	0.02**(0.01)	0.02(0.03)
Grassland area (mu)	X_{10}	0.00(0.00)	0.01(0.01)	-0.04(0.04)
the household participated the NFPP in the 1st year (if yes=1; otherwise =0)	Y_1^1	0.03(0.04)	-0.19***(0.06)	-0.26(0.46)
the household participated the NFPP in the 2nd year (if yes=1; otherwise =0)	Y_1^2	0.06(0.06)	-0.12*(0.07)	-0.21(0.44)
the household participated the NFPP in the 3rd year (if yes=1; otherwise =0)	Y_1^3	0.07(0.08)	-0.10*(0.06)	-0.22(0.58)
the household participated the NFPP in the 4th year (if yes=1; otherwise =0)	Y_1^4	0.04(0.09)	-0.10*(0.06)	-0.29(0.68)
the household participated the NFPP in the 5th year (if yes=1; otherwise =0)	Y_1^5	0.06(0.10)	-0.14**(0.07)	-0.08(0.80)
the household participated the NFPP in the 6th year (if yes=1; otherwise =0)	Y_1^6	0.05(0.12)	-0.03(0.05)	-0.16(0.76)
the household participated the NFPP in the 7th year (if yes=1; otherwise =0)	Y_1^7	0.05(0.13)	-0.01(0.06)	-0.27(0.86)
the household participated the NFPP in the 8th year (if yes=1; otherwise =0)	Y_1^8	-0.04(0.11)	0.10(0.08)	-0.60(1.16)
the household participated the NFPP in the 9th year (if yes=1; otherwise =0)	Y_1^9	-0.07(0.12)	0.02(0.07)	-0.48(1.14)
the household participated the NFPP in the 10st year (if yes=1; otherwise =0)	Y_1^{10}	0.13(0.09)	0.31***(0.10)	1.04(0.86)
the household participated the NFPP in the 11th year (if yes=1; otherwise =0)	Y_1^{11}	0.14(0.11)	0.15(0.23)	0.60(0.89)
the household participated the NFPP in the 12th year (if yes=1; otherwise =0)	Y_1^{12}	0.04(0.12)	0.37(0.31)	0.34(0.85)
the household participated the NFPP in the 13th year (if yes=1; otherwise =0)	Y_1^{13}	0.13(0.11)	0.48(0.35)	0.36(0.83)
the household participated the DCBT in the 1st year (if yes=1; otherwise =0)	Y_2^1	-0.13(0.08)	-0.10(0.19)	0.15(0.29)
the household participated the DCBT in the 2nd year (if yes=1; otherwise =0)	Y_2^2	-0.11(0.09)	-0.074(0.20)	0.33(0.40)
the household participated the DCBT in the	Y_2^3	-0.11(0.09)	0.01(0.13)	-0.58(0.45)

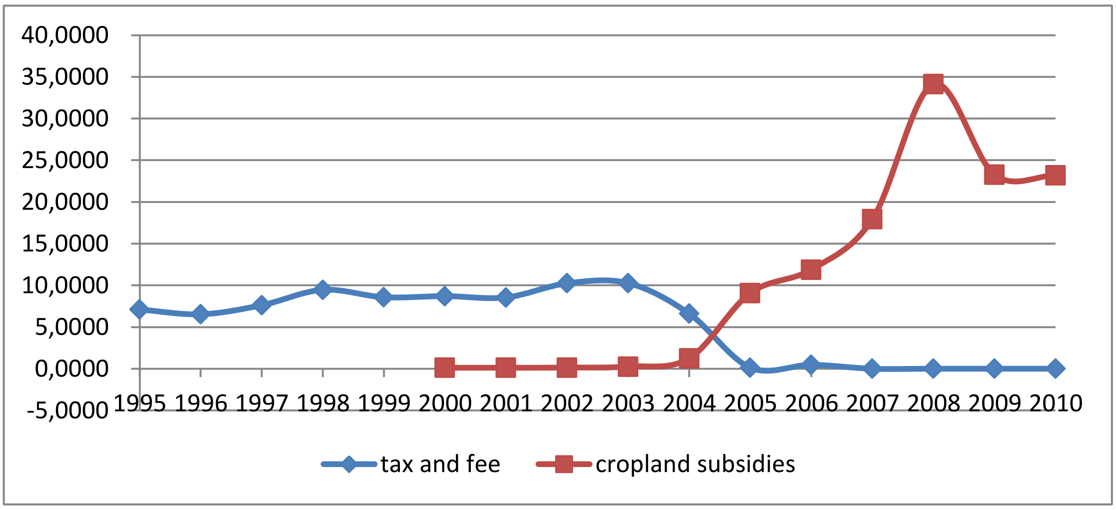
3rd year (if yes=1; otherwise =0)				
the household participated the DCBT in the 4th year (if yes=1; otherwise =0)	Y_2^4	-0.15***(0.06)	-0.15(0.19)	-0.11(0.75)
the household participated the DCBT in the 5th year (if yes=1; otherwise =0)	Y_2^5	-0.13***(0.04)	-0.20(0.20)	-0.04(0.74)
the household participated the DCBT in the 6th year (if yes=1; otherwise =0)	Y_2^6	-0.11(0.08)	-0.02(0.22)	0.02(0.94)
the household participated the DCBT in the 7th year (if yes=1; otherwise =0)	Y_2^7	-0.08(0.08)	0.17(0.22)	-0.07(0.96)
the household participated the DCBT in the 8th year (if yes=1; otherwise =0)	Y_2^8	0.03(0.09)	0.59***(0.19)	1.00(1.25)
the household participated the DCBT in the 9thyear (if yes=1; otherwise =0)	Y_2^9	0.13(0.17)	0.72***(0.27)	1.41(1.51)
the household participated the SLCP in the 1st year (if yes=1; otherwise =0)	Y_3^1	0.04(0.03)	0.15*(0.08)	-0.25(0.29)
the household participated the SLCP in the 2nd year (if yes=1; otherwise =0)	Y_3^2	0.02(0.04)	0.21*(0.11)	-0.16(0.32)
the household participated the SLCP in the 3rd year (if yes=1; otherwise =0)	Y_3^3	-0.06**(0.03)	0.08(0.11)	-0.39(0.29)
the household participated the SLCP in the 4th year (if yes=1; otherwise =0)	Y_3^4	-0.05*(0.02)	0.09(0.12)	-0.62**(0.27)
the household participated the SLCP in the 5th year (if yes=1; otherwise =0)	Y_3^5	-0.04(0.04)	0.18(0.12)	-0.62*(0.34)
the household participated the SLCP in the 6th year (if yes=1; otherwise =0)	Y_3^6	-0.01(0.05)	0.23**(0.11)	-0.15(0.47)
the household participated the SLCP in the 7thyear (if yes=1; otherwise =0)	Y_3^7	0.02(0.05)	0.42***(0.15)	-0.62*(0.37)
the household participated the SLCP in the 8thyear (if yes=1; otherwise =0)	Y_3^8	-0.02(0.05)	0.40***(0.15)	-0.54(0.52)
the household participated the SLCP in the 9thyear (if yes=1; otherwise =0)	Y_3^9	-0.00(0.06)	0.28(0.23)	-0.78(0.71)
the household participated the SLCP in the 10thyear (if yes=1; otherwise =0)	Y_3^{10}	0.10(0.07)	0.48**(0.24)	-0.78(0.89)
the household participated the SLCP in the 11th year (if yes=1; otherwise =0)	Y_3^{11}	0.11(0.08)	0.62*(0.34)	-0.60(1.11)
the household participated the SLCP in the 12th year (if yes=1; otherwise =0)	Y_3^{12}	0.19(0.11)	1.00**(0.46)	0.24(1.23)
the SLCP and the NFPP dummy (if yes=1; otherwise=0)	Y_{NS}	0.05(0.08)	0.13(0.11)	0.45(0.48)
the Year dummy of 1996 (if yes=1; otherwise=0)	$Year_1$	-0.03***(0.01)	-0.02(0.01)	-0.02(0.04)
the Year dummy of 1997 (if yes=1; otherwise=0)	$Year_2$	-0.01(0.01)	-0.04**(0.02)	0.17*(0.0)
the Year dummy of 1998 (if yes=1; otherwise=0)	$Year_3$	0.04(0.03)	0.04(0.05)	0.35**(0.18)
the Year dummy of 1999 (if yes=1; otherwise=0)	$Year_4$	0.09*(0.04)	0.04(0.07)	0.685***(0.170)
the Year dummy of 2000 (if yes=1; otherwise=0)	$Year_5$	0.16***(0.05)	0.08(0.07)	0.91***(0.22)
the Year dummy of 2001 (if yes=1; otherwise=0)	$Year_6$	0.22***(0.05)	0.11(0.08)	1.26***(0.21)
the Year dummy of 2002 (if yes=1; otherwise=0)	$Year_7$	0.32***(0.04)	0.20***(0.08)	1.46***(0.25)

the Year dummy of 2003 (if yes=1; otherwise=0)	Year_8	0.39***(0.04)	0.21***(0.06)	1.75***(0.23)
the Year dummy of 2004 (if yes=1; otherwise=0)	Year_9	0.47***(0.05)	0.21***(0.07)	2.35***(0.38)
the Year dummy of 2005 (if yes=1; otherwise=0)	Year_{10}	0.57***(0.04)	0.14(0.10)	3.34***(0.67)
the Year dummy of 2006 (if yes=1; otherwise=0)	Year_{11}	0.68***(0.05)	0.21**(0.10)	3.53***(0.76)
the Year dummy of 2007 (if yes=1; otherwise=0)	Year_{12}	0.70***(0.04)	0.02(0.11)	4.14***(0.97)
the Year dummy of 2008 (if yes=1; otherwise=0)	Year_{13}	0.72***(0.05)	-0.06(0.16)	4.18***(1.02)
the Year dummy of 2009 (if yes=1; otherwise=0)	Year_{14}	0.68***(0.05)	-0.76***(0.19)	5.94***(0.93)
the Year dummy of 2010 (if yes=1; otherwise=0)	Year_{15}	0.74***(0.06)	-0.79***(0.19)	5.94***(0.94)
Constant	α_0	7.69***(0.08)	5.82***(0.25)	-0.44(0.95)
R^2		0.43	0.41	0.41

1. Standard errors are in parentheses, and figures were rounded.
2. *** Means significant at the 0.01, level, ** at 0.05 level, and * at 0.10 level.
3. Year dummy variables included in model

Figure 1: Case study county spatial distribution

Figure 2 : Average tax and fee, subsidies on crop production (unit: Yuan/mu).



Source: Authors' survey