Detecting Potential Endogeneity in Households' Decisions to Participate in China's Large Ecological Restoration Program and Reallocate Their Labour Times

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1. Introduction

In 2001, China formally launched the Sloping Land Conversion Program (SLCP) (Bennett 2008, Yin 2009). As an initiative of payments for ecosystem services (PES), the SLCP has subsidized farmers in mostly poor rural areas of the West to retire marginal sloping cropland and other degraded fields and to restore them to forest and vegetation covers (Uchida et al. 2009, Cao et al. 2009). Because of its huge investment and broad geographical coverage, it has become the largest PES program in the developing world (Liu et al. 2008, Bennett 2008). While a number of studies have assessed the socioeconomic impacts of the SLCP over the last decade, few have addressed the fundamental question of whether there is endogenous selection in farmers' decision to participate, which has direct implications to the robustness of the estimated impacts and the relevance of suggested policy changes (Uchida et al. 2009, Liu et al. 2010, Yin et al. 2014). The goal of this paper is to fill this knowledge gap and thus contribute to assessing that and other PES programs more rigorously.

The international literature on assessing the socioeconomic impacts of the SLCP has been rapidly expanding. Among the published studies, Uchida et al. (2007) identify a moderate

success of the SLCP in achieving its poverty alleviation goal, and Uchida et al. (2009) further show that participating households are increasingly shifting their work time from on-farm to off-farm labor market, with the effects dependent on the initial levels of human and physical capital. Yao et al. (2010) find that the effects of program participation on incomes from crop production, animal husbandry, and off-farm work vary a great deal, mediated by local economic conditions and political leadership. Likewise, Grosjean et al. (2010) evaluate the effect of program participation on labor reallocation towards off-farm activities and find heterogeneous effects. Mullan et al. (2011) examine the role of incomplete property rights as well as participating in the SLCP in the migration decisions of rural households; their results indicate that tenure insecurity reduces migration, but participating in the SLCP does not increase migration significantly.

Nevertheless, these and other authors have rarely investigated whether there is self-selection in farmers' decision to participate in the SLCP. Understandably, if households have the full freedom to select, their decisions to participate and/or to seek more off-farm employment could become endogenous, induced by the generous program subsidies and the attractive earnings from non-farming job opportunities (Yin et al. 2014). Thus, an assessment of the program impacts must take these possibilities into account in order to avoid potentially biased estimates (Uchida et al 2007, Liu et al. 2010).

As a matter of fact, this type of endogenous selection, caused by omitted variable(s) and/or simultaneity, is a common concern encountered in program impact assessment (Khandker et al. 2010, Woodridge 2009). Studies have suggested that participation in the SLCP is of a quasi-voluntary nature, initiated and implemented by administrative orders that determine which plots to be enrolled on the basis of slopes and other characteristics of households' cropland plots, not necessarily household's own choice (e.g., Xu et al. 2004, Yao et al. 2010, Mullan and

Kontoleon 2012). In the words of Uchida et al. (2009), "Many households did not have either the choice of whether or not to participate in the program or the choice about which plot to enroll into the program. Because of this, there is less potential for self-selection. In addition, the program officers that were in charge of selecting who got to participate and which plots were able to be enrolled based their decisions on slope and other characteristics of each household's land holdings."

To our knowledge, Liu et al. (2010) is the only one that has formally tested the possible existence of endogenous selection in farmers' participation in the SLCP using the Hausman procedure. The authors first estimated a model specifying that the likelihood of participation was determined by a set of exogenous variables, from which they derived the predicted probabilities of participation by individual households. Those predicted probabilities were then used to identify the income effect of the program participation. By rejecting the hypothesis that there is a significant endogeneity bias in household's participation in the SLCP, they concluded that "it seems that voluntarism of the SLCP participation might be a questionable thesis. That is, farmers 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.'"

However, the robustness and thoroughness of the testing outcomes of Liu et al. (2010) could be questioned because of a combination of the following factors. First, that study covered not only the SLCP but also other PES programs, including the Natural Forest Protection Program and the Desertification Combating Program, which could have confounded the findings given the variations of these programs in their different orientations, policy instruments, and geographic configurations. Second, it considered possible endogeneity only in program participation, without simultaneously looking into it as probably reflected in the associated labor transfer into

off-farm activities. Further, by focusing on the likelihood of participation, they did not even examine the same issue as reflected in the extent of participation—the actual amount of cropland enrolled into the program by an individual household. It is thus necessary and worthwhile to investigate whether there has been endogenous selection in farmers' participation in a more appropriate and adequate manner, which has motivated the current study. It is expected that the large panel dataset that we have assembled, which covers over 1,000 households in six counties of the two representative provinces of western China (Shaanxi and Sichuan) over a period of 11 years (1998-2008), will help us address this question more systematically and effectively.

The rest of this paper is organized as follows. First, we introduce our data and model in the next two sections. Then, we describe the observed changes in labor allocation and income growth in section 4 to provide a clear context for understanding the potential program impacts as well as the possible endogeneity in farmers' decisions of participation and labor allocation. Next, we present the outcomes of endogeneity testing and the estimated impacts on labor allocation and income growth in section 5. Finally, some closing remarks will follow in section 6.

2. Background and data

The data used in this paper were gathered from four rounds of household surveys based on a stratified random sampling strategy. That is, six counties were first selected from two provinces—Sichuan and Shaanxi—for survey, according to the geographic coverage of the program and the distribution of farmers' income as well as our prior knowledge of the general regional conditions (see Fig. 1). Notably, these two provinces were identified by the central government as pilot and primary sites for implementing the SLCP, the former being in the upper Yangtze basin and the latter in the middle reaches of the Yellow basin (SFA 2009).

<INSERT Figure 1 here>

The four counties from Sichuan are Nanbu, Nanjiang, Mabian, and Muchuan; and the two from Shaanxi are Zhen'an and Yanchang. Then, townships, villages, and households were randomly selected in each of the chosen counties. In general, six townships were chosen in each county, three villages from each township, and around 15 households from each village. To ensure survey quality, pre-tests, focus group discussion, and enumerator training were carefully conducted. The initial survey was carried out in 2001 (Liu et al. 2010), at which we asked interviewees to recall their production activities and other relevant information back to 1998 before the SLCP pilot projects were launched. We repeated our surveys in 2003, 2005, and 2009 in building up our dataset. Because of the late initiation of our survey, however, we were concerned that recalling what had happened in the late 1990s might not give rise to information as accurate and reliable as that for the immediately past year (2002). But later we discovered that family incomes were generally low and did not vary much before the SLCP was initiated.[1]

Our surveys did not get complete information from all of the initially selected households for all of the years. This is because: (*i*) attrition resulted from some of the households having migrated to places other than the sample villages, deceased, or been disqualified; (*ii*) errors occurred in a small number of interviews; and (*iii*) a few families failed to clearly recall their production and employment activities in the previous year(s). These factors led to the gradual decline and slight fluctuation of the number of sample households, which began at 1447 in 1998, peaked at 1461 in 2003, and dropped to 1251 in 2007 (see Table 1). Nonetheless, as shown later, our testing found little effect of this attrition and fluctuation on the sample representativeness. Indeed, even if those sample households without full observations over the ten-year period are removed from the unbalanced panel, there remain 1065 households in the balanced one.

[1] See our survey data summary below for more detail.

<INSERT Table 1 here>

Our dataset contains information on land status (participating vs. non-participating), subsidy payment (amount and starting time), family demographics (size, number of labourers, and household head gender, education, and ethnicity), on- and off-farm production and employment activities as well as expenses and revenues for both participants and non-participants, and individual perceptions of the program. The nominal price, cost, and revenue information has been converted to real values using the provincial Consumer Price Indices, with 1994 as the base year. Note that the total number of enrolled households in a given year is the sum of the net annual enrollments accumulated over the previous years. The net annual household enrollments are the balance between new enrollments and withdrawals in a year. Withdrawals, albeit rare, may have resulted from family reasons (migrated to another place or deceased) or programmatic reasons (disqualified or no longer enrolled).

Upon enrollment, a household promises to retire a certain amount of marginal cropland and plant it to trees or grass, or enclose it for natural forest or vegetation regeneration. In return, the household receives the specified subsidies from the government. Agriculture includes grain and livestock production, and its expenses are for purchasing such items as seeds, fertilizers, pesticides, plastic mulch, feeds, and fodders. Other than income from agriculture and off-farm work, farmers may receive subsidies (monetary and in-kind compensations almost exclusively for land retirement/conversion and poverty alleviation under the SLCP) and other sources (minor gift, donation, and welfare items, if any, received from relatives, community, and public entities).

3. Program profiling

Before proceeding to develop our model and detail our test procedure, it is insightful to present a basic description of the SLCP implementation based on our sample data, including the dynamics of program enrollment and land and labor allocation, and the employment and income deviations between participants and non-participants.

3.1. Participation trends

Table 2 shows that the participating dynamics of the sample households over time. To avoid confusion and to maintain consistency, only those households having observations for each and every of the ten years covered in our dataset were included. It can be seen that participation in the SLCP grew rapidly in the first three years, but stabilized thereafter. An overwhelming majority of the sample households in Shaanxi were enrolled into the program immediately after it got underway, and virtually all participated by 2007. In comparison, only a small portion of the households in Sichuan got enrolled in the first two years and participation rose to roughly 62% of the households in 2006.

<INSERT Table 2 here>

3.2. Land and labor allocation

As detailed in Fig. 2(a), on average, cropland per household in Shaanxi experienced a dramatic decline—from 11.8 mu in 1999 to only 4.8 mu in 2008.[2] Meanwhile, forestland increased even more—from 8.5 to 27.0 mu. Obviously, the contraction of cropland is smaller than the amount of land enrolled in the program due to the inclusion of non-permanent farming plots or tree planting and forestation elsewhere. In Sichuan, the overall cropland reduction from 6.9 mu to 4.9 mu is relatively moderate during the period, but the forestland increase from 7.1 mu to 12.4 mu was

[2] Mu is a unit of land area measure, equivalent to 1/15 of a hectare.

substantial; thus, nonparticipating households held 6.4 mu of cropland and 9.3 mu of forestland in 2008, whereas participants held 4.0 mu of cropland and 14.4 mu of forestland.

<INSERT Figure 2 here>

In addition to the tremendous shifts in land use, labor allocation of the sample households changed a lot as well. Along with a marked decline in on-farm employment, a sharp increase in off-farm employment occurred simultaneously. Fig. 2(b) shows that family land-based labor time in Shaanxi reduced from 227 (person) days in 1999 to 175 days in 2008, whereas off-farm labor time grew from 66 days to 238 days, indicating that the share of off-farm work in total employment grew from 23% to 58% in a decade. In Sichuan, the average family labor time in agriculture decreased from 321 days to 232 days, while off-farm labor time grew from 133 days to 246 days over the period. In other words, the share of off-farm labor time grew from 29% to 53% in Sichuan.

3.3. Deviations between participants and non-participants

Because of the almost full participation in Shaanxi, it makes little sense for us to examine the deviations in employment and income between participants and non-participants. For that matter, therefore, we decided to focus our attention on Sichuan. In comparison, non-participating households were able to maintain a higher level of employment in agricultural activities, while participating households were forced to seek a higher level of off-farm work, as shown in Table 3. Moreover, the difference in land-based work time was significant all but the first (1999) and last year (2008) under our sample coverage, whereas the difference in off-farm work time was significant in every year between the two groups.

<INSERT Table 3 here>

Nevertheless, significantly higher off-farm work time for the participants may not lead to significantly higher off-farm income; likewise, significantly lower on-farm work time for the participants may not result in significantly lower on-farm income. These are indeed the outcomes revealed in Table 4. On-farm income was somehow significantly different between the two groups in 2000, 2001, and 2008; but notice that the large drop of on-farm income for the participating group in 2008 was mainly caused by the scaling back of the program subsidies by the government (Yin 2009). Meanwhile, significant difference of off-farm income appeared only in 1999 and 2000 between the two groups and it faded away quickly. As a result, significant difference of total income came in the early 2000s—2000, 2001, 2003 and 2004. Part of the difference in total income is apparently attributable to the higher income from off-farm sources for participants. These outcomes have to do with the much wider spreads of the wage distributions, especially in the later years of the sample coverage, relative to the work time distributions. Altogether, these findings imply that endogenous selection may not be a significant concern; or even if it is, its effect might be limited. Of course, any conclusion on this issue must come from careful and comprehensive testing, to which we now turn our attention.

<INSERT Table 4 here>

4. Modeling approaches

Consistent with what has been reported in the literature (e.g., Uchida et al. 2009, Grosjean et al. 2010, Liu et al. 2010), we posit that household income and employment are determined by production inputs, program participation, and/or other control variables including family and village characteristics. Specifically, we theorize that: (1) households' incomes from different sources are affected by their statuses and/or extents of participating in the SLCP, but the effects

on different categories of income may not be the same; (2) the increase in off-farm work time is also impacted by the participation statuses and/or extents; and (3) changes in income and employment are mediated by the influences of other variables, such as village and household characteristics. That is,

$$y = \beta_0 + \sum_{i=1}^{I} \beta_i x_i + \mu \quad (1)$$

where the dependent variable, y, is land-based or total income, or off-farm labor time; the independent variables, x_i, are production inputs and household and village characteristics (i = 1, 2, …, I) and/or time trend; and μ is the error term. Production inputs include expenses and labor time for land-based production, off-farm labor time, and amounts of farmland and forestland. Household characteristics include family size, age, years of schooling, and status of village leadership for the household head, and possible matching afforestation.[3] Village characteristics include road condition (whether there is a paved road) and annual rainfall.

Before exploring possible endogeneity and estimating program impacts, a couple of auxiliary tests are warranted to ensure that the procedures we adopt are appropriate and the results we obtain are robust. First, it is necessary to determine whether the mean values of the key variables of our sample are the same between the full panel, which is unbalanced, and the balanced panel, in which those households without observations throughout the ten years are removed. The purpose of doing so is to alleviate any concern about the attrition and fluctuation of the sample size over time. In case the attrition and fluctuation of the sample do not alter the mean values of the key variables, we will be more confident to use the balanced panel in our later econometric exercise, which is more technically convenient, in conjunction with a household-level, fixed-effects estimator. Second, it is also worthwhile to detect whether the

[3] Tree-planting outside of the subsidized cropland restoration efforts is adopted in some places as part of the condition for receiving the government subsidies.

229 participating and non-participating sample households shared similar characteristics in terms of
230 their different categories of income before the program was formally launched. If they did not,
231 the discrepancy between the two groups must be captured to avoid any improperly ascribed
232 program impact (Khandker et al. 2010).

233 To test possible endogenous selection in a farmer's decisions on whether or not to enroll
234 into the program and, if so, by how much, we will adopt the Hausman procedure because of its
235 popularity (Woodridge 2009) and our desire to make a comparison with what was reported in the
236 literature on the basis of that procedure (e.g., Liu et al. 2010). Given the above linear model, it is
237 assumed that $E(\mu) = 0$ and $Cov(x_i, \mu) = 0$ for the *OLS* estimates (β_i) to be consistent. If one of
238 the explanatory variables, x_K ($K \in 1, 2, \dots, I$), is correlated with the error μ, $Cov(x_K, \mu) \neq 0$,
239 because of omitted variable and/or simultaneity problem, then x_K is endogenous. One way to
240 detect the endogeneity is to identify an instrumental variable z for x_K and estimate a reduced-
241 form equation of it, $x_K = \alpha_0 + \alpha_1 z + \nu$, to obtain $\hat{\nu}$. Then, we add $\hat{\nu}$ as an additional
242 explanatory variable in equation (1). We know that x_K is correlated with the error μ if and only if
243 ν is correlated with μ (Woodridge 2009). Therefore, if the coefficient of $\hat{\nu}$ is significant, we
244 accept the null hypothesis that x_K is endogenous. Of course, z can be a vector if not one
245 instrumental variable (IV) but one set of IVs identified (Woodridge 2010).

246 Given the fact that program participation is reflected in either whether or not a household
247 is enrolled into the program, or how much cropland of a household is enrolled, the potential
248 endogeneity in program participation must be examined from both angles. One of our models
249 will thus be specified such that the likelihood of participation is determined by a set of
250 exogenous variables, including the participation status of the village as the IV of household
251 participation, which will allow us to derive the predicted probability of participation by an

individual household given those variables. Then, the predicted probabilities will be used in estimating the effect of the program participation on land-based income. Alternatively, we will predict the amount of household cropland enrollment using village cropland enrollment as the IV and then include the predicted values in quantifying the effect of program participation on land-based income. The question now becomes whether or not the village-level status of participation and amount of cropland enrollment can serve as the IVs adequately, to which we will return in next section where we present our empirical results.

Similarly, we can predict the amount of labor transfer into off-farm activities and quantify its effect on household total income. Here, the index of off-farm wage rate and the ratio of village-level off-farm work time to total work time in the previous year will be used as the IVs in predicting the off-farm work time. Again, we will scrutinize the suitability of the selected IVs in the following section.

5. Econometric results

First, we present the tested outcomes of the basic sample features of our dataset. Table 5 lists the results of our testing of whether or not the mean values of the key variables of the full panel, which contains all the sample households, and the balanced panel, which contains only those having observations for each and every of the ten years, are different. In each and every case, no significant difference was found on the basis of the high probability of accepting the no difference hypothesis, suggesting little effect of the attrition and fluctuation on the sample representativeness. As such, the attrition and fluctuation of annual observations have little altered the sample means and our decision to use the balanced panel to conduct our econometric analysis is validated.

<INSERT Table 5 here>

To determine whether participating and non-participating households shared same attributes before the program had been initiated, we tested whether or not the mean values of the income variables of the two groups are different in the two provinces. Table 6 lists the outcomes. In all but only one case, no significant difference was detected on the basis of the high probability of accepting the no difference hypothesis. This indicates that our initial random selection of the sample households was unbiased and thus representative, lending us confidence in the appropriateness of our econometric analysis of the program effects on employment and income, based on the household survey data.

<INSERT Table 6 here>

In performing the Hausman tests of possible endogeneity as reflected in the status and extent of program participation, we proposed to use the participation status and extent at the village level as the corresponding IV. The correlations between the status and extent of household program participation and these IVs are reported in Table 7(a). It can be seen that while the correlation between the potentially endogenous variable and the selected IV is high, the correlation between the residuals of the *OLS* regression,[4] in which the potential endogeneity is ignored, and the IV is virtually no existent. Similarly, in testing the possible endogeneity of the extent of participating in off-farm labor markets, we proposed to use the proportion of off-farm work time to total work time and the index of off-farm wage rate at the village level as the IVs. The regression coefficients (see Table 7(b)) show that these IVs are strongly correlated with the potentially endogenous variable, but they are barely correlated with the residuals of the *OLS* regression,[5] with the potential endogeneity being ignored. As such, these results have mitigated

[4] See Appendix A-1 for detail of the *OLS* regression results.
[5] See Appendix A-2 for detail of the *OLS* regression results.

297 any concern about the so-called "weak instrumentation" phenomenon—low correlation of an
298 identified IV with the possibly endogenous variable (Woodridge 2010)—and confirmed our
299 choice of the IVs.

300 **<INSERT Table 7 here>**

301 With the acceptance of our selected IVs, let us now look at the outcomes of our Hausman
302 tests of endogeneity. As shown in Table 8, the χ^2 values of the two alternative tests, based on
303 both the status and extent of program participation, are lower than the critical values. Therefore,
304 we reject the hypothesis that there is a significant endogeneity in households' decision of
305 program participation. That is, little evidence exists for farmers to self-select into the program
306 and the econometric estimation of the impact of program participation, based on the fixed-effects
307 estimator, remain unbiased and reliable. The coefficient of that impact, measured in terms of
308 participation status, suggests that participating in the program would have resulted in a 29% gain
309 in land-based income including the government subsidies, compared to non-participating.
310 Alternatively, the land-based income of participants could have increased by 4% should their
311 cropland enrollment have doubled.

312 **<INSERT Table 8 here>**

313 On the other hand, the χ^2 values of the two Hausman tests of off-farm labor time,
314 corresponding to the alternative measurement of households' program participation (in terms of
315 status and extent), are both greater than the critical values (see Table 9). That is, significant
316 endogenous choice was detected in household behavior of seeking off-farm jobs. The evidence
317 of farmers' self-selection into the off-farm labor markets invalidates the impact of the off-farm
318 labor market participation on farmers' total income derived from an *OLS* estimation of the fixed-
319 effects model. Thus, an IV method must be adopted to re-estimate that impact. It turns out that

regardless of the program participation measurement, the doubling of off-farm labor time could have led to a 5% increase of total income. Compared to the initial estimate derived from the *OLS* regressions (see Appendix A-2), the IV method gives rise a slight higher effect of off-farm labor time on total income. In contrast, the program's effect on total household income becomes no long significant if measured in terms of participation status; otherwise, it remains significant but small if measured in terms of participation extent.

<INSERT Table 9 here>

Having presented our findings of endogeneity tests, we can now move onto reporting the rest of our empirical results. As shown in Tables 8, no matter how participating in the SLCP is defined, land-based labor time and cash expenses and amounts of cropland and forestland all have a significant effect on land-based income. Likewise, number of family members, annual rainfall, and age of household head significantly affect land-based income in a positive way. Meanwhile, years of household head's schooling has a small, albeit significant, effect on land-based income when the status of household program participation in included in the model, but that effect becomes no longer significant when the extent of household program participation is included. Finally, matching afforestation, which could only be meaningfully included when the extent of household program participation is used, has a small positive effect.

In identifying the determinants of participating in off-farm labor markets, remarkably consistent coefficient estimates come from the two alternative specifications—again, one with the status of participation and the other with the extent of participation being included. In sum, forestland, number of family members, years of household head's schooling, and the two IVs—ratio of village-level off-farm labor time to total labor time in the previous year and index of off-farm wage rate—are all positively correlated with off-farm labor time. At the same time,

343 farmland has a negative effect, and village leadership status, age of household head, and road
344 condition dummy have little effect. Additionally, it is found that while land-based labor time has
345 a small negative effect on total income, farmland and forestland have a small positive effect.
346 Number of family members, paved road dummy, and years of household head's schooling have
347 positive impacts on total income. Finally, a significant coefficient of time trend is detected.
348
349 **6. Discussion and conclusions**
350 This study was inspired primarily by our desire to detect whether there has been endogeneity
351 selection in farmers' decisions to participate in the SLCP and to transfer labor into off-farm
352 activities. We have done so by conducting a series of tests based our knowledge of the induced
353 changes in program enrollment, land and labor allocation, and structural change of family
354 income. In a nutshell, we have shown that while little endogenous choice was detected in
355 farmers' program participation, endogenous selection was found in household decision of labor
356 transfer into off-market markets. Notably, this conclusion is predicated on the findings that our
357 initial sampling selection was unbiased and that the use of balanced panel is not problematic.
358 That little self-selection has been identified in farmer's decision to participate in the
359 SLCP is not surprising in view of the fact that once an area was designated by the local
360 government for retirement, the window of opportunity for households to enroll was brief, and
361 participation might not be fully voluntary (Yin et al. 2010, Liu et al. 2010). Further, we saw
362 immediate jumps in both the number of households and the land area enrolled in the first a few
363 years, followed with a virtually complete stabilization. Therefore, the chances for endogenous
364 selection seem very limited, if any. Meanwhile, the existence of endogeneity in moving labor
365 into off-farm markets has to do with the fact that greater program participation would have

366 triggered greater transfer of labor into off-farm activities. Interestingly, though, removing the
367 endogeneity with the selected IVs has given rise to a slightly higher effect of off-farm labor time
368 on total income. This suggests that without considering potential endogeneity, the effect of
369 participation in the SLCP could have been biased upwards, especially when a status dummy is
370 used. At the same time, regardless of how participating in the SLCP is measured (status or
371 extent), the effect of participation is very small, if any, in terms of its absolute magnitude or in
372 relation to its indirect effect on total income derived from the triggered increase in off-farm labor
373 time.

374 Here, it should be pointed out that implementing the SLCP has coincided with the
375 unprecedented socioeconomic transition in rural China, as manifested by the remarkable shifts in
376 land use, job opportunities, and income composition (Yin et al. 2014). It is thus essential to
377 recognize and acknowledge that the macro socioeconomic changes have played a major role in
378 transforming the rural employment and income structure (Grosjean and Kontoleon 2009, Groom
379 et al. 2010, Yin et al. 2014). This is partially captured in the large coefficient of time-trend
380 variable, which indicates an annual 8% increase of total income regardless the influences of
381 other factors. Past studies have largely ignored this broader context in their analyses of the
382 induced effects of the program on labor use, production change, and income growth, which could
383 have generated biased findings as well as inappropriate policy prescriptions (Yin et al. 2010).
384 While overestimating the direct effect of household's program participation on total income per
385 se may not constitute a gross mistake, ignoring the indirect effect of the triggered increase in off-
386 farm labor time is especially problematic in identifying the full income impact of household's
387 program participation.

Following data log transformation, the estimated coefficients can be interpreted as elasticities. But note that the proper range of a particular variable ought to be clearly understood in order to make sense of the estimated coefficients. Our analysis shows that among all the production inputs, land-based expenditure has a large positive impact on land-based income, but its effect on total income is small. In contrast, farming labor time has a modest, positive effect on land-based income, but it is negatively correlated with total income. On the other hand, off-farm labor time has a large positive impact on total income, but its effect on land-based income is slightly negative. Further, while farmland is positively correlated with land-based income, the effect is small. An expansion in forestland results in a gain in land-based income and also triggers an increase in off-farm work and thus total income; however, the coefficients are not large.

As to the influences of household and village characteristics, we find that access to a paved road benefits both on-farm and total income. Moreover, larger families tend to undertake more on-farm and off-farm work and therefore to increase both categories of income. More years of schooling of the house head is correlated with an increase in off-farm income and total income, whereas age of the house head has a positive correlation with every category of income.

In any case, it is found that at least in the short run, the SLCP has succeeded in achieving its goals of ecological restoration and income enhancement. Indeed, participating in the SLCP triggered increased work in and income from off-farm activities; and it also positively affected farm income by stimulating a structural adjustment of land-based production activities. Further, the observed income and employment changes are influenced by production inputs and other control variables, such as household and village features. Overall, farming expenditure, off-farm labor time, amounts of farmland and forestland, road condition, and family size are positively

411 correlated with family total income. In contrast, on-farm labor time and distance from nearest
412 township are negatively correlated with total income. These results are consistent with and
413 complementary to what has been reported earlier by Unichda et al. (2009), Grosjean and
414 Kontoleon (2009), Liu et al. (2010), and Groom et al. (2010). On the other hand, we did not
415 obtain any evidence that participating in the cropland restoration program has decreased farmers'
416 chances working off the farm, which was reported by studies of the U.S. Conservation Reserve
417 Program (Mishra and Goodwin 1997, Ahearn et al. 2006), a program that is similar to the SLCP.
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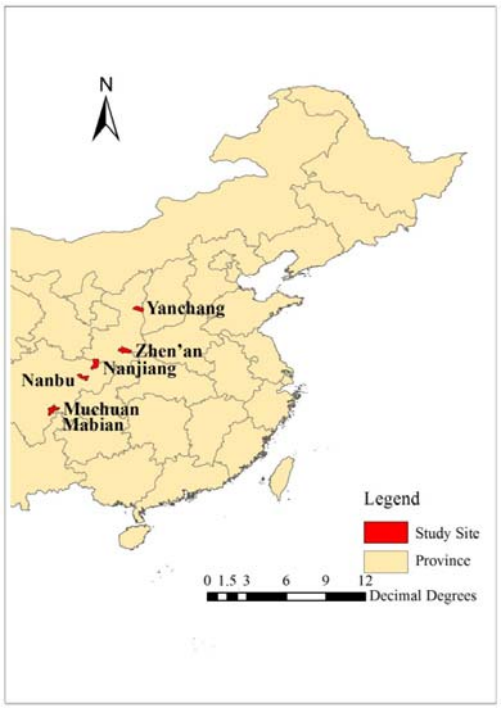
571 **Figure 1. Study sites (2 counties in Shaanxi and 4 in Sichuan)**



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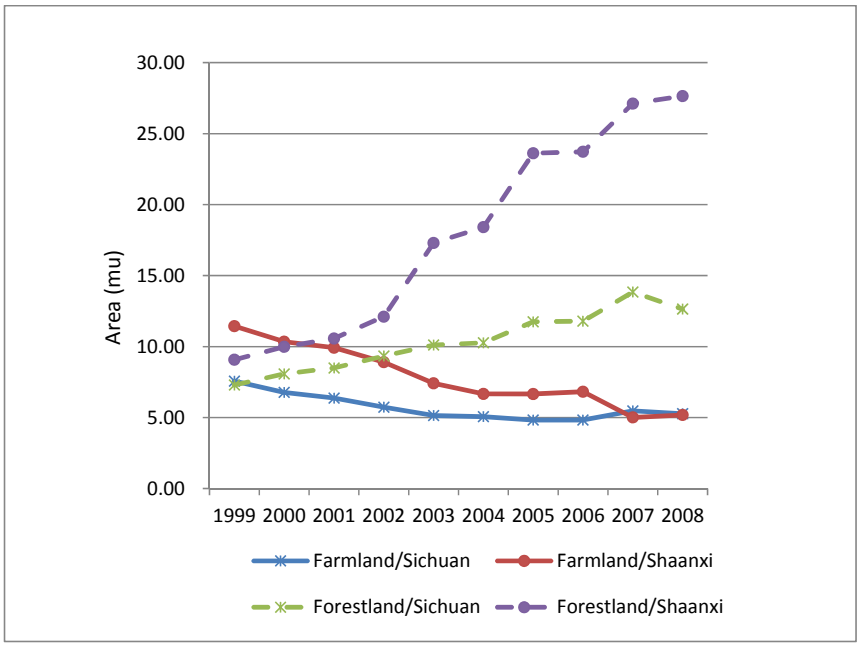
573

Figure 2. Land and labor allocation dynamics

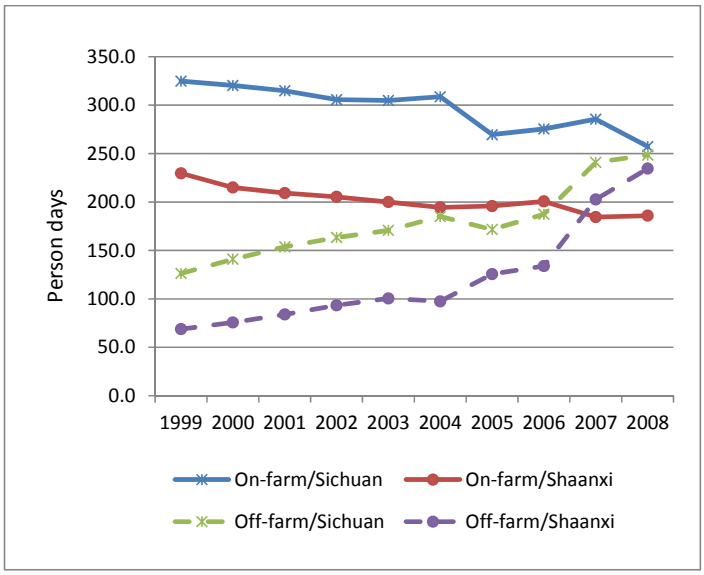
(a). Cropland and forestland dynamics for all sample households



Data source: Authors' surveys.

Comment [YR1]: Starting point of time in tables/figures: 1998 or 1999?

(b). Labor allocation in agricultural and off-farm/off-village employment activities



Data source: Authors' surveys.

590 **Table 1. Number of effective households in the sample provinces**

	Shaanxi	Sichuan
1999	531	916
2000	534	916
2001	534	919
2002	534	921
2003	534	927
2004	534	927
2005	537	912
2006	537	913
2007	472	779
2008	471	793

591
592 Data source: Authors' surveys.
593

594 **Table 2. Participating status of sample households**

Year	Sichuan (647)		Shaanxi (418)	
	Non-participants	Participants	Not-participants	Participants
1999	611	36	131	287
2000	482	165	52	366
2001	447	200	31	387
2002	369	278	16	402
2003	262	385	10	408
2004	256	391	30	388
2005	250	397	1	417
2006	246	401	1	417
2007	239	408	3	415
2008	254	393	4	414

595
596 Data source: Authors' surveys; those sample households without observations in each of the 10
597 years have been removed in order to make the comparison.
598

599

Table 3. Participating status and labor allocation in agricultural and off-farm/off-village employment activities in Sichuan (unit: person days)

Year	On-farm work time			Off-farm work time		
	Nonparticipants	Participants	Difference	Nonparticipants	Participants	Difference
1999	324	345	22	123	187	64**
2000	327	301	-26*	128	179	51***
2001	329	283	-47***	137	191	53***
2002	321	285	-36***	144	189	45***
2003	324	292	-32**	134	196	62***
2004	328	296	-32**	144	212	68***
2005	287	259	-28**	123	202	79***
2006	290	267	-23*	129	224	95***
2007	320	265	-55***	180	277	97***
2008	265	252	-13	212	272	60***

Data source: Authors' surveys; figures are calculated with the balanced panel dataset of 647 households; and ***, **, and * indicate significance at 99%, 95%, and 90% levels, respectively.

Table 4. Total, off-farm and on-farm incomes for the two different groups of households in Sichuan (unit: yuan in 1994 constant price)

Year	Total income			Off-farm income			On-farm income		
	Non-participants	Participants	Difference	Non-participants	Participants	Difference	Non-participants	Participants	Difference
1999	5020.9	5203.3	182.5	1673.5	2174.7	501.2 *	3347.4	3028.6	-318.7
2000	5248.9	6361.0	1112.0***	1797.7	2398.1	600.4**	3451.2	3962.8	511.6***
2001	5643.4	6528.0	884.6**	2070.9	2562.0	491.0	3572.5	3966.1	393.6**
2002	6330.7	6813.1	482.4	2373.3	2762.2	388.9	3957.4	4050.9	93.5
2003	6703.8	7433.2	729.4*	2516.3	3034.5	518.2	4187.5	4398.7	211.2
2004	7147.6	8077.6	930.0*	2631.7	3354.6	722.8	4515.9	4723.1	207.2
2005	7305.0	7931.2	626.2	3028.8	3616.9	588.2	4276.2	4314.3	38.1
2006	8204.0	8852.0	648.0	3411.1	4080.1	669.1	4793.0	4771.9	-21.1
2007	11467.5	11511.2	43.8	5480.7	5855.3	374.6	5986.8	5655.9	-330.9
2008	13495.3	12517.9	-977.4	6557.6	6617.1	59.6	6937.7	5900.8	-1037.0*

Table 5. Testing results of whether the balanced panel (I) and the full panel (II) share the same mean values in labor time, farmland, farming expenditure, forestland, and total income

	Sample Size		**Labor Time**			**Farmland**		
Year	Panel I	Panel II	Panel I	Panel II	*P*>*F*	Panel I	Panel II	*P*>*F*
1998	1,065	1,443	382.12	388.48	0.45	9.86	9.72	0.76
1999	1,065	1,447	391.11	394.97	0.66	9.09	8.97	0.79
2000	1,065	1,450	394.27	402.87	0.34	8.17	8.04	0.74
2001	1,065	1,453	399.69	407.88	0.38	7.76	7.62	0.72
2002	1,065	1,455	402.19	412.39	0.28	6.98	6.76	0.54
2003	1,065	1,461	406.81	414.40	0.43	6.04	5.73	0.32
2004	1,065	1,461	414.51	420.78	0.54	5.69	5.45	0.38
2005	1,065	1,449	394.21	398.64	0.63	5.54	5.26	0.25
2006	1,065	1,450	412.45	417.76	0.58	5.61	5.28	0.20
2007	1,065	1,251	471.78	470.23	0.90	5.29	5.19	0.68
2008	1,065	1,264	472.29	474.84	0.83	5.23	4.89	0.17

	Farming Expenses			**Forestland**			**Total Income**		
Year	Panel I	Panel II	*P*>*F*	Panel I	Panel II	*P*>*F*	Panel I	Panel II	*P*>*F*
1998	517.96	516.06	0.91	6.60	6.37	0.62	4010.25	4049.08	0.73
1999	567.98	566.16	0.92	7.99	7.64	0.47	4544.39	4546.33	0.99
2000	584.28	588.99	0.80	8.83	8.53	0.55	5049.36	5136.64	0.54
2001	610.53	611.92	0.95	9.31	8.99	0.53	5367.75	5416.59	0.75
2002	607.70	609.84	0.91	10.42	10.14	0.60	5963.95	6076.01	0.53
2003	622.87	621.41	0.94	12.93	12.81	0.84	6428.75	6539.77	0.56
2004	592.66	591.44	0.95	13.46	13.29	0.78	7024.71	7117.70	0.67
2005	553.84	544.44	0.58	16.41	15.97	0.59	7577.31	7466.47	0.58
2006	588.48	576.32	0.51	16.47	16.02	0.58	8476.63	8416.46	0.78
2007	1170.55	1176.87	0.95	19.05	19.57	0.66	10429.83	10712.49	0.45
2008	1253.01	1193.57	0.73	18.53	17.87	0.51	11778.44	11469.23	0.48

Note: Based on *F* tests, little difference was found between the two panels in each case given the high probability (*P*) of accepting the no difference hypothesis.

Table 6. Testing results of whether the participating (Y-P) and non-participating (N-P) households share the same mean values in on-farm income, off-farm income, and total income

		On-Farm Income			**Off-Farm Income**			**Total Income**		
	Year	N-P	Y-P	*P>F*	N-P	Y-P	*P>F*	N-P	Y-P	*P>F*
Sichuan	1998	2901.8	2877.7	0.87	1230.9	1471.7	0.24	4132.7	4349.4	0.39
	1999	3093.9	3065.6	0.85	1340.2	1759.7	0.06	4434.1	4825.3	0.14
Shaanxi	1998	2177.1	2110.4	0.76	604.5	824.4	0.34	2781.6	2934.8	0.61
	1999	2492.3	2279.2	0.38	684.2	923.9	0.32	3176.5	3203.2	0.93

Note: Based on *F* tests, in all but one cases little deviation was found between the participating and non-participating households given the high probability (*P*) of accepting the no difference hypothesis.

Table 7. Testing the selected instrumental variables

a. Coefficients between village-level participation status and extent and household-level participation status and extent

Coefficient	Residuals of Model I	Household participation status dummy	Residuals of Model II	Household participation amount
Village-level participation status dummy	-0.04	0.73***		
	(0.03)	(0.01)		
Village-level participation extent			-0.00	0.82***
			(0.00)	(0.01)
Intercept	0.03	0.05***	-0.00	-1.59***
	(0.02)	(0.01)	(0.01)	(0.02)
R^2	0.00	0.51	0.00	0.64

Note: The estimated results of Model I and II can be found in Appendix A-1; participation status is represented with a dummy variable taking 1 if yes and 0 otherwise and participation extent is transformed logarithmically; ***, **, and * indicate significance at 99%, 95%, and 90% levels, respectively. Because while the correlation between the potentially endogenous variable and the corresponding IV is high the correlation between the residuals of the *OLS* regression and the IV is non-existent, the proposed IVs are accepted.

b. Coefficients between village-level participation in off-farm job markets and household-level participation in off-farm job markets

Coefficient	Residuals of Model I	Residuals of Model II	Household off-farm labor time	Residuals of Model I	Residuals of Model II	Household off-farm labor time
Proportion of village-level off-farm labor in total labor time	0.03	0.03	8.61***			
	(0.02)	(0.02)	(0.39)			
Index of off-farm wage rate				-0.00	-0.01	1.56***
				(0.02)	(0.02)	(0.24)
Intercept	-0.01	0.01	-2.92	0.00	0.01	-1.95
	(0.01)	(0.01)	(0.13)	(0.02)	(0.02)	(0.27)
R^2	0.00	0.00	0.17	0.00	0.00	0.00

Note: The estimated results of Model I and II can be found in Appendix A-2; household off-farm labor time is transformed logarithmically; ***, **, and * indicate significance at 99%, 95%, and 90% levels, respectively. Because the correlations between the potentially endogenous variable and the corresponding IVs are high and the correlations between the residuals of the *OLS* regressions and the IVs are almost non-existent, the proposed IVs are accepted.

Comment [YR2]: Is this an error. If not, then the whole IV selection is problematic.

652 **Table 8. Hausman tests of the self-selection in program participation by households**
653

Coefficient	Test I		Test II	
	Participation status	Land-based income	Participation extent	Land-based income
Land-based labor time	0.00	0.11***	0.02*	0.11***
	(0.00)	(0.01)	(0.01)	(0.01)
Farmland	-0.01***	0.02***	-0.10***	0.02***
	(0.00)	(0.00)	(0.01)	(0.00)
Foreland	0.04***	0.03***	0.36***	0.02***
	(0.00)	(0.01)	(0.01)	(0.01)
Land-based production expenses	0.00	0.16***	0.01	0.16***
	(0.00)	(0.00)	(0.01)	(0.00)
Number of family members	-0.01	0.19***	-0.18	0.19***
	(0.01)	(0.06)	(0.13)	(0.06)
Annual rainfall	0.02	0.10*	0.25*	0.09*
	(0.01)	(0.06)	(0.13)	(0.06)
Paved road dummy	-0.02	0.04	-0.06	0.04
	(0.01)	(0.04)	(0.10)	(0.04)
Years of household schooling	0.00**	0.01*	0.03*	0.01
	(0.00)	(0.01)	(0.02)	(0.01)
Village leadership dummy	0.02	0.10	0.12	0.10
	(0.02)	(0.09)	(0.22)	(0.09)
Age of household head	0.37***	1.09***	2.07***	0.90***
	(0.03)	(0.13)	(0.28)	(0.12)
Village-level participation status	0.59***			
	(0.01)			
Household-level participation status		0.29***		
		(0.05)		
Village-level participation extent			0.68***	
			(0.01)	
Household-level participation extent				0.04***
				(0.00)
Matching afforestation			0.12***	0.01*
			(0.01)	(0.00)
Intercept	-1.40***	1.31**	-10.66***	2.39***
	(0.14)	(0.57)	(1.34)	(0.59)
R^2	0.50	0.28	0.65	0.30
Test statistic		$P(> \chi^2) = 0.85$		$P(> \chi^2) = 1.00$

654 Note: The total observations in the balanced panel were 11715 (1065 a year and 11 years);
655 coefficients were obtained based on a fixed-effects estimator; corresponding each variable, the
656 statistics in second row are the *t* values; all but the dummy variables were transformed
657 logarithmically for better fitting and easier interpretation (as elasticity); dummy variable takes 1
658 if yes and 0 otherwise; rounding was made in reporting the estimated results; ***, **, and *
659 indicate significance at 99%, 95%, and 90% levels.

Table 9. Hausman tests of the self-selection in off-farm labor participation by households

Coefficient	Test I		Test II	
	Off-farm labor	Total income	Off-farm labor time	Total income
Off-farm labor time		0.05***		0.05***
		(0.01)		(0.01)
Land-based labor time		-0.01*		-0.01*
		(0.00)		(0.00)
Land-based production expenses		0.00		0.00
		(0.00)		(0.00)
Farmland	-0.05*	0.01***	-0.04*	0.01***
	(0.02)	(0.00)	(0.02)	(0.00)
Forest-land	0.05**	0.01***	0.040*	0.01***
	(0.02)	(0.00)	(0.02)	(0.00)
Number of family members	3.77***	0.19***	3.77***	0.19***
	(0.28)	(0.04)	(0.28)	(0.04)
Paved road dummy	-0.10	0.13***	-0.11	0.13***
	(0.21)	(0.02)	(0.21)	(0.02)
Years of household head schooling	0.16***	0.01***	0.16***	0.01***
	(0.04)	(0.00)	(0.04)	(0.00)
Village leadership dummy	0.43	-0.01	0.43	-0.01
	(0.46)	(0.04)	(0.46)	(0.04)
Age of household head	0.20	0.03	0.05	0.04
	(0.61)	(0.08)	(0.61)	(0.08)
Household-level participation status dummy	0.60***	0.02		
	(0.15)	(0.02)		
Household-level participation extent			0.07***	0.01***
			(0.02)	(0.00)
Matching afforestation			0.00	0.00
			(0.02)	(0.00)
Ratio of village-level off-farm labor time over total labor time	7.25***		7.19***	
	(0.45)		(0.45)	
Index of off-farm wage rate	0.60**		0.60**	
	(0.24)		(0.24)	
Time trend		0.08***		0.08***
		(0.00)		(0.00)
Intercept	-9.28***	7.46***	-8.13***	7.50***
	(2.20)	(0.30)	(2.26)	(0.30)
R^2	0.18	0.29	0.18	0.28
Test statistic		$P(>\chi^2)=0.03$		$P(>\chi^2) = 0.05$

Note: The total observations in the balanced panel were 11715 (1065 a year and 11 years); coefficients were obtained based on a fixed-effects estimator; corresponding each variable, the statistics in second row are the *t* values; all but the dummy variables were transformed logarithmically for better fitting and easier

interpretation (as elasticity); dummy and proxy variable takes 1 if yes and 0 otherwise; rounding was made in reporting the estimated results; ***, **, and * indicate significance at 99%, 95%, and 90% levels.

Appendix A-1: Results of *OLS* regression of land-based income against program participation and other covariates

Coefficient	Land-based income	
	Model I	Model II
Land-based labor time	0.11***	0.11***
	(0.01)	(0.01)
Farmland	0.02***	0.02***
	(0.00)	(0.00)
Forestland	0.02***	0.01***
	(0.00)	(0.00)
Land-based production expenses	0.16***	0.16***
	(0.00)	(0.00)
Number of family members	0.18***	0.19***
	(0.06)	(0.06)
Paved road dummy	0.05	0.04
	(0.04)	(0.04)
Years of household head education	0.01	0.01
	(0.01)	(0.01)
Village leadership dummy	0.10	0.10
	(0.09)	(0.09)
Age of household head	0.95***	0.85***
	(0.11)	(0.11)
Annual rainfall	0.11*	0.10*
	(0.06)	(0.06)
Participation status dummy	0.39***	
	(0.03)	
Participation cropland amount		0.04***
		(0.00)
Matching afforestation		0.01*
		(0.00)
Intercept	1.72***	2.56***
	(0.55)	(0.56)
R^2	0.29	0.30

Note: The total observations in the balanced panel were 11715 (1065 a year and 11 years); coefficients were obtained based on a fixed-effects estimator; corresponding each variable, the statistics in second row are the *t* values; all but the dummy variables were transformed logarithmically for better fitting and easier interpretation (as elasticity); dummy variable takes 1 if yes and 0 otherwise; rounding was made in reporting the estimated results; and ***, **, and * indicate significance at 99%, 95%, and 90% levels.

Appendix A-2: Results of *OLS* regression of total income against program participation, off-farm labor time, and other covariates

Coefficient	Total income	
	Model I	***Model II***
Off-farm labor time	0.03***	0.03***
	(0.00)	(0.00)
On-farm labor time	-0.01*	-0.01*
	(0.00)	(0.00)
Farmland	0.01***	0.01***
	(0.00)	(0.00)
Forestland	0.01***	0.01***
	(0.00)	(0.00)
Land-based production expenses	0.00	0.00
	(0.00)	(0.00)
Number of family members	0.26***	0.26***
	(0.03)	(0.03)
Paved road dummy	0.13***	0.13***
	(0.01)	(0.02)
Years of household head education	0.02***	0.02***
	(0.00)	(0.00)
Village leadership dummy	-0.01	-0.01
	(0.04)	(0.04)
Age of household head	0.07	0.07
	(0.08)	(0.08)
Participation status dummy	0.04***	
	(0.01)	
Participation cropland amount		0.01***
		(0.00)
Matching afforestation		0.00
		(0.00)
Time trend	0.08***	0.08***
	(0.00)	(0.00)
Intercept	7.18***	7.25***
	(0.29)	(0.29)
R^2	0.33	0.33

Note: The total observations in the balanced panel were 11715 (1065 a year and 11 years); coefficients were obtained based on a fixed-effects estimator; corresponding each variable, the statistics in second row are the *t* values; all but the dummy and proxy variables were transformed logarithmically for better fitting and easier interpretation (as elasticity); dummy variable takes 1 if yes and 0 otherwise; rounding was made in reporting the estimated results; and ***, **, and * indicate significance at 99%, 95%, and 90% levels.