Environmental Management (2010) 45:502–512
DOI 10.1007/s00267-009-9376-7

An Empirical Analysis of the Effects of China's Land Conversion Program on Farmers' Income Growth and Labor Transfer

Shunbo Yao · Yajun Guo · Xuexi Huo

Received: 16 August 2008 / Accepted: 27 August 2009 / Published online: 24 September 2009

Abstract In this article, we hypothesize that in addition to participation status and household characteristics, the impact of China's Sloping Land Conversion Program on income growth and labor transfer is determined by local economic conditions, program range, and political leadership, and the degree of impact on income may vary among different economic sectors. To test these propositions, we have compiled a panel data set of 600 households in three counties in the Loess Plateau region, with observations for times both prior to and after the program's inception (1999 and 2006), for both aggregate and categorical incomes, and for both participating and non-participating households. Using a difference in differences model and repeated cross-sectional data, we find that participation status, local economic conditions, program extent, and political leadership indeed have significant impacts on household income and off-farm employment. Moreover, the effects of participation on crop production income, animal husbandry income, and off-farm income vary substantially. These results carry major policy implications in terms of how to improve the effectiveness and impact of ecological restoration efforts in and outside of China.

Keywords Sloping Land Conversion Program · Income increase · Labor transfer · Panel data · Northern Shaanxi · Difference in differences model · Economic development · Program extent · Political leadership

S. Yao (✉) · Y. Guo · X. Huo
College of Economics and Management, Northwest A&F University, 712100 Yangling, Shaanxi, China
e-mail: yaoshunbo@126.com

Y. Guo
e-mail: guoyajun71@126.com

X. Huo
e-mail: dxhxx1988@yahoo.com.cn

Introduction

The Sloping Land Conversion Program (SLCP) is a primary national program that has been launched by the Chinese government to mitigate soil erosion, desertification, and other ecological problems in order to achieve more sustainable development. In 1999, the pilot projects of this program were carried out in Shaanxi, Gansu, and Sichuan. By the end of 2006, government had subsidized 32.5 million rural households in over 2,200 counties to retire and convert degraded (sloping) and desertified croplands (State Forestry Administration [SFA] 2007). Its original goal was to convert 14.7 million hectares of cropland to forest and grass coverage by the end of this decade, with a total investment of over 220 billion yuan (Yin and others 2008). This total investment for this decade amounts to about US$32 billion, given the current exchange rate of $1 = 6.85 yuan. The government has also decided to extend the program implementation and thus subsidies for another decade, with a projected additional investment of over 200 billion yuan (Yin and Yin 2008). The government claims that this program has already made a predominantly positive impact on rural household production and livelihood, as well as on the environment (SFA 2007). Additionally, many scholars agree that if the SLCP is properly implemented, it will deliver great socioeconomic and environmental benefits; to implement it properly, however, they insist that major policy and technical changes must be made (Xu and others 2006; Uchida and others 2005; Jacoby and others 2002). The objective of this article is to assess whether

implementing the SLCP has led to an increase in farmers' income and a transfer of labor into off-farm sectors, and what the key conditions are in determining program outcomes.

Ever since the official announcement of the SLCP, its effectiveness and sustainability have been hotly debated, and researchers have found divergent and even contradicting evidence of the SLCP's socioeconomic effects. Drawing on household data collected from Gansu and other provinces and descriptive statistics, Zhi (2004) shows that implementing the SLCP has promoted the transfer of rural labor out of the farming sector and the growth of farmers' income. Using a multi-objective programming model, Feng and others (2004) find that the program will not have a major effect on China's grain supply. With sample data collected from four counties in Shaanxi and Qinghai, Xie and others (2006) demonstrate that the SLCP could provide increased household net profits and claim that their result is robust under a range of discount rates and output prices. The study by Wang (2003) of the program's impact on production and income in Wuqi, Shaanxi reveals that the SLCP has contributed to an improvement in productive efficiency, an increase in farmers' income, and an expansion of off-farm jobs. Dong and others (2005) find that the food security of households participating in the SLCP has improved relative either to their own level of food security before the program's implementation or to that of non-participating households. Li (2004) shows that in many areas, the adjustment of the rural economy induced by the SLCP has already benefited farmers' income growth. Given the detected positive effects of labor transfer, economic adjustment, and income increase, a general implication of the above studies is that the SLCP can be sustained in the long run.

On the other hand, some analysts have questioned the SLCP's effects on labor transfer and income increase, and thus its sustainability. For instance, with household data collected in Shaanxi, Gansu, and Sichuan, Xu and others (2004) find that until 2002, the SLCP did not have a significant impact on the adjustment of the production structure, employment in non-farming sectors, or increases in farmers' income. In addition, quite a few studies have emphasized that while the program has attempted to retire plots that are most susceptible to soil erosion, there is room for better targeting (de Janvry and others 2005; Li and others 1998; Xu and others 2005); additionally, the government may be able to generate fiscal savings if the payments more accurately reflect differences in the opportunity costs of different plots (Soule and others 2000; Uchida and others 2005). More specifically, Xu and others (2005) present evidence of the SLCP's potential failure to reach its goals due to flaws in its design and implementation. Guo and others (2005) indicate that since animal husbandry in Sichuan was hit hard by implementing the SLCP, participating households experienced a decline in their living standards. Yi and others (2006) also show that while the effectiveness of the program was enhanced after 2004, its impact in facilitating rural employment, production adjustment, and income growth has remained insignificant.

Several observations can be drawn from the previous studies. First, those studies suggesting positive income and employment effects tend to focus on the direct government subsidies that farmers have received and on the aggregate structural adjustment of the local economy that the program has implied. However, few have considered the induced reduction in crop or animal production and displacement of farm labor. Many of these studies also lack analytic rigor. In contrast, those works showing insignificant or even detrimental effects of the program seem to have taken a more quantitative approach as well as a more balanced and disaggregate view by incorporating the concomitant negative effects on production and employment. Moreover, they argue that without adequate government assistance and training, it is not easy to quickly adjust the local economy and transfer displaced farming labor. Nonetheless, these scholars have rarely moved beyond the features of the retired lands and engage households to account for the socioeconomic outcomes of the program. Of course, it seems unrealistic to expect a uniform outcome for such a large program, given its broad coverage and the varying biophysical and socioeconomic conditions across the country. In addition, where the sample sites are selected and the data are collected makes a difference in determining the program effects, just as the time span of an investigation does. More importantly, the effectiveness and impact of the program are predicated on the internal and external local conditions under which it is executed (Yin and others 2008). Therefore, it is crucial to identify these conditions and incorporate them into the assessment of the SLCP impact, which is what we will do in this article.

Formally, the propositions we make here are that in addition to the participation status and household characteristics, the impacts of the SLCP on income growth and labor transfer are determined by local economic development, program extent, and political leadership, and the impact on income may vary from sector to sector. In other words, implementing the SLCP can result in quite different outcomes in farming, animal husbandry, and thus total income, and it is likely for the program to make a greater impact where there exist a better developed economy, a larger program range, and stronger political leadership.

To test these propositions, we have selected three counties—Wuqi, Dingbian, and Huachi—in the Loess Plateau region, covering two time periods, 1999 and 2006. While these counties are adjacent, they belong to different jurisdictions, which can better reflect the varying extents of

program execution, political setting, and economic development. The time span of the study, from 1999 to 2006, represents the longest of this type of inquiry so far. Also, dividing the aggregate income into incomes from farming, animal husbandry, off-farm work, and other sources will enable us to look into the gains and losses experienced by different sectors. Furthermore, the difference in differences (DID) model that we adopt is well-suited to the task of quantifying the program's impacts on the transfer of rural surplus labor and the growth of farmers' income (Lee 2005). As a result, we expect that our empirical analysis will generate a rich set of interesting results and will thus make a timely contribution to a better understanding of the program's performance and to a more thorough discussion of how to improve its effectiveness and impact. We also hope that our work will shed light on other countries' undertaking similar ecological restoration efforts.

Overall, it is found that along with other variables, participation status, local economic conditions, program range, and political leadership have indeed had a significant influence on household income and off-farm employment. Moreover, the effects of participation on crop production income, animal husbandry income, and off-farm income vary substantially. These results confirm our hypotheses and have major policy implications. The article is organized as follows. We devote the next two sections to theory and methods, and study site and data. Then, we present our empirical results in section four and conclude in the final section.

Theory and Methods

We hypothesize that the impact of implementing the SLCP on income growth and labor transfer is determined by local economic development, program range, and political leadership, in conjunction with the participation status, and that impact on income may well vary from sector to sector. Specifically, we argue that if the program's implementation involves only a small portion of the sloping farmland, its impact will be marginal; otherwise, if it covers a large proportion of the land base, then it can cause a major impact (positive or negative). Therefore, the program extent should be considered when we examine its impact.

It is simple to understand the relevance of local economic conditions to the program's impact. In a more developed and wealthier region, it is not only unnecessary for the local cadres to profiteer from the program by diverting farmers' subsidies and exaggerating the set-aside targets to their own benefit but also damaging, as more local financial and personnel resources can be possibly devoted to facilitating the program implementation (Xu and others 2006). Additionally, a better-developed economy will provide more opportunities to absorb the displaced farm labor into off-farm and/or non-rural jobs. As a result, it is more likely for the program to effectively increase farmers' income and transfer of farm labor (Guo and Yao 2007). In contrast, if the local economy is such that it has little means to provide the basic administrative support, let alone to supplement the implementation and absorb the surplus rural labor, then it will be less likely to make a difference, and it may even open up the door for local program managers to graft part of the subsidies under various excuses (Xu and others 2004).

In addition, program outcome is associated with the local political leadership. If the local agency is committed to its implementation, then it is more likely for the program to succeed and thus lead to a more positive impact (World Bank 2002). Also, in a transparent political environment, it is not so hard for the farmers to track the performance of their local leaders and detect any inappropriate behavior, including corruption (World Bank 2002). Otherwise, an opaque political setting makes it easy for a local agency to engage in misconduct, which can inevitably compromise the program's effectiveness and constitute a disincentive for farmers. Finally, since participating in subsidized land conversion affects various production activities in different ways, it is expected that incomes from these activities will change dissimilarly. That is, cropland retirement can cause a reduction in yield and thus income if no improved inputs or management practices are adopted to intensify land use. Otherwise, if better inputs and management practices are adopted, then intensified land use will not lead to a proportionate decrease in yield and thus income. Also, cropland conversion and/or crop yield reduction may mean that open herding is restricted and/or feed stocks reduced, in which case income from animal husbandry will be negatively affected.

Our task in this article is to test the validity of the above hypotheses by fitting an adequate empirical model to a sound dataset. To that end, we have compiled repeated cross-sectional data of household production activities in three counties of the Loess Plateau region. With observations made for times both prior to and post the program's initiation and for both participating and non-participating households, our DID model will allow us to detect the program's impact effectively. In particular, including separate variables of economic condition, program extent, and political leadership in the estimation will make it possible to derive less-biased results and to explain the program's success or failure in the proper context. To our knowledge, this is one of the first studies to attempt to incorporate a broader set of variables, both internal and external to the program's implementation, into its impact determination.

Nonetheless, it should be pointed out that as an alternative, we may try to detect the program's impact simply

by using a regional dummy variable instead of the specific variables of economic condition, program extent, and political leadership, and that the estimation would be easier if we opted to do so. However, this approach has some drawbacks. First, it will lead to biased estimates because the regional variation renders the underlying assumption of parallel trends between the regions no longer valid (Imbens and Woodridge 2007). And, of course, it will preclude us from identifying which factors are responsible for the program's success or failure and to what extent they are so. In addition, replacing the regional variation of multiple dimensions with a single dummy variable will probably produce lower degrees of goodness of fit, which is undesirable. Nevertheless, we also will consider this simplistic approach in our estimation to illustrate the rationality of our choice.

The concrete model is as follows:

$$Y_{it} = \alpha_0 + \alpha_1 T + \delta D_{it} + \beta Z_{it} + \gamma X_{it} + c_i + \mu_{it} \quad (1)$$

where Y is a dependent variable representing farmers' income (from different sources) or off-farm employment; i and t denote household and time, respectively; T is a time dummy, taking the value of 0 for the state prior to the program's initiation or 1 for the state after it; D is another dummy variable to reflect the status of program participation, taking a value of 1 if a household participates and 0 otherwise; Z_{it} represents controlled variables affecting farmers' income and off-farm employment, including those commonly used ones, such as family size, numbers of household laborers, and farmland per capita, as well as the ones that we propose to use—local program extent, economic condition, and political leadership (see discussion below); X_{it} is a group of variables that may not vary over time or vary spontaneously, including the age of the head of household and the family member serving as a village leader; c_i is a set of unobservable variables that affect family income and off-farm employment; and μ_{it} is the error term. Included in the parameters to be estimated are α_0, the intercept, α_1, the time effect, δ, the effect of the participation status on income growth and labor transfer, and β and γ, the effects of the controlled variables on the dependent variables.

Understandably, the effects of local economic conditions, program range, and political leadership on farmers' income and labor transfer are conditional on the household's engagement in the program. If so, these variables may not be directly included in Z_{it}; rather, they should enter the above equation as interactive terms with the participation dummy (Imbens and Woodridge 2007). We use the per capita GDP of the township to which the household belongs as a proxy for the local economic condition, the percentage of a household's retired cropland as an indication of the program's range, and another dummy variable to distinguish the political leadership of the sample counties.

After first-order differentiation, the above model becomes:

$$Y_{i1} - Y_{i0} = \alpha_0 + \delta D_{it} + \beta(Z_{i1} - Z_{i0}) + (\mu_{i1} - \mu_{i0}) \quad (2)$$

Note that the unobservable effect c_i and the time invariant factors X_{it} have disappeared following the first-order differentiation. In order to obtain consistent estimates, farmers' self-choice of participation should not be a serious problem in the above model. That is, whether a household participates in the program is not an endogenous choice (Lee 2005). Given the short time span and the government dominance of cropland set-aside planning and execution (Yin and others 2008), this assumption seems plausible. Our surveys suggest that almost 85% of the participating households were selected by the government; likewise, 72% of the non-participating households were unable to be enrolled into the program. In fact, Xu and others (2004) have demonstrated that the problem of farmers' endogenous choice is not severe. As such, we will not look into the issue of endogenous choice in this study.

Site and Data

The site for this study constitutes three counties of the Loess Plateau region—Wuqi in the Yan'an municipality of Shaanxi, Dingbian in the Yulin municipality of Shaanxi, and Huachi in the Qingyang municipality of Gansu (Fig. 1). The rationale for this selection is as follows. First, these three counties represent the typical ecological conditions found in the region, where land degradation and soil erosion were so severe that there had been a great need for farmland retirement and conversion. Second, their adjacent locations and similar landscapes as well as program implementation schedules (all initiated the farmland conversion in the late 1990s and were virtually complete by 2005) are conducive to a comparison among them. Third, their different jurisdictions make it more likely for us to capture the variations in program extent, political leadership, and economic status and thus their influence on the outcome of program implementation.

Before proceeding to the presentation of our data, a brief description of the basic conditions of these three counties is in order. Situated in the northeast of Yan'an municipality, Wuqi has a total population of 127,369, of which rural residents account for 109,470. Like its neighbors, Wuqi is well known for its rich petroleum and gas reserves. But unlike its neighbors, the county has enjoyed preferential treatment by the central government due to its oil and gas reserves. This treatment came in the mid 1980s as a result of its significance in contemporary Chinese history as the

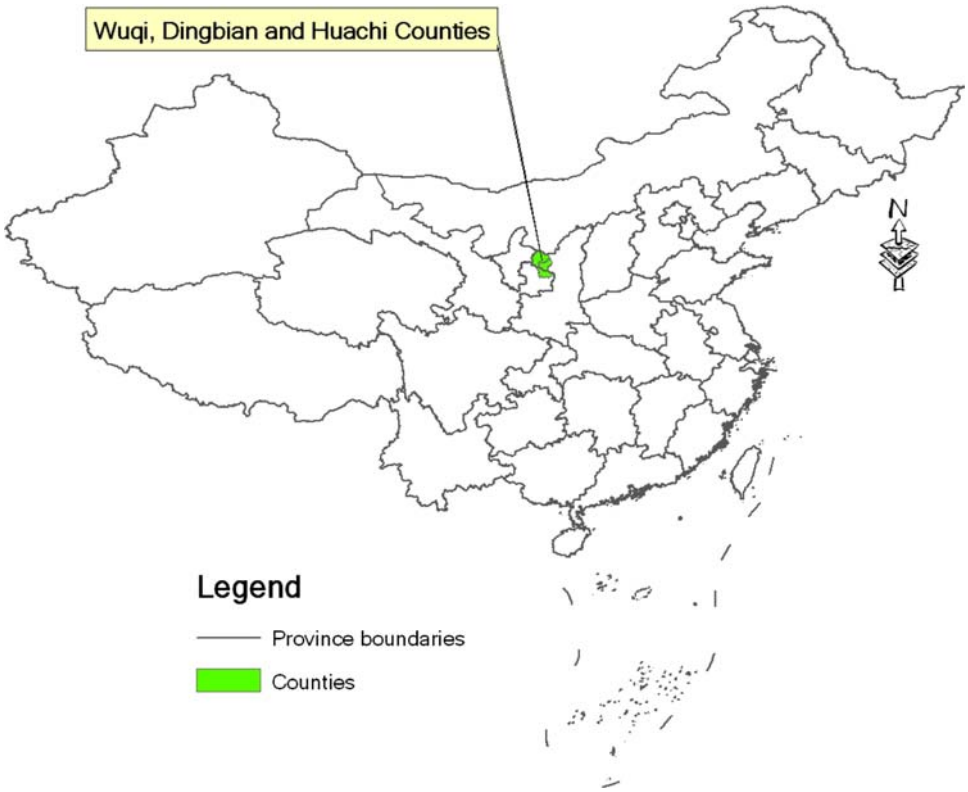

Fig. 1 Location of the study site

ending place of the Red Army's Long March, combined with its extreme poverty (Wuqi SLCP Office 2007), which has enabled Wuqi's economy to grow rapidly in recent years. The county's GDP was 2.1 billion yuan in 2005, when its own revenue reached 0.7 billion yuan., Wuqi has since become one of the richest counties in western China (Wuqi Statistics Bureau 2006).

Before 1998, Wuqi had a cultivated land of 123,700 hectares (ha), or 3.40 ha per household, and a large number of the rural households also raised goats—their population peaked to 280,000. As a consequence of extensive farming and open grazing, the county's land and vegetation were heavily degraded, making the problems of water runoff and soil erosion extremely severe. In response, Wuqi began retiring croplands on steep slopes and converting them to forest and grass coverage in 1998. Taking advantage of the national initiative, Wuqi's land set-aside and conversion expanded tremendously in 1999. Croplands were cut back to 10,000 ha, and open grazing was banned in favor of raising goats in pens and vegetation recovery (Wuqi SLCP Office 2007). To complete the ecological and economic transformation, the county government has invested heavily in activities such as improving the quality of the remaining farmland, introducing new breeds of crops and animals, and promoting best land-use practices to supplement the SLCP. Now, over 97,000 ha of converted cropland have passed the national survival, growth, and stocking inspections (Wuqi SLCP Office 2007). Due to its decisive action and tremendous change, Wuqi has attracted broad attention. Government leaders, program managers, and journalists across the country flock there to learn its experience and lessons, and scholars from research institutions travel there to conduct field experiments and surveys.

Lying in the transitional zone between the Loess Plateau and the Erdos Desert, Dingbian is located in the west part of Yulin. Of its population of 315,851, over 87% live in rural areas (Dingbian Statistics Bureau 2006). Huachi is located in the eastern part of Gansu province, and 86% of its 130,175 population is rural residents (Huachi Statistics Bureau 2006). As with Wuqi, extensive farming and open grazing existed in these two counties. Also similarly to Wuqi, these two counties are endowed with rich petroleum and gas resources. However, they have not been allowed to develop these resources locally as Wuqi has been. Instead, the national company, Changqing Petro Co., holds the exclusive right of exploration. While figures show that the GDP of Dingbian and Huachi in 2005 was close to 3 billion yuan and 4.6 billion yuan, respectively, higher than that of Wuqi, much of this was contributed by the oil company, which did not significantly benefit the local treasury and employment. Consequently, the total budget for Dingbian and Huanchi counties was less than 60 million yuan in 2005 (Dingbian Statistics Bureau 2006; Huachi Statistics Bureau 2006).

These two counties have also participated in the SLCP. Their total amount of retired cropland is 10,966 ha for Huachi and 21,905 ha for Dingbian, suggesting a much smaller

extent of program implementation, given their total cropland holding of 57,265 ha and 83,333 ha in 1997, respectively. Also, extensive farming and open grazing in these two counties are still the norm rather than the exception. Furthermore, their local investment in the land retirement has been negligible, and incidences of delayed delivery and deduction of farmers' subsidies have occurred (Dingbian SLCP Office 2007; Huachi SLCP Office 2007). Some township officials have even attempted to use the subsidies to offset households' taxes and other financial obligations.

In sum, marked differences exist among Wuqi and the other two counties. Compared to Wuqi, Dingbian and Huachi have lacked political leadership, local investment, and extensive participation, among other things. We expect that these variations will be reflected in the program's impact on each region. To capture differences in political leadership, the dummy variable we use is 1 for Wuqi and 0 for the other two.

In August 2007, our research team conducted a survey of 200 randomly chosen households in each of the three counties, and our questionnaire included basic household characteristics, production, consumption, income, and farmland retirement and conversion. The basic characteristics of surveyed households are listed in Table 1. It can be seen that there is little difference in number of laborers, the average amount of education in years, and the average age of household head between participating and non-participating households. Noticeable differences exist in family size, cultivated land, and years of schooling for household heads; all wanted inclusion in our formal analysis.

Table 2 compares per capita income of the two household groups in Wuqi 1999 and 2006. Except for participating households' income from animal husbandry, all kinds of income increased during that period of time. The non-participating households' income from crop production rose from 5591 yuan in 1999 to 5788 yuan in 2006, while that of participating households rose from 3733 yuan in 1999 to 4653 yuan in 2006. The non-participating households' income from animal husbandry grew from 1162 yuan to 1948 yuan, but that of participating households declined from 3575 yuan in 1999 to 1409 yuan in 2006. The off-farm income of non-participating households rose from 2475 yuan to 2917 yuan, whereas that of participating households increased from 10404 yuan in 1999 to 13785 yuan in 2006.

In 1999, the crop production income of non-participating households was 1,859 yuan, which was significantly higher than that of participating households. In 2006, however, this gap shrank to 1,136 yuan and became insignificant. Even though the cultivated land of participating households was greatly reduced, their improved productive efficiency could have reduced the gap of crop production income, compared to non-participating households (Guo and Yao 2007). Before the land set-aside, the two groups had significant differences in their incomes from animal husbandry, off-farm employment, and other sources as well as in their total income. But the animal husbandry income gap narrowed and was no longer significant in 2006 due to the banning of open grazing, which adversely affected both groups. The difference of income from other sources between the two groups was never significant.

Table 3 compares incomes of the two household groups in Huachi and Dingbian between 1999 and 2006. All households witnessed an increase in their crop production income, off-farm income, income from other sources, and total income. The animal husbandry income of non-participating households dropped from 2,371 yuan to 1,591 yuan, whereas that of participating households declined slightly. The crop production income of non-participating households increased from 2,176 yuan in 1999 to 4,511 yuan in 2006, and that of participating households also increased from 2,475 yuan to 4,614 yuan. The off-farm

Table 1 The basic features of the surveyed households in the three counties

	Non-participating households (108)	Participating households (492)	*F*-test of variance	*T*-test family differences
Family size	4.95 (1.25)	4.63 (1.51)	1.46[a]	1.63[a] (0.104)
Number of laborer	2.56 (1.18)	2.45 (1.17)	1.01	0.66 (0.51)
Years of educated per person	4.20 (3.67)	4.39 (4.32)	1.24	0.34 (0.73)
Age of household head	50.53 (10.73)	48.77 (10.99)	1.05	1.15 (0.25)
Years of education for household head	5.20	5.89	1.39[a]	1.23 (0.21)
	4.26	3.62		
Cultivated land	9.93 (5.29)	11.42 (7.26)	1.88[c]	1.66[a] (0.09)

Of the 108 nonparticipating households, 2 were in Wuqi, 62 in Dingbian, and 44 in Huachi; of the 492 participating households, 198 in Wuqi, 138 in Dingbian, and 156 in Huachi. Columns 2 and 3 are the mean values for non-participating and participating households; figures in parenthesis are standard deviations; column 3 is the *F* test of variance uniformity of the two groups; column 4 is the *t* test of family characteristics; and [a,c] represent significance at the level of 10% and 1%, respectively

Table 2 Per capita income of surveyed households in Wuqi in 1999 and 2006

	Non-participating households		Participating households		Between group income difference	
	1999	2006	1999	2006	1999	2006
Crop production income	5591 (7303)	5788 (12417)	3733 (3907)	4653 (8860)	1859 (2.3)[b]	1136 (0.7)
Animal husbandry income	1162 (1734)	1948 (3163)	3575 (11951)	1409 (1540)	−2413 (−2.0[b])	539 (1.5)
Off-farming income	2475 (5711)	2916 (7733)	10404 (13867)	13785 (24502)	−7930 (−5.3[c])	−10869 (−4.3[c])
Other income	0 (0.0)	5411 (3494)	61 (603)	6778 (8244)	−61 (1.0)	−1367 (−1.5)
Total income	9228 (5835)	16064 (7158)	17773 (12697)	26625 (20664)	−8544 (−5.3[c])	−10561 (−3.4[c])

Crop production income is income from producing corn, potatoes, and other minor crops; animal husbandry income is income from raising livestock, predominantly goats; off-farm income is income from off-farm employment, mainly construction and service work in local towns as well as large cities; other income is income from other sources, such as family properties and government subsidies; and total income is the gross income from all sources. Note that because these statistics are rounded mean values, they may not add up to the total exactly. Columns 2–5 are the mean values for the two groups, standard deviations are in the parentheses; columns 6–7 are the between-group differences, the *t* statistic is in the parenthesis; and [b,c] represent significance levels of 5% and 1%, respectively

Table 3 Per capita income of surveyed households in Huachi and Dingbian in 1999 and 2006

	Non-participating households		Participating households		*T*-test of between-group difference	
	1999	2006	1999	2006	1999	2006
Crop production income	2176 (3282)	4511 (4193)	2475 (2708)	4615 (4363)	−299 (−0.9)	−104 (−0.6)
Animal husbandry income	2371 (8136)	1591 (1830)	1358 (1514)	1265 (1186)	1012 (1.5)	326 (1.5)
Off-farm income	6409 (9802)	5568 (19489)	6642 (13823)	9912 (24765)	−234 (−0.1)	−4344 (−1.4)
Other income	1459 (1355)	1708 (5275)	487 (1020)	535 (1247)	972 (5.8[c])	1172 (1.9[a])
Total income	12414 (12661)	13379 (1906)	11962 (9703)	16327 (12802)	1452 (−0.4)	−2948 (−1.9)

Crop production income is income from producing corn, potatoes, and other minor crops; animal husbandry income is income from raising livestock, predominantly goats; off-farm income is income from off-farm employment, mainly construction and service work in local towns as well as large cities; other income is income from other sources, such as family properties and government subsidies; and total income is the gross income from all sources. Note that because these statistics are rounded mean values, they may not add up to the total exactly. Columns 2–5 are the mean values for the two groups, standard deviations are in the parentheses; columns 6–7 are the between-group differences, the *t* statistic is in the parenthesis; and [a,c] represent significance levels of 10% and 1%, respectively

income of non-participating households dropped from 6,409 yuan to 5,568 yuan, while that of participating households rose from 6,642 yuan in 1999 to 9,912 yuan in 2006. In 1999, the crop production income of participating households was 299 yuan higher than that of non-participating households. In 2006, this gap narrowed to 104 yuan. The insignificant differences in crop production income, off-farm income, and total income between the two groups in Huachi and Dingbian indicates their smaller share of land retirement did not make a large difference.

Estimated Results

Tables 4 and 5 list the estimated results. The former was based on specific regional variables of economic condition, program extent, and political leadership in the econometric estimation, whereas the latter was derived with the inclusion of a dummy variable to distinguish the regional variation. In comparison, the former is less biased and features slightly higher degrees of goodness of fit. The R^2 value ranges from 0.58 to 0.25 in four of the six cases, which is encouraging for first-order differentiated models; even in the two cases (income from other sources and total income) where the R^2 value is very low, it is not unusual for this type of policy, or more broadly treatment, effect model (Wooldridge 2002; Lee 2005). More importantly, while the two sets of results are qualitatively and even quantitatively similar in certain cases, the former provides more detailed and relevant empirical content. As such, our result presentation below will focus on those regressions with specific regional variables of economic condition, program extent, and political leadership (Table 4).

First, all of the variables have a positive effect on the crop production income regression. Compared to that of the non-participating households, crop production income of the households participating in the SLCP increases by 131.1 yuan, which is not a large figure in magnitude but significant at the 99% level. A better-developed local economy, a larger program extent, and a stronger political leadership,

Table 4 Regression results of income and off-farm employment based on the model with specific variables for regional variation

	Crop production income	Animal husbandry income	Off-farm income	Other income	Off-farm employment	Total income
Status of participation	131.11	−2445.52	3170.06	382.16	0.09	5397.04
	6.23	−2.67	1.54	0.14	3.05	3.87
Economic condition	619.27	202.64	187.94	−269.32	0.25	286.52
	5.90	1.04	2.63	−0.68	8.00	2.35
Program extent	170.25	73.69	62.95	−145.46	0.12	175.97
	2.57	0.63	2.63	0.05	2.15	1.97
Political leadership	251.33	68.18	55.18	−50.79	0.07	91.63
	9.08	1.14	2.16	−0.05	11.48	2.39
Education of household head	83.55	191.92	522.17	138.29	0.02	1059.97
	67.11	1.26	1.61	1.22	1.35	2.83
Family size	8.37	507.66	191.12	1309.85	0.14	1867.99
	2.11	1.05	0.19	3.63	3.60	2.02
Number of laborers	190.59	258.93	−1792.95	−498.13	0.07	1376.97
	2.07	1.62	−1.17	−0.59	1.76	3.13
Non-agricultural employment	187.41	−606.91	9191.11	126.79	****	11046.10
	21.71	−1.25	5.09	0.20	****	3.44
Per capita cultivated land	984.56	−159.15	−328.14	252.31	−0.02	231.62
	2.59	−0.34	−0.33	0.69	−4.19	0.13
Intercept	−543.62	1726.65	7536.26	−596.58	0.49	3052.57
	−0.18	0.99	0.94	−0.23	1.54	0.21
R^2	0.58	0.40	0.25	0.20	0.48	0.15

Corresponding to each variable, the figure in first row is the estimated coefficient, and the figure in the second row is the *t* statistic value

**** represent that the non-agricultural employment variable is not included in the off-farm employment transfer model

respectively, result in an increase in the household's crop production income by 619.3, 170.2, and 251.3 yuan at the 99% significance level. Together, these add up to a sizable amount (1240 yuan), and they have partially confirmed what we hypothesized—variations in local programmatic, economical, and political conditions all impact the crop production income. Education level of the household head also has a significant influence on crop production income, with one more year of schooling leading to an increase of 83.6 yuan. Other variables like number of household labor, per capita cultivated area, and non-agricultural employment lead to a significant increase in crop production income as well. Here off-farm employment includes employment in local non-agricultural activities and off-village employment as migratory workers.

Second, the regression of animal husbandry income reveals that participation status is negatively associated with the income at the 95% significance level. Animal husbandry income of participating households is decreased by 2445.5 yuan, in comparison to that of non-participating households. Here, program extent, economic development, and political leadership do not matter much. Variables like schooling years of household head, family size, and number of household labor have a positive but statistically insignificant effect. Likewise, per capita cultivated area and local non-agricultural employment have a negative but statistically insignificant effect.

Third, the off-farm income is positively related to participation status and years of schooling of the household head at the 90% significance level. Participation allows a farmer household's off-farm income to increase by 3170.1 yuan, and one more year of schooling for the household head leads to an increase of 522.2 yuan. Local economic development, program extent, and political leadership make the household off-farm income to increase by, respectively, 187.9, 62.9, and 55.2 yuan. These effects are all significant at the 99% level. Additionally, non-agricultural employment has a positive effect at the 99% significance level, again. One more person employed in the non-agricultural sector results in the household's off-farm income increasing by 9191.1 yuan. In contrast, family size, number of household labor, and per capita cultivated area do not have strong correlations with off-farm income. As to income from other sources, the regression has only one significant variable, family size, suggesting that the larger the family, the greater the income. All the other variables, including those policy ones, have little effect.

Fourth, the regression of number of off-farm employment shows that participation has a positive effect on off-farm employment at the 95% significance level. Other

Table 5 Regression results of income and off-farm employment based on the model with no specific variables for regional variation

	Crop production income	Animal husbandry income	Off-farm income	Other income	Off-farm employment	Total income
Status of participation	122.46	−3971.27	2917.93	565.01	0.049	5026.51
	8.54	−2.57	1.52	0.49	2.29	0.87
Regional dummy	1958.19	542.02	339.88	−1127.19	0.25	1078.85
	89.73	0.35	2.10	−0.99	2.51	0.19
Education of household head	83.59	224.34	505.97	137.02	0.02	1114.41
	44.32	1.47	1.59	1.23	1.14	1.95
Family size	24.38	601.25	140.50	1,311.07	0.183109	2000.34
	2.28	1.23	0.14	3.67	3.55	1.20
Number of laborers	115.83	659.75	−1476.44	−462.69	0.054522	3888.79
	13.94	1.19	−1.28	−1.15	1.99	1.89
Non-agricultural employment	197.71	−777.09	9482.34	104.49	****	10314.91
	20.86	−1.18	6.87	0.22	****	4.18
Per capita cultivated land	975.99	−128.01	−344.01	208.88	−0.03	267.79
	83.44	−0.27	−0.35	0.61	−2.50	0.15
Intercept	230.06	1056.75	5139.92	−684.59	0.29	10802.55
	3.96	0.36	0.83	−0.32	0.91	0.98
R^2	0.38	0.26	0.24	0.12	0.11	0.14

Corresponding to each variable, the figure in first row is the estimated coefficient, and the figure in the second row is the *t* statistic value

**** represent that the non-agricultural employment variable is not included in the off-farm employment transfer model

things being equal, participation causes 0.09 units of labor to shift out. Although there is a positive relation with years of schooling for household head, this relation was statistically insignificant. While family size and number of household labor have positive effects on off-farm employment, per capita cultivated area has a negative effect on off-farm employment. These results illustrate that: (1) the more surplus labor a family has, the more off-farm income it generates; and (2) the larger the per-person cultivated area, the less likely it is for the household to engage in intensive farming, making it harder to shift labor out. Local economic development has a positive relation with off-farm employment; a coefficient of 0.25 indicates that the condition is a key factor of labor transfer. Program extent has an effect of 0.12, and political leadership has an effect of 0.07. Together, these variables cause 0.45 units of labor to shift out of farming, which is more than four times greater than the coefficient of participation status alone. This has further proven the proposition we proposed: the realized transfer of surplus farming labor depends on both internal and external conditions, coupled with program participation.

Fifth, total income has a positive correlation with years of schooling for the household head, family size, number of labor, and non-agricultural employment. The contributions of these variables are 1056 yuan from one more year of household head education, 1870 yuan from one more person in the household, 1377 yuan from one more family laborer, and, more substantially, 11046 yuan from one more non-agricultural job. Participation in the land conversion program results in an increase in total income by 5397 yuan. In addition, local economic development, program extent, and political leadership are positively correlated with total income. Their coefficients are 287 yuan, 176 yuan, and 91.6 yuan, respectively. Again, these findings validate our basic hypothesis: the impact of the SLCP on farmers' income is determined by local conditions in conjunction with participation status. Notably, these effects, estimated with the replacement of specific regional differences by a simple dummy variable, become insignificant (Table 5).

Conclusions and Discussion

We set out to test the hypothesis that the impact of implementing the SLCP is determined by local economic conditions, program extent, and political leadership in conjunction with participation status. We also speculated that the income effects may vary across sectors. To that end, we have estimated two difference-in-differences models with data collected from 600 households in three counties of the Loess Plateau, covering both times before and after the program's inception (1999 and 2006) and both participating and non-participating categories. Our results have nicely confirmed the plausibility of our model selection and the sensibility of our conceptual hypotheses.

It is found that participation in the SLCP has affected incomes from different sectors in different ways. While it has a significant positive impact on crop production

income, the magnitude of this effect is small. In comparison, better local economic conditions, larger program extent, and stronger political leadership have much greater impact. These results suggest that cropland retirement does not necessarily cause a reduction of crop yield or income if the production mode can be sufficiently transformed by adopting more improved inputs and management practices. However, participation has a substantial negative effect on income from animal husbandry, which is almost ten times greater than the combined positive effects of local economic conditions, program extent, and political leadership. Clearly, animal husbandry was hit hard by the grazing and feeding constraints in carrying out the SLCP, even with local efforts in maintaining its vitality.

On the other hand, participation has a very large positive effect on both off-farm income and total income. In combination, these results indicate that although animal husbandry is negatively affected, the program's impact on other sectors is positive and thus more than offsets the negative effects in the aggregate. The results of the off-farm employment and income regressions highlight the fact that participating in the program has accelerated the transfer of farming labor and has greatly stimulated income growth from off-farm opportunities. Moreover, these positive effects are reinforced by better economic development, larger program extent, and stronger political leadership. These findings are new to the literature, and they have provided further supporting evidence to our claim that the socioeconomic effects of the program are indeed predicated on the program's local range and conditions, coupled with participation status. Also, they indicate that it is essential to incorporate the relevant variables into any reliable assessment of the SLCP's impact.

The government should take these elements into account in its program planning and execution. For one thing, in case it delivers great ecological benefits, the program may be more concentrated in the selected sites where the local agencies are committed to an effective and transparent implementation and where the local economies are conducive to intensifying crop production on reduced land, absorbing displaced surplus labor, and/or sustaining animal husbandry. However, it should be made clear that the evolving local economic conditions can alter the comparative advantages of different production and income opportunities. As such, tradeoffs between them must be made properly. This means that the government entities should identify where and by how much the production and income will contract or expand and should design measures to deal with the associated winners and losers. It also implies that it may not be a simple and easy matter for the program to fulfill its dual objectives of poverty alleviation and ecological restoration.

While the findings of the program's negative effect of participation on animal husbandry income and its positive effect on off-farm employment and total income conform to what was previously reported (Guo and others 2005; Dong and others 2005), the finding of a positive effect on cropping income is new as well. This new result implies that cropland reduction will not inevitably cause a decline in crop yield and thus income. We conjecture that the significance of these effects has to do with the features of our sample, including the selection of a representative study site, the coverage of a long span of time, the division of total income into specific categories, and the capture of specific regional variations. It seems that in these aspects lies the distinction between our results and those of Xu and others (2004) and Yi and others (2006).

In addition, as an indication of family human capital accumulation, the household head's amount of schooling contributes to cropping income as well as to total income, illustrating the importance of education for families' livelihoods (Hayami 2003). Meanwhile, the number of laborers and the family size boost income from crop production, off-farm employment, and thus total income. Further, family size helps increase income from other sources, and number of labor benefits income growth from animal husbandry. Also reasonable, the evidence that per capita cultivated land favors income from cropping and leads to less off-farm employment, which implies that while cropland retirement reduces crop production and income, it also accelerates a shift in labor out of farming. Moreover, it is encouraging to observe that more favorable local conditions can work to more than offset the negative effect of land retirement on income from crop production.

Finally, it is worth noting that because the data used in this study cover only three counties in the Loess Plateau region, our findings may not apply elsewhere. To reach broader conclusions, more data should be collected from other regions. Also, follow-up analyses should be pursued to examine what will happen to the sample sites of this study over the long term.

Acknowledgments This study is sponsored by the National "11th Five-Year Plan" Science & Technology Support Project (2006 BAD03A0308), the International Research Center of Sediment project of "Study on Wuqi County Sustainable Development" (2005-01-10), and the Shaanxi Provincial Key Forestry special project "Ecological Forest Policy Research." The authors are grateful for Professor Runsheng Yin's help in editing this article.

References

Dingbian SLCP Office (2007) A summary report of Dingbian's implementation of the Sloping Land Conversion Program

Dingbian Statistics Bureau (2006) 2005 Dingbian statistics yearbook

De Janvry A, Sadoulet E, Zhu N (2005) The role of non-farm income in reducing rural poverty and inequality in China. Working paper

Dong M, Zhong BN, Wang GJ (2005) An empirical analysis of the effect of China's farmland conversion program on food security in Ningxia Hui Autonomous Region. China's Population, Resources, and Environment 1:104–108

Feng Z, Yang Y, Zhang Y, Zhang P, Li Y (2004) Grain for green policy and its impact on grain supply in West China. Land Use Policy 22:301–312

Guo XM, Gan TY, Li S, Luo H (2005) An investigation of the Sloping Land Conversion Program implementation in Tianquan, Sichuan. China Rural Observation 3:73–79

Guo ZQ, Yao SB (2007) A study of the sustainability of China's Sloping Land Conversion Program in Wuqi. Forest Economics 3:32–35

Hayami Y (2003) Development economics. Chinese Social Science Press, Beijing

Huachi SLCP Office (2007) A summary report of Huachi's implementation of the Sloping Land Conversion Program

Huachi Statistics Bureau (2006) 2005 Huachi statistics yearbook

Imbens G, Woodridge J (2007) Mini-course of *What's New in Econometrics* taught at the National Bureau of Economic Research Summer Institute in Cambridge, Massachusetts

Jacoby H, Li G, Rozelle S (2002) Hazards of expropriation, tenure insecurity and investment in rural China. American Economic Review 92:1420–1447

Lee MJ (2005) Micro-econometrics for policy, program, and treatment effects. Oxford University Press, Oxford

Li G, Rozelle S, Brandt L (1998) Tenure, land rights and farmer investment incentives in China. Agricultural Economics 19:63–71

Li RN (2004) The influence of China's land retirement efforts on rural economy in Luoyang, Henan. Agriculture Modernization Research 5:363–366

Soule M, Tegene A, Wiebe K (2000) Land tenure and the adoption of conservation practices. American Journal of Agricultural Economics 82(4):993–1005

State Forestry Administration (2007) 2006 China forestry development report. China Forestry Press, Beijing

Uchida E, Xu J, Rozelle S (2005) Grain for green: cost-effectiveness and sustainability of China's conservation set-aside programme. Land Economics 81(2):247–264

Wang JJ (2003) The economic and ecological foundations for converting farmland into forest and grass coverage. Agricultural Economic Issues 8:21–27

Wooldridge JM (2002) Econometric analysis of cross section and panel data. The MIT Press, Cambridge

World Bank (2002) Building institutions for markets. Oxford University Press, Oxford

Wuqi SLCP Office (2007) A summary report of Wuqi's implementation of the Sloping Land Conversion Program

Wuqi Statistics Bureau (2006) 2005 Wuqi statistical yearbook

Xie C, Zhao J, Liang D, Bennett J, Zhang L, Dai G, Wang X (2006) Livelihood impacts of the conversion of cropland to forest and grassland program. Journal of Environmental Planning and Management 49:555–570

Xu J, Bennett M, Tao R, Xu J (2005) China's Sloping Land Conversion Programme four years on: current situation, pending issues. Working paper

Xu JT, Tao R, Xu ZG (2004) An empirical analysis of the cost effectiveness, structural adjustment, and long-term sustainability of the farmland conversion program in three western provinces. Economic Research Quarterly 4:139–162

Xu JT, Yin RS, Li Z, Liu C (2006) China's ecological rehabilitation: unprecedented efforts, dramatic impacts, and requisite policies. Ecological Economics 57(4):595–607

Yi FJ, Xu JT, Xu ZG (2006) An analysis of the income and employment impacts of the farmland conversion program. China Rural Economy 10:28–36

Yin RS, Yin GP (2008) China's ecological restoration programs: initiation, implementation, and challenges. An Integrated Assessment of China's Ecological Restoration Programs. Springer Netherlands Press, pp 1–19

Yin RS, Yin GP, Li LY (2008) China's ecological restoration: program initiatives, implementations, and imperatives. MSU Department of Forestry working paper

Zhi L (2004) Research on the multiple goal characteristics of our country's relief by grain from the backgrounds of Chinese and foreign returning farmland to forests. Forest Economy 7:29–32