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The Sloping Land Conversion Program in China: Effect on the Livelihood Diversification of Rural Households

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Summary. — Through addressing the motivations behind rural households' livelihood diversification, this paper examines the effect of the Sloping Land Conversion Program (SLCP) on livelihood diversification using a longitudinal household survey data set spanning the overall implementation of the SLCP. Our results show that the SLCP works as a valid external policy intervention to increase rural livelihood diversification. In addition, the findings demonstrate that the implementation of the SLCP has had heterogeneous effects on livelihood diversification across different rural income groups. The lower income group was more affected by the program in terms of income diversification.

Key words — Sloping Land Conversion Program, China, livelihood diversification, income diversity index, identification condition, difference in differences

1. INTRODUCTION

The contradiction of rural poverty and the environment has been the subject of discussion since the end of the previous century (Leonard, 1989; World Bank, 1992). Environmental resources can be broadly utilized by rural populations in various ways, such as gathering, grazing, and other managed planting. It would be advantageous if people could regulate the use of certain resources. However, this balance is fragile and can easily break down in rural areas in developing countries. Leonard (1989) points out that rural poverty is intimately connected with environmental degradation, and poverty is seen as both a cause and a result of natural resource depletion.

From the point of view of the poverty–environment nexus, a lack of an income source and land resource due to population growth drives rural populations to rely heavily on the extraction of environmental resources, such as gathering (firewood, building materials, and fodder for animals), overgrazing grasslands, and the overuse of marginal land (Brundtland, 1987). On the other hand, environmental degradation such as soil erosion, the over-grazing of pastures and the loss of watershed protection further intensifies the degree of poverty experienced by rural households. In response to this, Ellis (2000) indicates that rural livelihood diversification [1] is of significance in solving the poverty–environment equation, because it can directly switch the time allocation of the household from activities based on environmental resources, to off-farm or non-farm income-generating activities by providing alternative sources to relieve the pressure on the environment. In China in 1999, the central government initiated the SLCP, which introduced a fixed-payment incentive mechanism to compensate rural households that convert sloped arable land to forest- or grassland. The main objective of the program is to reverse the adverse poverty–environmental connection, improve environmental conditions and alleviate poverty through inducing structural economic change at the local level by means of financial incentives (Grosjean & Kontoleon, 2009). By converting arable land to forest or grassland, the program could directly shift rural surplus labor from activities based on sloped cropland to off-farm or non-farm income-generating activities, which tends to alleviate rural poverty by diversifying livelihoods. However, in this process, rural households have difficulties in overcoming entry barriers to off-farm and non-farm income-generating activities, which include both human capital constraints such as education, skill and health, and financial capital constraints (Ellis, 2000; Smith, Simard, & Sharpe, 2001). These barriers could be overcome by policy intervention which aims to improve the asset holdings of the rural, either by endowing them with additional financial, fixed, human, natural, or social assets, or by increasing the productivity of the assets they already hold, or both (Barrett, Reardon, & Webb, 2001). This paper introduces the Sloping Land Conversion Program (SLCP) as an example to illustrate the effects of policy intervention on livelihood diversification by switching rural surplus labor to off- and non-farm income-earning activities as well as overcoming the entry barriers, both of which contribute to the sustainability of rural livelihoods.

According to the 'dual' objectives of the SLCP, environment protection and poverty alleviation, the success of the program is determined by providing the rural households with alternative income sources that reduce their reliance on gathering activities from the local environment and reducing their

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motivation to initiate cultivation in environmentally sensitive locations. This is achieved by providing options that make time spent in exploiting natural resources (above examples, gathering activities in forests and farming on sloping land) less remunerative than time spent doing other things (Ellis, 2000). The growth of non-farm income sources if accessible in remote rural areas might reduce the need for landless dwellers to carry out extractive practices in local environments for their survival. This has been called the 'substitution of employment for the environment' and has received quite a lot of attention in the policy literature (Lipton, 1991).

Obviously, the implementation of the SLCP has an influence on the livelihood strategies of farm households in rural areas, which has inspired extensive empirical policy evaluation studies on, e.g., income growth, inequality, and off-farm labor participation. Li, Feldman, Li, and Daily (2011), Liu, Lu, and Yin (2010), Uchida, Rozelle, and Xu (2009) and Yao, Guo, and Huo (2010) all find that the program has had a significant positive effect on the income of participating households, whereas Xu, Bennett, Tao, and Xu (2004) found that the effect on the income of participants is statistically insignificant. Besides, Kelly and Huo (2013), Qu, Kuyvenhoven, Shi, and Heerink (2011) and Uchida *et al*., 2009 argue that participating households are increasingly shifting their labor endowment from on-farm work to the off-farm labor market, which is also a kind of diversification reaction, while the program was not successful in shifting labor into off-farm sectors during the first few years of implementation (Xu *et al*., 2004).

As described above, much literature discusses either the change in income, or the change in the distribution of income activities. Our particular focus is on the impact of the SLCP on rural households' livelihood diversification as this captures the changes in income activities and their distribution simultaneously, which we consider a neglected aspect of the existing literature. In addition, as shown previously, livelihood diversification is an effective way of solving the problem caused by poverty and environmental degradation. Therefore, livelihood diversification can be used as an efficient indicator to evaluate the success and sustainability of the SLCP in China.

We make three contributions to the existing literature. First, the paper sheds light on the internal and external factors that motivate rural households to diversify their livelihood or income sources. Particularly, we attempt to investigate whether SLCP works as a valid external policy intervention on livelihood diversification, which is considered an effective means of solving the problem caused by poverty and environmental degradation. To the best of our knowledge, our study is the first to shift the focus from analyzing the impact of SLCP on income growth and off-farm labor participation to livelihood diversification. Second, this study attempts to examine heterogeneity regarding the policy impact among different income groups by analyzing whether the effect on livelihood diversification differs across different rural income groups. Our results show that the low-income group benefits more in terms of livelihood diversification from the policy intervention. Accordingly, poverty alleviation in rural areas can be achieved by implementation of the SLCP. Our third contribution is that we apply an updated database of household-level data covering the period 1999–2010 which saw the implementation of the SLCP and a policy adjustment in 2007. Hence, our study attempts to provide a more comprehensive analysis of the policy impact of the SLCP and may fill the gap in the literature by providing evidence from the collected rural household data after the policy adjustment.

The paper proceeds as follows: Section 2 provides some background on the SLCP in China; Section 3 outlines the conceptual framework; Section 4 presents the data and defines the livelihood diversification index used in our study; Section 5 describes the empirical strategy and empirical specification; Section 6 reports the empirical results and discussions, while Section 7 concludes.

2. BACKGROUND OF SLOPING LAND CONVERSION PROGRAM

In response to growing environmental pressure and public protection awareness, the Chinese government initiated several ecological restoration programs in the late 1990s. The SLCP, which is also known as Grain for Green (GFG), is distinct from the other programs since it is one of the first, and certainly the most ambitious, programs based on payments for environmental services in China (Bennett, 2008).

(a) *The initial state of SLCP*

The main reasons for the implementation of this payment for environmental services program was the drought of the Yellow River in 1997 and the massive floods along the Yangtze River in 1998 (Xu & Cao, 2002). The Chinese government initiated the SLCP to limit water and soil erosion by afforestation in three provinces – Sichuan, Shaanxi, and Gansu – in 1999 and formally launched the program nationwide in 2002, which was originally designed to convert 14.67 million hectares of farmland to forest or grassland (4.4 million of which is on land with slopes above 25°), and an additional "soft" goal of afforesting a roughly equal area of denuded mountains and wasteland by 2010 (SFA, 2003).

The program focuses mainly on cultivated land on steep slopes (greater than 15° in the northwest and 25° in the southwest), which is the kind of land which tends to experience serious erosion resulting from cultivation. The original plan was to convert 14.67 million hectares of farmland to forest or grassland. However, in reality, only 9.3 million hectares were finally converted.[2] The State Forestry Administration (SFA) charged by the State Council and provincial and sub-provincial forestry bureaus are primarily responsible for targeting general areas of land for enrollment in the program as well as in setting and distributing enrollment quotas to local government (Zuo, 2002). Local governments were in charge of evaluating land plots. Households whose land plots fell into the planned project area were eligible for inclusion in the program. The participant households were granted seedlings as well as technical guidance for planting, and they could receive subsidies on condition that the survival rate of the planted trees on the sloping land reached 70%, the inspection work for which is conducted by local governments. There were two subsidy levels between regions, the annual grain subsidy was 1,500 kg/ha in the Yellow River Basin and 2,250 kg/ha in the Yangtze River, reflecting inherent differences in regional average yields. However, in 2004, the grain subsidies were changed to cash payments (the conversion rate of grain to cash is 1 kg grain = 1.4 CNY (1 USD = 6.77 CNY, in 2010) (Liu & Wu, 2010). Besides, participant households are also given 300 CNY annually for managing and protecting the planted trees per hectare of converted sloping land. Obviously, the first and primary goal of the SLCP is to contribute to ecological restoration by increasing forest cover on sloped cultivated land in the upper reaches of the Yangtze and Yellow River basins to prevent soil erosion (SFA, 2003). However, the program

has another important objective, i.e., that the financial incentives or subsidies provided alleviate rural poverty in the areas with heavy ecological degradation (Grosjean & Kontoleon, 2009; Xu *et al*., 2004). This was officially announced by the State Council of China in 2005.

(b) *The adjustment of SLCP*

In 2007, before the compensation contract expired, the Chinese government adjusted the policy in two ways. As a result of the sharp reduction in the grain output, which had been falling continuously, reaching its lowest point (430.70 million tons) in 2003, the Chinese government became concerned about food security, while the significant growth in government subsidies led to financial pressure. Therefore, afforestation on converted sloping farmland under this program was suspended in 2007, although afforestation on barren mountains and wasteland under the SLCP program is still under way, while the planned afforestation areas have to be completed in the next few years. On the other hand, because a number or participants still had problems earning a living because of the unsuccessful or uncertain economic structural change after the first stage of the program, the government prolonged the contract in order to subsidize participating households for another 8 years, while basic farmland construction will be developed by government investment, which could also help rural households improve their long-term livelihoods, something which is in line with our livelihood diversification analysis above.

By the end of 2012, the total area of afforestation under the SLCP had reached 29.4 million hectares, of which 9.26 million hectares of sloping land had been converted to forest. In addition, the total investment amounted to 438.5 billion CNY including the grain subsidy, seed fund, maintenance fees, and various special funds, of which 326.2 billion was paid directly to households, thereby benefitting a total of 32 million households in 25 provinces. However, the government has reduced the pace of implementation and the conversion of farmland under the SLCP stands at 61.76% of the original plan (14.67 million hectares) due to concerns over domestic food security and financial pressure. Nevertheless, the program has made a significant contribution to ecological recovery and poverty alleviation.

3. CONCEPTUAL FRAMEWORK

By reviewing the theoretical and empirical literature on livelihood diversification, this section establishes a framework for clarifying the mechanisms behind rural households' livelihood diversification activities as shown in Figure 1 and presents our hypotheses.

(a) *The causal origins and determinants of diversification*

Households in some rural areas often have to cope with poverty and income variability. Diversification of income sources has been put forward as one of the strategies to minimize substantial income fluctuations and to ensure a certain level of income. Multiple motives prompt rural households to diversify their income-generating activities. According to Barrett, Reardon *et al*. (2001), there are two types of motivations, the first is related to "push factors" and the second is related to "pull factors".

With regard to "push factors", rural households tend to select a portfolio of activities which stabilizes their income, reduces the risk of seasonality, climatic uncertainty and natural disasters, diminishing factor returns, and liquidity constraints (Barrett, Reardon *et al*., 2001). Diversification which is driven by push factors is highly dependent on the household's access to productive assets such as land, labor, and livestock (Schwarze, 2004). On the other hand, push factor-induced diversification is greatly affected by the individual characteristics of the household (Abdulai & CroleRees, 2001). Hence, in this study, we introduce internal determinants of diversification, household endowments, and characteristic variables – the size of farmland and forest land, labor supply, age, and educational attainment of the household head – to investigate the relationship between the household's income diversification and its internal determinants. It appears that rural households with a higher education level are more likely to be involved in non-farm activities since non-farm employment often requires higher levels of education (Schwarze, 2004). Hence, we assume that households with a higher education are associated with greater non-farm employment opportunities and so tend to have more income sources to diversify. Following Woldenhanna and Oskam (2001), we expect a negative relationship between farmland size and income diversity. Because non-farm wage employment is considered to be a residual employment that absorbs the surplus family labor, the farm households' participation in non-farm wage employment is driven by the availability of surplus family labor, greater farm size, and greater farm and relatively less non-farm income sources, resulting in less income diversity.

Regarding "pull factors", motivation is comprised of the following aspects: realization of strategic complementarities between activities, such as crop and livestock integration, i.e., crop stalks being fed to animals, while animal manure can replace chemical fertilizer; specialization development in that individuals or households will exhibit diverse assets, activities, and income even if there is specialization due to comparative advantage at the level of the individual (Barrett & Reardon, 2000; Barrett, Reardon *et al*., 2001). Local engines of growth such as commercial agriculture or proximity to an urban area create opportunities for income diversification in production- and expenditure-linkage activities. In this study, we use 'distance to nearest county capital' and 'road condition' as proxies to capture the external impact of local engines of growth on income diversification. We anticipate that diversification is negatively associated with the distance to the nearest county capital, but is positively associated with road condition as the shorter the distance to the county capital, the greater the opportunities for diversification of income-generating activities, while better road conditions means easier access to the non-farm work market. On the other hand, living in remote areas leads to higher transaction costs associated with non-farm work (Abdulai & CroleRees, 2001), which results in less opportunities for livelihood diversification.

(b) *The SLCP effect on household diversification*

The above analysis addressed the internal and external determinants of rural households' income diversification. When the SLCP comes into effect, it affects rural income diversification via different patterns, which are related to "push factors".

As a result of the implementation of the SLCP, a reduction in cropland due to afforestation reduces the marginal returns of farm labor. In response to diminishing labor returns, the rural participants tend to switch the surplus labor to non- and off-farm income-earning activities in the presence of land constraints (Barrett, Reardon *et al*., 2001), which confirms the

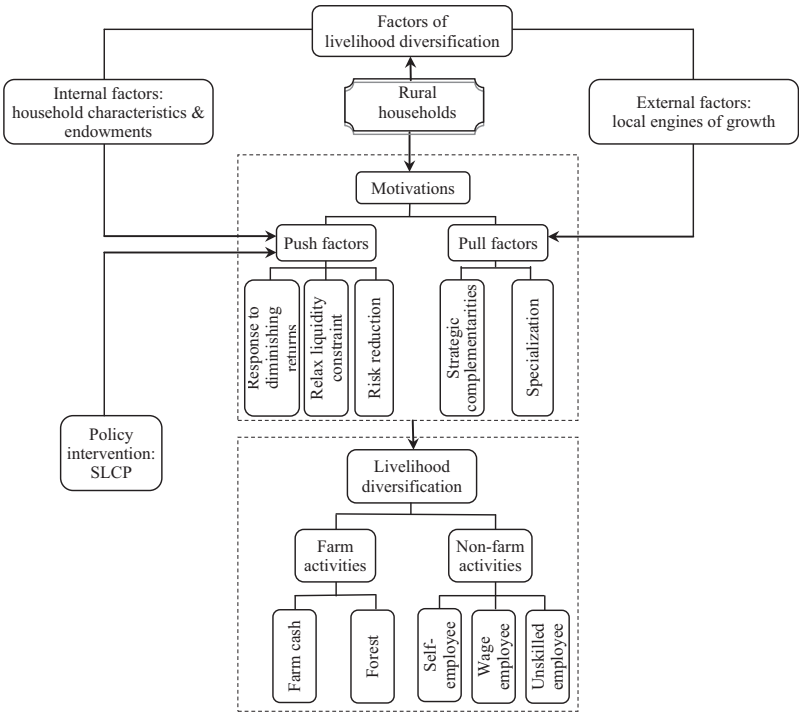

Figure 1. *Scheme for conceptual framework.*

argument in Kelly and Huo (2013) and Uchida *et al.* (2009) who state that enforcement of the SLCP leads to a labor reallocation effect.

On the other hand, households always encounter difficulties in overcoming binding entry barriers such as capital endowments, educational attainment, skill acquisition, and liquidity constraints when taking part in non-farm activities with higher returns, which may lift them out of poverty (Abdulai & CroleRees, 2001; Barrett, Reardon *et al.*, 2001; Woldenhanna & Oskam, 2001). One of the most important barriers is financial capital, which includes liquidity constraints and restricted access to credit. As a policy intervention, the SLCP aims to improve the asset holding of rural populations and is considered to be a strategy to overcome this barrier as it enables rural households to relax their liquidity constraints by endowing them with additional financial assets such as program subsidies (Kelly & Huo, 2013; Uchida *et al.*, 2009). Apart from this, farmers have been granted free seedlings for trees as well as free technical guidance after returning farmland to forests. The government also established some public employment service agencies to provide skill training to farmers, and guidance and help for those choosing to work and live in cities (Démurger & Wan, 2012; Weyerhaeuser, Wilkes, & Kahrl, 2005; Zuo, 2002). Thus, the SLCP, to some extent, overcomes the barrier caused by relatively low-quality rural human resources, and thus helps rural households diversify their on- and off-farm income-generating activities.

Both the labor reallocation effect and liquidity effect mentioned above are expected to be positively associated with rural income diversification as they shift surplus farm labor, and overcome the liquidity constraint to non- and off-farm activities respectively. As Kelly and Huo (2013) indicate, there is a possible income effect with the implementation of the SLCP. The income effect, where enrollment increases income, will decrease non- and off-farm working time, and thereby livelihood diversification, while when it decreases income, it will increase the working time in non- and off-farm activities, which is more likely to lead to livelihood diversification.

In addition to examining the relationship between livelihood diversification and its internal and external determinants, this study aims to test the hypothesis that the SLCP acts as an effective intervention regarding households' participation in non-farm activities and the diversification of their livelihoods.[3] Moreover, compared to their richer counterparts, poorer participant households are considered to have less resources and endowments and so are less associated with an effect on income diversification because they face wealth-differentiated barriers, while they have fewer opportunities to enter into non-farm activities (Abdulai & CroleRees, 2001; Barrett, Reardon *et al.*, 2001; Woldenhanna & Oskam, 2001). Therefore, we attempt to compare the policy effect across different income groups based on our further hypothesis that the livelihood diversification of poor households is more inclined to be targeted by the SLCP than the other groups.

4. DATA

(a) *Sampling and collection*

The analyses were based on data collected mainly from a rural household survey that was conducted by the SFA. The survey was designed in 2004 and implemented in the following five provinces (with erosion and desertification control and SLCP): Sichuan, Shaanxi, Guangxi, Hebei, and Jiangxi. Sichuan and Shaanxi provinces initiated the SLCP as a pilot program in 1999, while the program started in 2002 in the remaining provinces. As for the configuration of the sample (See Table 1), a stratified sampling technique was adopted (Yin *et al.*, 2014). In the survey, 14 counties, which are targeting areas for implementation of the SLCP and have similar geographic coverage, were selected from the above five provinces. Townships, villages, and households were randomly

Table 1. *Descriptive statistics of participation status*

Year	No. of new participants	No. of cumulative participants	No. of cumulative nonparticipants
1995	0	0	1226
1996	0	0	1226
1997	0	0	1226
1998	0	0	1226
1999	127	127	1099
2000	119	246	980
2001	42	288	938
2002	204	492	734
2003	187	679	547
2004	26	705	521
2005	31	736	490
2006	3	739	487
2007	42	781	445
2008	5	786	440
2009	0	786	440
2010	0	786	440

selected in each of the chosen counties. On average, three townships were randomly selected in each county, three villages were selected in each township, and 13 randomly sampled households were interviewed in each village. To ensure survey quality, pre-tests, group discussions, and enumerator training were carefully conducted. A total of 1,458 rural households entered the dataset with a follow-up survey being conducted once in the subsequent 10 years from 126 administrative villages and 42 townships in 14 counties. The last year for which the data were entered, checked, and made available was 2010 when the balanced number of household tracked reduced to 1,226 in 2010. [4]

A large amount of comprehensive, reliable, and accurate data are necessary and paramount for a successful assessment. Normally, this kind of data is not easily available, accessible, or of high quality in China. However, our data may be considered to be the sole existing panel data of top quality from a rural household survey. These surveys were sponsored by the Asian Development Bank and China's Ministry of Finance, which provided compelling support to finish the longitudinal and large scale data collection. Plus, the cooperation of local governments is also a necessary condition for interviewing farmers, as it is much easier to access relatively reliable information from farmers after officials' have mediated. The household is defined as the smallest decision-making unit which sets the strategy concerning the generation of income and the allocation of this income for consumption and reproduction (De Janvry, Fafchamps, & Sadoulet, 1991; Sadoulet & de Janvry, 1995). Information about peasant households is important for policy. Therefore, our survey contains detailed information regarding demographic and location characteristics, the economic activities, and program participation of households. This study mostly focuses on income source activities including various kinds of on-farm and off-farm income activities, which are described in detail in the next section.

In order to better understand the effect of the program, we asked interviewees to recall their livelihood information back to 1995, and then we conducted the same survey in each subsequent year. The only shortcoming of this data set is the question of veracity of the data in former years, as you cannot guarantee that farmers can recall their family situation in the first few years and few people keep detailed accounts. In order to minimize this recall bias in our data, we used local government statistics to help respondents recollect.

The number of annual household observations is 1,226 in our balanced sample. Once the State council had initiated the SLCP in 1999, more and more households enrolled for participation in the program each year. [5] Hence, we can observe that the number of cumulative participants increases annually, while the number of cumulative nonparticipants decreases as shown in Table 1. There has been a sharp decrease in the number of new participants since 2003, which may be attributed to the adjustment of the SLCP induced by the problem of food security (Liu & Wu, 2010). [6] However, we can still observe a few households joining the program until 2008, but no more new participants entered the program after this date.

(b) *Measures of rural livelihood diversification*

Regarding the measurements on rural income diversification, two approaches can be distinguished by the measurable dimensions they account for. One contains one-dimensional indexes and only counts the number of income-earning activities or evaluates changes in the volumes of different divisions, whereas the other is based on two or more dimensional measurements and considers both the number of earning activities and their share of total income.

An increasing level of diversification reflects variation in the number of activities and their share of total income. In China, to generate additional income sources, rural households with low income are usually involved in multiple income-earning activities. Hence, the diversification measurement for poor rural households should stress the number of income sources, while the income share does not seem to be an important component since rural poor households are incapable of selecting job opportunities [7] (Zhao & Barry, 2013). However, this is not the case for rich households, who are able to undertake more lucrative jobs and allocate their household labor to multiple income-earning activities to diversify business risk, and so the share of income sources should be given greater weight when measuring income diversification. Thus, a one-dimensional income diversification index fails to provide an accurate reflection of improvement in households' income. To integrate diversification measures for different types of rural households, Zhao and Barry (2013) empirically compared various dimensional diversification indices and found that a two-dimensional diversification measurement was a better fit for the income diversification situation in rural China, which is also confirmed by Chang (1997) and Ellis (2000). Therefore, we decided to use the two-dimensional diversification measurement known as the inversed Herfindahl–Hirschman Index:

$$\mathrm{HDI} = \left[\sum_{h=1}^{n} \mathrm{IP}_h^2\right]^{-1}$$

where HDI is the household income diversity index, IP_h is the proportion of income activity h to total income and n is the number of income activities for a specific household. According to the characteristics of rural China, here we develop the income category based on the rural household income categories (Adams & He, 1995; Brundtland, 1987; Ellis, 2000), which include forest income, farm income, which consists of both farm cash and subsistence (grain, meat and others) and nonfarm income, which is subdivided into unskilled employee income, including labor payment during the harvest, the construction of agricultural infrastructure (building reservoirs, repairing roads, and constructing ditches), wage employment, which includes relatively fixed and stable long-term employment (usually in the service industry, city construction, and manufacture), which requires good health, special skills or

Table 2. *Descriptive statistics of income diversity index and per capita income for participants and nonparticipants*

Year	Total participants				Total nonparticipants				National average
	(1) Per capita income (CNY)		(2) Income diversity		(3) Per capita income (CNY)		(4) Income diversity		(5) Per capita income (CNY)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean
1995	1247.78	1014.91	1.50	0.47	1293.09	821.93	1.51	0.48	1342.76
1996	1184.99	1027.87	1.51	0.47	1242.09	769.09	1.50	0.48	1519.19
1997	1195.58	926.55	1.53	0.47	1280.89	818.95	1.52	0.49	1608.39
1998	1274.21	1053.19	1.55	0.48	1343.23	824.74	1.54	0.50	1680.48
1999	1397.97	1049.72	1.62	0.48	1430.65	886.99	1.56	0.49	1744.23
2000	1523.06	1140.93	1.65	0.48	1535.24	936.76	1.61	0.52	1780.01
2001	1667.52	1238.43	1.70	0.49	1664.82	1050.42	1.63	0.51	1854.42
2002	1843.21	1282.66	1.75	0.48	1817.92	1207.29	1.64	0.50	1947.81
2003	1931.50	1387.42	1.78	0.49	1921.51	1228.64	1.67	0.52	2030.67
2004	2048.03	1451.06	1.80	0.47	2045.44	1327.32	1.70	0.52	2169.80
2005	2053.18	1260.54	1.93	0.51	2063.51	1079.60	1.83	0.56	2353.40
2006	2235.36	1321.19	1.95	0.54	2325.61	1221.08	1.83	0.56	2555.20
2007	2669.00	2042.45	1.92	0.60	2591.72	1771.75	1.82	0.60	2798.24
2008	2768.47	2250.99	1.88	0.66	2850.98	2203.34	1.69	0.53	3021.07
2009	2895.29	2930.27	1.78	0.56	2560.03	2371.61	1.66	0.50	3280.03
2010	3171.47	2882.55	1.78	0.54	2990.45	3028.76	1.65	0.51	3636.57

a. "SD" is short for standard deviation.
b. The participant group constitutes the households who were involved in the program no matter when they participated; while the non-participant group constitutes the households which did not participate in the program.
c. Values of income are in real terms which have been corrected for inflation by using rural CPI for which the base year is 1994.
d. The fifth column presents Rural Households' average per capita income values at the national level which are from China Statistical Yearbooks, which have also been corrected for inflation by using rural CPI.

Table 3. *Share of income sources for participants and non-participants (%)*

Year	Forest income		Farm income		Self-employed income		Unskilled employee income		Wage employee income	
	Par	Non	Par	Non	Par	Non	Par	Non	Par	Non
1995	8.16	11.38	75.11	70.98	2.38	2.86	7.29	6.15	7.05	8.63
1996	8.19	11.12	74.44	71.19	2.40	2.77	7.55	6.01	7.43	8.90
1997	8.41	10.94	73.19	69.87	2.52	2.74	7.85	6.19	8.04	10.26
1998	8.53	10.90	72.02	68.71	2.64	2.89	8.39	7.04	8.42	10.45
1999	8.57	10.74	64.87	67.14	2.85	2.93	14.49	7.21	9.22	11.98
2000	9.23	11.00	63.11	64.67	2.94	3.33	14.49	7.28	10.24	13.73
2001	9.08	10.24	59.12	62.54	3.56	3.35	17.25	7.73	10.99	16.14
2002	10.26	10.25	57.76	60.91	3.94	3.83	16.71	8.09	11.33	16.91
2003	10.43	10.61	56.35	59.76	4.16	3.90	17.53	8.56	11.52	17.17
2004	11.13	10.41	54.51	57.91	4.58	3.86	17.77	9.45	12.00	18.37
2005	13.33	11.19	47.13	47.75	4.72	5.44	17.95	12.50	16.87	23.12
2006	13.36	10.78	45.98	47.58	4.80	5.28	18.52	13.52	17.34	22.82
2007	11.91	10.15	44.97	45.14	7.89	8.99	16.70	14.09	18.53	21.63
2008	12.20	7.65	42.26	46.43	8.00	8.44	17.40	14.57	20.14	22.90
2009	11.87	8.03	36.83	43.42	11.27	12.75	17.36	16.01	22.67	19.78
2010	11.56	8.90	36.38	42.03	11.86	13.21	17.26	15.64	22.94	20.22

a. "Par" is short for participant group and "Non" is short for non-participant group.
b. The participant group comprises the households which were involved in the program regardless of when they participated, while the non-participant group comprises the households who did not participate in the program.

high education and self-employment where rural people do some non-farm business locally. Generally, the above category covers almost all the income activities of rural households in China. The maximum number of n in our study is 5, encompassing farm and non-farm activities as shown in Table 3. The index ranges from a minimum of 1 for a household that derives all its income from a single activity, to a maximum of 5 for a household that receives its income evenly across five farm and non-farm activities.[8]

The use of a total income diversification index instead of a non-farm diversification index as in Barrett, Reardon *et al.* (2001) and Escobal (2001) is based on the following considerations. Firstly, diversification into non-farm activities reflects a greater diversity of income sources, but this is not always the case. For instance, if a household raises its share of income from non-farm resources from 10% to 50%, this implies diversification into non-farm activities, but not income diversification in terms of the number of diversification activities and

the balance of income sources. In addition, Minot, Epprecht, Anh, and Trung (2006) reviewed a branch of literature which examined the relationship between non-farm income and its share of total rural income, and highlighted the conflicting evidence regarding whether rich or poor rural households earn a higher share of their income from non-farm activities. This may be inadequate to support our underlying fundamental hypothesis, which supposes a positive relationship between income and its diversification. Furthermore, concerning the situation in China, as quite a number of rural households only focused on farm activities before the implementation of SLCP, the application of a non-farm diversification index is likely to generate a large number of missing observations when calculating the diversification index.

Table 2 presents the descriptive statistics in terms of average per capita income and the income diversity index for both participants and non-participants from 1995 to 2010. Figure 2 based on Table 2 illustrates the evolution of average per capita income and the income diversity index for the period 1995–2010. As shown in Figure 2, the average per capita income exhibits a gradually increasing trend for both participants and non-participants, which increased from 1,247 and 1,293 in 1995 to 3,171 and 2,990 in 2010, respectively. There is no significant difference between the average per capita income of the two groups before implementation of the SLCP until it declined sharply for participants in 1999 (the year when the SLCP was initiated). This may be attributed to the loss in converted sloping lands that had previously been used for farming. Although it was initially planned that households would be provided with a certain level of subsidies for participating in the SLCP, the allocation of the funds was often delayed and sometimes the payments were insufficient (Uchida, Xu, Xue, & Rozelle, 2007; Xu *et al.*, 2004), so the subsidies in the early stages of the SLCP could not make up for the loss of converting sloping land to forest. The average income gap between participants and non-participants continued to decrease until 2009, when the average income of participants began to exceed that of nonparticipants.

With regard to income diversification, there was no difference between participants and non-participants before the implementation of the SLCP in terms of absolute value of diversity index. After a steady increase throughout 1999 and 2006, both of them reached their highest point in 2006 after which they dropped slightly until 2009 and then remained stable. Though the income diversity index appeared to exhibit a similar trend for both participants and non-participants, the absolute value of participants' diversity index was consistently higher than that of nonparticipants after the implementation of the SLCP.

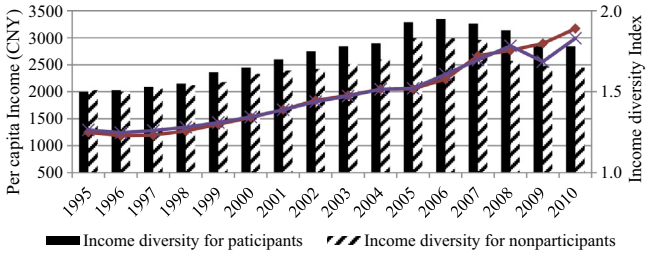

Figure 2. *Average per capita income vs. average income diversity for participants and non-participants (1995–2010).*

Table 3 provides more details about the changes in income sources of households during the periods. Figures 3 and 4, which are based on Table 3, facilitate the comparison between participants and nonparticipants. We can see that, for both participants and nonparticipants, the share of farm income displayed a downward trend from 1995 to 2010 indicated by farm cash, whereas the share of non-farm income showed a general upward trend. In detail, the share of forest income showed an increasing trend from 1995 to 2000 and fluctuated afterward for participants, while it stagnated for nonparticipants during the period. Turning to average wage income share, this increased from 7% and 8% in 1995 to 23% and 20% in 2010 for participants and nonparticipants respectively, with the absolute value being higher for participants than nonparticipants. The absolute value in terms of the share of unskilled employment is also higher for participants than non-participants. Regarding the share of income from self-employment for participants and nonparticipants, there is not a large difference in the change in average shares between two groups.

The descriptive statistics of the main variables used in our empirical analysis are presented in Table 4. To see the difference between participants and nonparticipants, we divide our sample observations into two groups: participants and non-participants. As shown in Table 4, the average values for most characteristics do not show a significant difference between households who participated in the SLCP and those who did not, indicating that the participants and non-participants are theoretically comparable. For example, households in two groups have similar characteristics in terms of age, education level of the head of the household, the condition of roads, labor force, and distance to the nearest county capital. However, we can still see some differences between the two groups of participants which may be caused by the implementation of the SLCP. For instance, non-participants have more farmland (5.8 mu) compared to participants (5.3 mu), while participant households have more forestland than non-participants, both of which may be attributable to participation in the SLCP which aimed to convert sloping farmland to forest.

5. ECONOMETRIC SPECIFICATION

Since the 1990s, econometricians have been paying treatment effect analysis more attention (Abadie, 2002; Hahn, 1998; Lee, 2000). The approach of treatment effect analysis

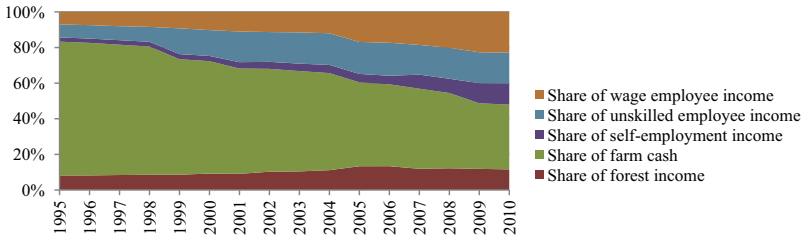

Figure 3. *Share of income sources for participants.*

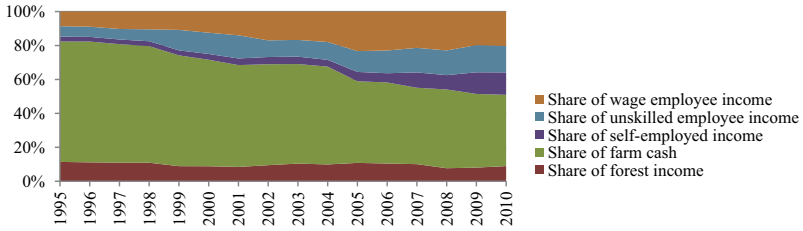

Figure 4. *Share of income sources for non-participants.*

Table 4. *Descriptive statistics of the variables*

Variables	Description	Participant		Nonparticipant	
		Mean	SD	Mean	SD
Age	Age of household head in years	45.08	11.61	45.73	11.64
Education	Number of years of schooling for household head	6.50	2.89	6.43	2.88
Road	Type of road to the household (0 = soft surface, 1 = hard surface)	0.41	0.49	0.43	0.50
Cadre	Do any household members work for the government? (0 = no, 1 = yes)	0.09	0.29	0.10	0.30
Farmland	Amount of household farmland (mu = 0.067 hectare)	5.32	4.99	5.83	6.66*
Forestland	Amount of forest land owned by the household (mu = 0.067 hectare)	1.09	2.12	0.96	2.06*
Labor	Number of workers in each household	2.91	1.29	3.11	1.42
Distance	Distance to the nearest county capital (per 100 km)	0.43	0.26	0.44	0.27
No. of observations		12576		7040	

* Indicates a significant difference between the average value for participant and nonparticipant households at the 0.05 level.

is to compare two groups, one of which has received a treatment, while the other has not, which are called the treated and control group respectively. One of the most popular treatment effect analysis methods is difference in differences (DID) (Lee, 2005), which involves comparing the before–after change of the treated group with the before–after change of the control group.

(a) *The empirical models*

We apply the DID approach to measure the impact of the SLCP on rural households' income diversification. The basic empirical regression specification is:

$$Y_{it} = \alpha + \beta D_{it} + \theta T_t + \delta_i T_t D_{it} + \gamma \mathrm{X}_{it} + \varepsilon_{it} \quad (1)$$

where subscripts i and t represent household i and time period t, respectively, Y represents households' outcome which is livelihood diversity in our context. T is the time dummy, which is equal to 1 for all years when the outcome Y is observed after program implementation and equal to 0 otherwise. D is the dummy for being treated, which equals 1 if the household participated in the program. T^*D is the interaction term. The coefficient β is the counterfactual difference in livelihood diversity between the treatment group and control group, while θ represents the common time trend of this and δ captures the treatment effects. X is a vector including a variety of household and village characteristic variables that may be correlated with the livelihood diversity and γ is a vector of coefficients on X.

Considering the fact that households received the treatment in different years during the expansion process of the SLCP (see Table 1), our estimating equation originating from Eqn. (1) can be described by:

$$\begin{aligned} Y_{it} = \alpha + \sum_{t=1999}^{2010} \beta_t T_t + \sum_{t=1999}^{2010} \delta_t T_t * D_{it} + \gamma_1 \mathrm{age}_{it} + \gamma_2 \mathrm{edu}_{it} \\ + \gamma_3 \mathrm{road}_{it} + \gamma_4 \mathrm{cadre}_{it} + \gamma_5 \mathrm{farmland}_{it} \\ + \gamma_6 \mathrm{forestland}_{it} + \gamma_7 \mathrm{labor}_{it} + \gamma_8 \mathrm{distance}_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

Let $D_{it} = 1$ indicate all households which participated in the SLCP in a specific year t, and $D_t = 0$ otherwise, and $T_t = 1$ means the observations are observed in year t. T_t is the time dummy, which is equal to 1 if the outcome Y is observed in year t and equal to 0 otherwise. β_t indicates the different year time effect of the program, and δ_t is the main parameter of interest as it is the treatment effect from the different treatment groups. The control variables for household and village characteristics (X_{it}) include age, education, labor, leadership, road condition, distance to county capital, household farmland, and forestland size.

(b) *Unbiased identification*

In order to achieve consistent estimation of the impacts of the SLCP, the identification condition (same time-effect condition) of the DID estimate in the above setting has to hold as follows:

$$E(Y_{1t} - Y_{1t-1} | D = 0) = E(Y_{0t} - Y_{0t-1} | D = 0) \quad (3)$$

In other words, the change in outcomes between the treatment and control groups would have been identical in the absence of the intervention. In our case, the same time-effect condition is that the other changes will have an equal influence on the participant group and nonparticipant group in the absence of the SLCP. However, in reality, the same time-effect condition as Eqn. (3) is impossible to test as the counterfactual cannot be observed.

Nonetheless, we can test whether the average outcome pre-treatment trends were similar between the proposed treatment and comparison groups instead (Gertler, Patrinos, & Codina, 2007). If the pre-treatment trends (at $t' < t$) were not significantly different between the treatment and comparison households, there is reason to believe that changes would have been similar in the post-intervention periods (t) when the treatment was not in place. Then, the identifying assumption can be rewritten:

$$E(Y_{1t'} - Y_{1t-1'} | D = 0) = E(Y_{0t'} - Y_{0t-1'} | D = 0) \quad (4)$$

We can test the validity of the identification or same time-effect condition in our data by running the following equation for all pre-intervention years:

$$Y_{it} = \alpha + \sum_{t=1996}^{1999} \beta_t T_t + \sum_{t=1996}^{1999} \delta_t T_t * \mathrm{PD}_{it} + \mathrm{u}_{it} \quad (5)$$

where PD_{it} is a dichotomous variable which equals 1 if the household participated in the program after 1999. T is a year dummy variable for all pre-intervention years. In this test, we chose the period 1995–98 as the pre-intervention period because the SLCP started in 1999. Then we have 3 year dummy variables T_{1996}, T_{1997}, T_{1998} and three interaction terms with year dummy, while year 1995 works as the baseline year. If the δ_t is not significantly different from zero, then the pre-intervention trends for households that will eventually participate in the SLCP are not significantly different from those in the comparison group at each time.

Table 5 above reports results for averaged livelihood diversification index in the pre-intervention period.[9] Regressions assess the equality in all aspects other than their treatment status in each pre-intervention year across heterogeneous subjects. The results present no significant differences in the pre-intervention period. This indicates that the livelihood diversification in comparison groups and in treatment groups followed rather similar patterns during the pre-intervention years. Therefore, our same time-effect condition holds in our case.

(c) *Self-selection of participation*

To obtain consistent estimators of the effect of the SLCP with our regression models, it is necessary to assume that there is no selection bias. Otherwise, the participation of the household becomes endogenous, which is likely to cause biased estimates. Participation in the SLCP is commonly believed to be "quasi-voluntary", with households being "strongly encouraged" by local governments to participate.

In practice, if households' land plots are included in the planned project areas, they were willing to participate since the compensation in most cases exceeded foregone income from cultivation (Liu *et al*., 2010; Uchida *et al*., 2009). On the other hand, if households' plots were excluded in the planned project areas, they were not eligible to be participants. The study by (Xu *et al*., 2004) finds that only 15% of the participating households in the sample were consulted before program implementation. Therefore, there is less potential for self-selection, and the related previous research (Kelly & Huo, 2013; Liu & Wu, 2010; Uchida *et al*., 2007) about the SLCP is based on the assumption that enrollment is mandatory or exogenous from the perspective of the household.[10] Considering the different degrees of households' resistance toward participating in the SLCP, it is quite possible that some local governments tend to choose households that are more likely to participate in the program according to their accumulated experience on distinguishing the characteristics of participant and non-participants. Therefore, due to the data limitation, we cannot rule out the possibility that in some rural areas, the local government is inclined to lobby for participation in the SLCP.

6. RESULTS AND DISCUSSION

As we use household level panel data in our empirical analysis, we need to pay attention to the dynamic panel data characteristics of our dataset. We carry out both fixed effects and random effects regressions for the full sample and low-, medium-, and high-income groups.

(a) *Full sample*

The regression results of the average effects on the full sample are presented in Table 6, which focuses on the aggregative treatment effects in the different treatment years. The results of Hausman tests on full sample regression suggest that fixed effects estimates are consistent as the χ^2 values are 46.97 for the above estimation at the 10% significance level. Therefore, we place great emphasis on the fixed effect results in the case of full sample analysis.

Table 5. *Difference in pre-intervention trends of the livelihood diversity between treatment and comparison groups*

Variables	Observations from full sample				Observations from provinces initiating SLCP in 2002			
	Fixed effect		Random effect		Fixed effect		Random effect	
	COEF	SE	COEF	SE	COEF	SE	COEF	SE
T_{1996}	−0.002	0.009	−0.001	0.009				
T_{1997}	0.015	0.009	0.015	0.009				
T_{1998}	0.036***	0.009	0.037***	0.009				
T_{1999}					0.080***	0.023	0.081***	0.023
T_{2000}					0.133***	0.023	0.133***	0.023
T_{2001}					0.171***	0.023	0.172***	0.023
$\mathrm{PD}^*_{1996}T_{1996}$	0.015	0.012	0.015	0.012				
$\mathrm{PD}^*_{1997}T_{1997}$	0.016	0.012	0.015	0.012				
$\mathrm{PD}^*_{1998}T_{1998}$	0.016	0.012	0.015	0.012				
$\mathrm{PD}^*_{1999}T_{1999}$					0.033	0.030	0.032	0.029
$\mathrm{PD}^*_{2000}T_{2000}$					0.007	0.030	0.006	0.029
$\mathrm{PD}^*_{2001}T_{2001}$					−0.012	0.030	−0.013	0.029
R^2	0.082		0.081		0.064		0.064	
N	4904				3248			

a. *Significant at 10%; **Significant at 5%; ***Significant at 1%.
b. "COEF" is short for coefficient; "SE" is short for standard error.
c. Before 1999, the tested observations include participants and non-participants from full sample; after that, the observations are from provinces that initiated the SLCP in 2002.

Table 6. *Estimation results of average treatment effects on livelihood diversification of the full sample*

Variables	COEF	SE
Age	0.015***	0.003
Education	0.0001	0.004
Road	0.054*	0.029
Cadre	−0.043	0.061
Farmland	−0.001	0.002
Forestland	0.025***	0.006
Labor	0.004	0.008
Distance	−0.120*	0.069
T_{1999}	0.035***	0.008
T_{2000}	0.063***	0.011
T_{2001}	0.074***	0.014
T_{2002}	0.074***	0.017
T_{2003}	0.072**	0.020
T_{2004}	0.078**	0.023
T_{2005}	0.184***	0.032
T_{2006}	0.172***	0.034
T_{2007}	0.145**	0.040
T_{2008}	−0.003	0.041
T_{2009}	−0.048	0.043
T_{2010}	−0.075	0.044
$T_{1999}D_{1999}$	−0.038	0.031
$T_{2000}D_{2000}$	−0.042	0.025
$T_{2001}D_{2001}$	0.012	0.024
$T_{2002}D_{2002}$	0.048**	0.021
$T_{2003}D_{2003}$	0.068***	0.022
$T_{2004}D_{2004}$	0.062***	0.023
$T_{2005}D_{2005}$	0.067**	0.033
$T_{2006}D_{2006}$	0.082**	0.035
$T_{2007}D_{2007}$	0.064	0.042
$T_{2008}D_{2008}$	0.147***	0.042
$T_{2009}D_{2009}$	0.071*	0.040
$T_{2010}D_{2010}$	0.080**	0.040
R-squared	0.110	
Hausman (FE *vs.* RE)	46.97	{0.043}
F-statistic	5.63	{0.000}
N	19616	19616

a. *Significant at 10%; **Significant at 5%; ***Significant at 1%.
b. The regression includes a constant (not reported), four pre-treatment years (1995–98) are treated as base year; all regressions allow for clustering by county.
c. *p*-Values of Hausman tests are shown in brackets. According to Hausman tests, the estimation results of full sample analysis are based on a fixed effect model.
d. *F*-statistic is the test statistic on the *F*-test of the joint significance of the treatment–year interactions, with *p*-value in brackets.
e. Clustered standard error at the county level reported.

The coefficients of the interaction terms in the first 3 years do not show any significant difference between participants and nonparticipants, although they become significantly positive with diversification for the remainder of the treatment years. These results are consistent with some previous findings, where the SLCP was not successful in shifting labor to off-farm sectors during its first few years of implementation (Uchida *et al.*, 2007; Xu *et al.*, 2004), but participation in off-farm activities increased more for participants than non-participants after the first 5 years of the program (Uchida *et al.*, 2009). This result, to some extent, may be due to the fact that it takes some time for participants to adopt their livelihood strategy after policy intervention and also the actual compensation received by households sometimes falls short of the compensation standards for some reason (one is logistic delay in that the local government responsible for program supervision may not have sufficient manpower to check whether the converted land satisfies government-stipulated requirements, while another may be that local governments keep some compensation to make up for expenditure on plant seedlings, tax arrears or other costs) (Xu, Tao, Xu, & Bennett, 2010). From 2002, the results reveal that participants' livelihood diversification level increased more than non-participants and the differences are statistically significant for the remainder of the treatment years. One explanation for this is that participation in the program relaxes a household's liquidity constraint so that it becomes much easier for participants to shift their surplus labor force from farming to non-farming activities with the financial support of the program, while non-participants in the same condition may have more liquidity constraints (Groom, Grosjean, Kontoleon, Swanson, & Zhang, 2010; Uchida *et al.*, 2009). In particular, the difference increased rapidly from 2002 to 2006 when most participant households joined the program, while the effect of the SLCP on livelihood diversification strengthened with the participation of more rural households. This is followed by a slowdown in the diversification trend of participants in the following year when the first contract was due to expire, which may be attributed to the uncertainty regarding the longevity of the program.[11] In addition, the study by (Cao, Xu, Chen, & Wang, 2009) found that a large proportion (37.2%) planned to return to cultivating on sloping land once the contract had expired, which highlights the importance of program longevity for the decision making of rural households. In 2008, the diversification level of participants rose sharply after the new policy about renewable subsidies was announced in 2007 and then continues to be higher than the diversification level of nonparticipants for the last 2 years.

The estimation results from the time dummy indicate that livelihood diversification increased from 1999 to 2007 for both participants and nonparticipants. This increase over time in livelihood diversification may be ascribed to the improved income-earning opportunities in urban areas. For instance, the rapid development of the construction industry in the urban area creates lots of job opportunities for the rural labor force. In addition, both participants and nonparticipants have a strong motivation to diversify their livelihoods (Uchida *et al.*, 2009) due to diminishing returns to labor or land, market failure and coping with risk (Barrett, Reardon *et al.*, 2001). Most coefficients of time trends are significantly positive regarding the diversification level, while the last 3 years witness a negative effect which is not statistically significantly different from zero. This decline or stagnation may be caused by the rapid increase in grain prices in China in this period,[12] while the introduction of the comprehensive agricultural subsidies in 2006 encouraged agricultural production, which to some extent would decrease livelihood diversification by reducing participation in non- and off-farm employment.

The results reveal that households with older heads are more likely to diversify their income sources than those with a younger head. This confirms the argument in (Abdulai & CroleRees, 2001) that older decision makers in the households tend to have broader experience and so have more sources to diversify their livelihood.

With regard to the level of education of the household head (Education), the coefficient is insignificant, which is consistent with the finding of (Woldenhanna & Oskam, 2001). The insignificant relationship between education and rural income diversification may be attributable to the multiple job vacancies with respect to different education levels for rural migrant workers. Hence, rural migrant workers can obtain jobs regardless of whether they are well educated or not.

The coefficient of total household workforce (labor) shows that the labor force has a significantly positive effect on rural income diversification. This result is consistent with the theory. According to Abdulai and CroleRees (2001), participation in non-farm activities is driven by the availability of surplus household labor. The greater the household labor force, the greater the surplus labor available to take up a variety of non-farm activities.

The results in Table 6 show that forestland size is significantly positive, suggesting that households with more forestland are provided with additional and stable income from forest resources and forest-related activities and so are more likely to have a greater income diversity index. Regarding the extent of the household's farmland (farmland), the results show that rural income diversification is significantly and negatively associated with the extent of the household's farmland. A similar finding was reported in Corral and Reardon (2001), who argue that the greater the extent of farmland, the greater the opportunity costs of participation in non-farm activities. Thus, households with more farmland are less likely to become involved in non-farm employment, leading to a lower income diversification index.

The results with cluster standard error show an insignificant relationship between cadre status and rural income diversification. The insignificant result may reflect the fact that cadres do not have an advantage over ordinary migrant rural workers when acquiring information about off-farm work opportunities, though they are supposed to have stronger social networks.

The development of infrastructure plays an important role in encouraging diversification. This is reflected in the positive and significant coefficient of road condition. The diversity index of households with an asphalt surface road is 0.046 higher than households with other hard surface roads. A better road network actually induces diversification in farm and non-farm income sources as it implies lower transport costs and the quick and easy disposal of commodities. The coefficient for distance to the nearest county capital (Distance) is significant with an expected negative sign. The state of the roads used to travel to work may therefore be an important factor governing the decision to work off-farm. The result indicates that the closer a household is to the nearest county center, the higher its income diversification index.

(b) *Low-, medium-, and high-income groups*

To gauge the relationship between the affluence of a household and its income diversification, we divide the sample observations into three sub-groups according to the households' average monetary income in the 4 years prior to program implementation.[13] They are low-income group, medium-income group, and high-income group. The income is defined as disposable cash income, which includes annual income from off-farm employment and on-farm production, but excludes the consumption of own produce and irregular receipts such as government transfer payments or personal remittance. In the case of low-, medium-, and high-income groups, the Hausman test results indicate that random effects regression is efficient in the low-income and medium-income groups, while the high-income group prefers consistent estimation from fixed effects model.

Table 7 reports the results in the case of low-, medium-, and high-income groups.[14]. The results of the interaction term in three regressions indicate that implementation of the SLCP has heterogeneous effects on livelihood diversification across the various income groups. The average treatment effects for the three groups are positive in most scenarios, although most of the significant cases are from the regression results for the low-income group. This suggests that the positive and significant treatment effect for the full sample is mainly ascribed to the low-income group. The results from the sub-samples reveal that households with lower income are more likely to be affected by the program than the others. This is in line with the findings of (Uchida *et al*., 2009) who showed that the subsidies for setting aside cultivated land are more important to relax the liquidity constraints for the households with less liquid assets prior to the program than the other groups (Uchida *et al*., 2009). Thus, the more constrained the household, the larger the effect of the program on off-farm participation and diversification levels. Furthermore, this result complies with poverty reduction quite well, which is another aim of the program. In addition, the insignificant treatment effects on high-income households indicate that the constraints on participation in non-farm activities are not only due to liquidity, but also physical and human capital or even the external economic environment and system. In the first few years, the treatment effect on the livelihood diversification of low-income households is also insignificant. A possible explanation for this may be that the compensation is delayed or insufficient, which makes it much more difficult for the low-income group to develop or explore other income activities in the initial phase. In contrast, the coefficients of the treatment effect for medium- and high-income groups are significantly correlated with the livelihood diversification at the beginning of the period. This result may be explained by the fact that it is easier for relatively rich participant households to access other resources to diversify their income sources, which can be immediately promoted by extra subsidies.

In terms of forestland size (forestland) and household working days (labor), the results are consistent with those of our full sample analysis for the three income groups. Besides, it is also interesting to see that the coefficients of the other characteristic variables differ across the different income groups in terms of the signs and the magnitudes.

With regard to education levels (Education), the estimated result shows the significantly negative coefficient for the poor-income group and the significantly positive coefficient for the high-income group, although the model of the medium-income group shows an insignificant coefficient. The negative relationship between education level and income diversification for the low-income group may be explained by the poor farmers' trade-off between taking an education and participating in farm and non-farm activities at schooling age. To raise their incomes, poor farmers are keen to obtain off- and non-farm job opportunities so their income diversification is likely to be obtained by taking factory or manual jobs which are associated with a low level of education. However, a higher level of education encourages farmers from the high-income group to seek non-farm employment thereby diversifying their livelihoods.

The coefficients regarding road condition (Road) show that road condition has an insignificant effect on the income diversification for medium- and high-income groups, but a significantly positive effect for the low-income group. This result reflects the fact that low-income farmers' livelihood diversification activities are more reliant on rural infrastructure compared with their counterparts. The results imply that policy makers should make greater investments to improve rural infrastructure in order to encourage rural income diversification.

Turning to the variable of distance to nearest county capital (Distance), which is another proxy for accessibility to the non-farm labor market, the coefficient associated with the high-

Table 7. *Estimation results of average treatment effects on livelihood diversification with respect to different income groups*

Variables	(1) Low-income group		(2) Medium-income group		(3) High-income group	
	COEF	SE	COEF	SE	COEF	SE
Age	−0.002	0.001	0.002	0.001	0.013***	0.004
Education	−0.010**	0.004	0.001	0.004	0.012*	0.007
Road	0.069***	0.024	0.021	0.022	−0.020	0.041
Cadre	0.013	0.049	−0.140**	0.058	0.020	0.062
Farmland	0.002*	0.001	−0.002*	0.001	−0.002	0.003
Forestland	0.010**	0.005	0.026***	0.007	0.030***	0.006
Labor	0.017***	0.005	0.019***	0.006	0.009	0.013
Distance	0.046	0.086	0.011	0.050	−0.393*	0.215
T_{1999}	0.100***	0.019	0.066**	0.019	0.001	0.013
T_{2000}	0.161***	0.022	0.100***	0.021	0.017	0.017
T_{2001}	0.204***	0.023	0.124***	0.021	0.013	0.022
T_{2002}	0.246***	0.027	0.156***	0.025	−0.022	0.027
T_{2003}	0.273***	0.033	0.162***	0.029	−0.028	0.032
T_{2004}	0.291***	0.032	0.170***	0.029	−0.006	0.038
T_{2005}	0.564***	0.044	0.290***	0.036	−0.022	0.053
T_{2006}	0.582***	0.045	0.295***	0.038	−0.045	0.059
T_{2007}	0.560***	0.055	0.268***	0.049	−0.048	0.070
T_{2008}	0.432***	0.048	0.158***	0.046	−0.208***	0.071
T_{2009}	0.395***	0.048	0.067	0.042	−0.191**	0.076
T_{2010}	0.387***	0.050	0.066	0.045	−0.224*	0.079
$T_{1999}D_{1999}$	0.004	0.045	0.039	0.060	0.071	0.071
$T_{2000}D_{2000}$	−0.021	0.034	0.024	0.041	−0.005	0.041
$T_{2001}D_{2001}$	0.041	0.038	0.100**	0.041	−0.017	0.047
$T_{2002}D_{2002}$	0.060*	0.035	0.033	0.035	0.128***	0.036
$T_{2003}D_{2003}$	0.090**	0.040	0.062*	0.036	0.090**	0.031
$T_{2004}D_{2004}$	0.114***	0.039	0.071**	0.035	0.041	0.034
$T_{2005}D_{2005}$	0.107**	0.051	0.069	0.044	0.017	0.053
$T_{2006}D_{2006}$	0.109**	0.052	0.103**	0.047	0.022	0.054
$T_{2007}D_{2007}$	0.070	0.064	0.079	0.059	0.024	0.073
$T_{2008}D_{2008}$	0.259***	0.062	0.081	0.057	0.063	0.068
$T_{2009}D_{2009}$	0.103**	0.055	0.087*	0.052	0.012	0.069
$T_{2010}D_{2010}$	0.122*	0.056	0.067	0.053	0.049	0.067
R-squared	0.270		0.111		0.039	
Hausman (FE *vs.* RE)	40.98	{0.108}	32.43	{0.396}	38.49	{0.024}
F-statistic					1.31	{0.207}
Chi^2-statistic	54.53	{0.000}	20.82	{0.053}		
N	6544		6544		6528	

a. *Significant at 10%; **Significant at 5%; ***Significant at 1%.
b. All regressions include a constant (not reported), four pre-treatment years (1995–98) are treated as base year; all regressions allow for clustering by county.
c. *p*-Values of Hausman tests are shown in brackets. According to the Hausman tests, the estimation results for the Low- and medium-income groups are based on a random effect model and the results for the high-income group are based on a fixed effect model.
d. *F*-statistic is the test statistic on the *F*-test of the joint significance of the treatment–year interactions for fixed effect estimations, with *p*-value in brackets; Chi^2-statistic is the test statistic on the *F*-test of the joint significance of the treatment–year interactions for random effect estimations, with *p*-value in brackets.
e. Clustered standard error at the county level reported.

income group is significantly negative. However, the coefficients are found to be insignificant for the low- and medium-income groups. One possible explanation for the insignificant coefficients is the existence of entry barriers to participating in non-farm activities for relatively poor households. Barrett, Bezuneh, and Aboud (2001) suggest that poorer households do not have the resources to overcome the skill and capital entry barriers that prevent them from engaging in non-farm activities even though they live close to the labor market.

The results consistently show that income diversification is significantly and negatively associated with farmland size for the medium- and high-income group. However, the results of the regression analysis show an insignificant coefficient for the low-income group, which confirms the argument that the income diversification decisions of poor farmers are driven by household endowments rather than household characteristics.

The estimation results from the time dummies indicate that the low-income group experiences a greater increase in terms of diversification than the other two groups in the period. Also, the regression result from the medium-income group shows that the time effect is significantly positive for most time of the period, though it appears to be insignificant after 2009. However, for the high-income group, the time effect is insignificant for most of the time, but somewhat surprisingly, it becomes significantly negative in the later period of the SLCP. Therefore, the positive time effect for the full sample is mainly derived from that of the low- and medium-income groups.

This finding confirms the discussion in Reardon, Berdegué, Barrett, and Stamoulis (2007, chap. 8) who find that the relatively poorer households are strongly motivated to diversify their livelihood strategy (mainly by taking up low-return nonfarm rural activities), even though they probably have more barriers to accessing non-farm alternatives. The significant negative time effect on the high-income group in the later years can be interpreted by the argument of Reardon *et al.* (2007, chap. 8), which suggests that greater diversification at the household level actually involves specialization among individuals, and households from the high-income group are more likely to specialize in either purely farm or purely nonfarm pursuits.

7. CONCLUSION

In this paper we use a household level panel data set from 1995 to 2010 consisting of 19,616 observations to examine the internal and external determinants of rural income diversification. We focus on examining the effects of the implementation of the SLCP on livelihood diversification, which is thought to be the solution to poverty and environmental dilemmas and the key to success regarding sustainable development by providing alternative non-farm employment. The results clearly show that both participant and nonparticipant households experienced an increase in livelihood diversification, which mainly derived from an increase in participation in non-farm activities and non-farm income. More importantly, a significant average treatment effect suggests that households significantly broaden their income sources and balance the proportion of each income component with participation in the SLCP.

This study has benefited from the extensive data on the implementation of the program to test the volatility around the time when the first contract expired and the new policy was introduced. The results suggest that the second round of contracts improved the confidence of participants in shifting labor endowment from on-farm to off-farm activities, while the reduction in subsidies did not significantly change the treatment effect, all of which suggest that policymakers made the prospect of policy clear including the duration and the level of the financial incentive targeting the success and sustainability of the SLCP at the lowest possible opportunity cost.

The results also demonstrate that the implementation of the SLCP does indeed have heterogeneous effects on livelihood diversification across the income groups. The households with greater liquidity constraints are more likely to be affected by the program, which seems to be consistent with policy aimed at alleviating poverty. The insignificant effects on the households with high incomes indicate that the policy challenge lies in relaxing additional constraints such as institutional and market failures as well as liquidity constraints. More positive effects may be achieved if institutional constraints on the land exchange market, tenure security or the credit market are alleviated (Groom *et al.*, 2010). Besides, the analysis of the characteristics and endowment of households suggests that the policymakers should increase investments in physical infrastructure such as improving the condition of roads and public transportation, which would make it easier for households to access alternative off-farm employment opportunities.

Finally, we expect that our findings will provide guidance to improving the implementation and performance of the SLCP and will contribute to the on-going debate of how to improve the effectiveness of the program regarding poverty reduction. We also hope that our work will make a difference to other similar treatment effect studies of ecological restoration programs.

NOTES

1. Rural livelihood diversification is defined as the process by which rural households construct an increasingly diverse portfolio of activities and assets in order to survive and improve their standard of living (Ellis, 2000).

2. According to Liu and Wu (2010), afforestation on converted sloping farmland has been almost suspended since August 2007 as the Chinese government is concerned about food security. The central government has established a national minimum of 123 million hectares of farmland. Continuing to convert sloping farmland would reduce the total amount of farmland toward the minimum, or even below. Therefore, not all sloping farmland included in the original plan could be converted to forest or grassland.

3. Though the routes by which the SLCP influences rural income diversification are addressed, it is difficult to decompose and measure each component effect due to data limitation. The purpose of this study is to see whether the SLCP acts as an effective policy intervention on households' participation in non- and off-farm activities. Hence, in this study, we explore the overall effect of SLCP on rural income diversification.

4. According to the survey design, the number of observations should be 1,638 (=14 counties * 3 townships * 3 villages * 13 households). However, in practise, the total number of surveyed household is slightly different from the expected total since not all selected households were available to complete the questionnaires during the period (due to migration, death, failure in recall, logic mistakes, and so on).

5. In terms of program timing, the batch of 3 pilot provinces includes Sichuan, Shaanxi, and Gansu when the State council initiated the SLCP in 1999. After this, the SLCP was formally launched nationwide in 2002. Thus, the timing of the program is different for counties in different provinces.

6. In view of food security, since 2003, the Chinese government has clearly begun to slow the process of converting sloping land and has reduced the plots of land that will enter into the SLCP program. By 2007, when the price of grain increased dramatically, China had almost ceased converting sloping cropland to forestland.

7. Compared to their richer counterparts, poor households are usually faced with greater constraints in terms of liquidity, skills, human capital, and so on, which are required for selecting job opportunities. Hence, they are more likely to be involved in low-paid activities which require relatively low skill, level of education, and entry cost (Zhao & Barry, 2013). Therefore, with low income from the certain source, poor households focus on participating in multiple income-earning activities to generate additional sources of income. The greater the number of revenue sources obtained by a household, the higher the income generated. Accordingly, the diversification measure for poor rural households should stress the number of income sources, while the income share seems less important since they are more likely to be involved in low-paid farm or non-farm work.

8. According to Ellis (2000), the upper limit index value possible is equal to the number of income activities which can be obtained when each income source is shared equally among total income, while the lowest limit is when a given household has only one source of income.

9. The pre-intervention period is from 1996 to 1998 for the full sample, and the period of 1996 to 2001 for observations from provinces that initiated the SLCP in 2002. This means that the tested observations include participants and non-participants from the full sample before 1999; after that, the observations are from provinces that initiated the SLCP in 2002.

10. Liu *et al.* (2010) ruled out the possibility of self-selection bias in their study. Since the data of this study are from the same source, we believe that self-selection bias is not a serious concern in this paper.

11. Government-financed programs often start as pilot programs followed by an expansion. Thereafter, the size of these programs tends to change with annual budget allocations, which cause policy inconsistency and payment uncertainty. See details in Zheng, Glewwe, Polasky, and Xu (2011) that identify the impact of uncertainty regarding the likely longevity of the program-on-program participation.

12. See China Statistics Year Books at http://www.stats.gov.cn/tjsj/ndsj/. The total amount of grain produced in 2008 surpassed the previous highest level which was achieved before implementation of the program.

13. In practice, we rank the households on the basis of their average annual incomes from 1995 to 1998 before the implementation of the SLCP and divide the observations into three equal groups containing equal numbers of households. Then we divide the first 1/3 of observations with highest incomes into the high-income group, the following 1/3 of observations into the medium-income group, while the remainder are included in the low-income group.

14. We apply the Chow test to see whether the coefficients of the independent variables differ across different income groups. In practice, we conduct the Chow test separately to check whether the coefficients of the independent variables are significantly different between the low- and medium-income groups, the low- and high-income groups, and the medium- and high-income groups (see Table 8 in Appendix). The results of the Chow tests show that the differences in coefficients across the three income groups are statistically significant, implying that we should divide observations into three subgroups and run the model separately for each group.

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APPENDIX

Table 8. *Results of Chow tests*

Groups for comparison	Chi^2-statistic	Prob > Chi^2
Low-income group *vs.* medium-income group	216.29	0.000
Low-income group *vs.* high-income group	555.12	0.000
Medium-income group *vs.* high-income group	107.47	0.000