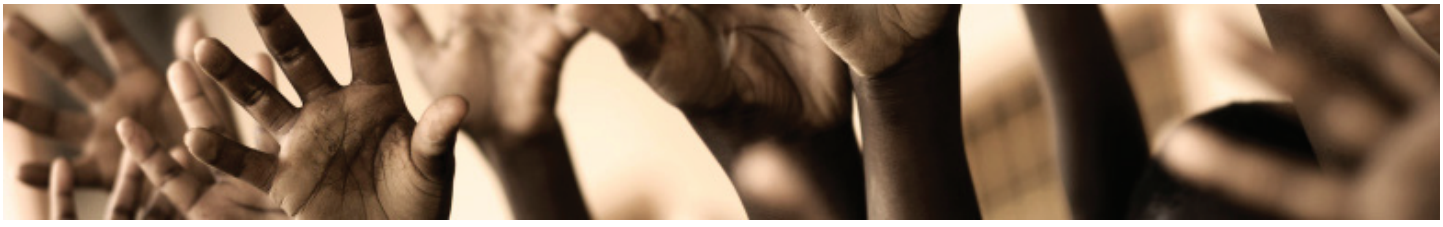
working paper
2012-10

The impact of China's priority forest programs on rural household income mobility

Can Liu
Sen Wang
Hao liu
Wenqing Zhu

October 2012



partnership for economic policy pep

The Impact of China's Priority Forest Programs on Rural Households Income Mobility

Abstract

Over the past two decades, China has undertaken unprecedented forest programs in an effort to restore damaged ecosystems and increasing farmers' income. Using survey results of 2,070 rural households in 15 counties of six provinces, we estimate the effects of China's Priority Forest Programs (PFPs) on rural households' income mobility. The effects of the area enrolled in the PFPs on rural households are mixed. It appears that larger area enrolled in the Industrial Timber Plantation Program and the Sloping Land Conversion Program pushed up rural households' income mobility, whereas greater area enrolled in the Natural Forest Protection Program constrained their income mobility, and the size of enrollment in the Desertification Combating Program around Beijing and Tianjin and the Shelterbelt Development Program in the Three-North Regions and the Yangtze River Basin seem to have little effect on rural households' income mobility.

Keywords: Priority Forest Programs, income mobility, rural development, forest economics, policy

JEL Codes: D1. 14C. 92R. Q

Authors

Can Liu
China National Forestry Economics and Development Research Center
Beijing, China
beijing1992nanjing@gmail.com

Hao Liu
China National Forestry Economics and Development Research Center
Beijing, China
6hao1121@163.com

Sen Wang
Canadian Forest Service
Natural Resources Canada
Ottawa, Canada

Wenqing Zhu
China National Forestry Economics and Development Research Center
Beijing, China
zhuwenqing2009@gmail.com

Acknowledgement

We gratefully acknowledge financial and scientific support from the Partnership for Economic Policy (PEP), which is financed by the Australian Agency for International Development (AusAID) and by the Government of Canada through the International Development Research Centre (IDRC) and the Canadian International Development Agency (CIDA). www.pep-net.org . We are also grateful for the financial supports from Technical Assistance (TA-4307) of the Asian Development Bank, from 2004 to 2006, and the Ministry of Finance of the Peoples' Republic of China, from 2004 to 2012

Table of content

1. Introduction

As a concept advanced by Friedman (1962), income mobility describes changes in the income of an individual or a set of individuals in the overall income distribution of a defined group. The focus in income mobility studies is to observe movements in income levels by employing relevant methods to estimate and analyze dynamic changes of a targeted position in the income distribution. Income mobility has already become a crucial part of income distribution analysis (Fields et al. 2002, 2003; Alesina et al. 2004; Shorrocks 1978, 1982; Chakravarty et al. 1985; Peter and Huynh 2006; Dragoset et al. 2007). For reasons of data availability, empirical studies of income mobility began with cases pertaining to developed countries (Atkinson et al. 1992; Gottschalk 1997; Wodon 2001; Maasoumi and Trede 2001; Fields 2007; Jarvis and Jenkins (1998) and just a few developing countries (Gaiha 1988; Kapitány and Molnár 2004; Yitzhaki and Wodon 2004).

China's per capita gross domestic product (GDP) has increased eightfold since 1978 (Zheng et al. 2008). Similarly, farmers' per capita income increased from 134 yuan in 1978 to 1,060 yuan in 2008 (1978 constant price), or an increase of 6.9 times (China National Statistics Bureau 2009). However, income disparity of rural households has expanded since 1978, whereas the Gini coefficient widened from 0.21 in 1978 to 0.37 by 2007 (Ministry of Agriculture 2008). Obviously, how to further reduce rural poverty and income inequality remains a top priority in China. Some studies related to income mobility in China have been carried out (Nee 1996; Nee et al. 1997; Khor and Pencavel 2006; Yin et al. 2006; Sun 2007; Wang et al. 2007; Wang 2005), and found that income mobility contributed to income equality and urban households' income mobility appeared to be stable or changing slowly over time.

Since 1998, the Natural Forest Protection Program (NFPP), the Sloping Land Conversion Program (SLCP), the Desertification Combating Program around Beijing and Tianjin (DCBT), the Shelterbelt Development Program in the Three-North Regions and the Yangtze River Basin (SBDP), the Wildlife Conservation and Nature Reserve Program (WCNR), and the Industrial Timber Plantation Program (ITPP) have been gradually launched by the Government of China to restore degraded ecosystems (see Appendix 1 for detail). In addition to improving the environmental and natural resource conditions, the Government of China has used these PFPs to enhance the income levels of

rural residents (State Forestry Administration 2002, 2003). The number of rural households that participated in the SLCP and the DCBT in 2001 was 3,577,296 and 13,610, respectively, but the participation number jumped to 26,840,778 and 2,524,382, respectively in 2008 (State Forestry Administration 2008). Large tracts of forestland of rural households have been enrolled under the NFPP, WCNR, ITPP and the SBDP within the PFPs program areas.

Large-scale and effective land conversion and forest ecological restoration programs have mainly taken place in developed countries, notably the Conservation Reserve Program in the United States of America (Cowan and Johnson 2008), the Permanent Cover Environmental Program in Canada, and a variety of short-term set aside programs and long-term forest programs in the European Union (OECD 1997). In many developing countries, on the other hand, rapid population growth and the associated increase in food demand have led to a continued reclamation of marginal land and deforestation (Scherr and Yadav 1996). Many developing countries have also paid attention to forest ecological restoration (FAO 2009). Given China's significant experience in this respect, an assessment of the impact of the PFPs on rural households' income mobility is not only useful for China, but also insightful for other countries, especially those countries that are about to embark on similar pathways of economic transitions.

The implementation of the PFPs has direct and indirect impact on rural households' income levels. From the perspective of rural households, the direct effects of these PFPs are mainly reflected in the government subsidies (under the SLCP and the DCBT), the government restrictions (under the NFPP and the WCNR), and the government incentives (under the ITPP and the SBDP). The indirect impact on rural households' income is mainly reflected in production endowment adjustments caused by these PFPs. Some rural households have participated in these PFPs while others have not. There exist numerous tradeoffs, most of which can result in changed patterns of land use and production. Induced by the land reallocation and production shift, farmers have to intensify farming and commercial forestry activities on their remaining lands, switch animal husbandry from open grazing to pen raising, or search for off-farm jobs in order to sustain their income growth. Therefore, it is expected that following their participation in the PFPs, rural households' income sources and employment structure, and production technology will undergo major transformation. To be sure, in addition to farmers' own initiatives, efforts, and inputs, the extent and trend of their income and

employment changes depend critically on the availability and effectiveness of technical, financial, and personnel assistance provided by the local public agencies. Finally, the PFPs have been gradually launched in a number of counties and rural households have been enrolled in the PFPs in different years. For example, provinces such as Shaanxi, Sichuan, Hebei, Jiangxi, and Guangxi Zhuang Autonomous Region have participated in the SLCP since 1999, 1999, 2002, 2001 and 2002, respectively. In the meantime, even in a same village, rural households varied in their involvement in the SLCP and the DCBT from one year to another. Changes have taken place in the income levels of an individual or a set of individuals in terms of the overall income distribution of a defined group, i.e., income mobility.

Some studies related to the direct and indirect effects of the PFPs on rural households' income have been conducted (Zhao and Wang 2006; Hu 2005; Li et al. 2004; Guo and Yao 2007; Liu and Zhang 2006; Xu et al. 2004; Yi et al. 2006). Besides, change in income structure has also been examined (Zhu et al. 2005; Guo et al. 2005; Yi et al. 2006; Zhao et al. 2006; Hu 2005; Xu et al. 2004). For those participating households, the area of farmland and forestland committed has varied considerably, due to different preferences and responses to market signals. It is reasonable to hypothesize that the PFPs have altered rural household income, income inequality and income mobility. The impact of the PFPs on rural households' income inequality has been explored (Liu et al. 2010) by means of dataset involving short intervals. It has been recognized that understanding income mobility is of great importance, because it helps explain entrenched nature of households' income.

To our best knowledge, because of data limitations and constraints of sample sizes, earlier studies used dataset covering one year or a few years and one region or a few regions. It is very difficult for those researchers to consider the impact of the implementation of the PFPs on rural households' income mobility. This paper uses a dataset of 2,070 rural households collected from 15 counties in provinces including Shandong, Shaanxi, Guangxi Zhuang Autonomous Region, Sichuan, Hebei and Jiangxi from 1995 to 2008 to analyze the impact of the PFPs on income mobility of rural households, with a view to understanding whether long-term income inequality has been reduced. With the assistance of a large dataset involving a relatively long period of time, we were interested in estimating the effects of the PFPs on rural households' income mobility and, in turn, analyze changes

in income distribution. Our empirical results indicate that the impacts of the PFPs on rural households' income mobility are mixed. The Government of China has made it clear that the PFPs will continue to be implemented in the 12th Five-Year National Development Plan (2011-2015) and the 13th Five-Year National Development Plan (2016-2020). Therefore, the findings of our study will be helpful to government agencies for the next phases of implementation to attain the goals of both ecological restoration and poverty reduction.

The structure of the paper is as follows: the next section describes the methodology and data; then, the empirical results are presented. The paper ends with a discussion and conclusion.

2. Methodology

Consider an initial vector of sample rural households' income $X=(x_1,x_2,..,x_k,...,x_n)\in R_+^n$, where x_k is the k[th] household income ranked in an ascending order of income ($k=1,2,3,...,n$), and $n>1$ is the population. After t period(s), x becomes $y\in R_+^n$, where the households are ordered the same in y as in x. Suppose each household in x is allocated to one of m equally populated ranked income groups indexed by i. The households in y are grouped in groups based on y income. Let $P_{ij}\geq 0$ be the probability that a household in group i will be in group j t periods later, and define the $m\times m$ transition matrix:

$$P:=[P_{ij}],\ \text{with}\ \sum_{j=1}^{n}P_{ij}=\sum_{i=1}^{n}P_{ij}=1 \qquad (1)$$

If the possible values of variable X_n have m kinds of status and they are arranged into a probability matrix P after one period:

$$P=\begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1m} \\ P_{21} & P_{22} & \cdots & P_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ P_{m1} & P_{m2} & \cdots & P_{mm} \end{bmatrix} \qquad (2)$$

The $m\times m$ transition matrix $P:=[P_{ij}]$ is called one step transition probability matrix, obviously,

$$P_{ij}\geq 0\ \text{ And }\ P_{ij}=P_{ji} \qquad (3)$$

If variable is in state i at period T_n, but shift to state j by t steps, we then call this probability of transition t step transition probability, which is:

$$P(X_{n+k} = j / X_n = i) = P_{ij}(k), i, j = 1,2,...,m \quad (4)$$

For $P := [P_{ij}]\ i, j = 1,2,\cdots,m$, it could be written as:

$$P_{ij}(k) = \begin{bmatrix} P_{11}(k) & P_{12}(k) & \cdots & P_{1m}(k) \\ P_{21}(k) & P_{22}(k) & \cdots & P_{2m}(k) \\ \cdots & \cdots & \cdots & \cdots \\ P_{m1}(k) & P_{m2}(k) & \cdots & P_{mm}(k) \end{bmatrix} \quad (5)$$

The element P_{ij} indicates the probability of number i rural household in the base year shifting to number j income group in the final year. The matrix is full mobility matrix with $P_{ij} = 1/\mathrm{n}$, which has absolute time-independent and acts as the frame of reference.

Because rural household income mobility is not easily observed from income mobility transition matrix, it is necessary to calculate the Average Quintile Immobility Rate (AQIR) and the Average Quintile Move Rate (AQMR). Reflecting the income mobility of rural households, the AQIR is the average proportion of rural households that have the same income at t period after the initial income, which is the average of the diagonal values in the matrix. The equation is:

$$AQIR = \frac{1}{m}\sum_{i=1}^{m} P_{ij} \quad (6)$$

The AQIR estimates the average proportion of rural households at the same position. The higher the rate means the less the mobility. The AQIR of the full mobility matrix is $1/n$. The AQMR is the weighted average of transition probability and the weight is the shift between different groups.

$$AQMR = \frac{1}{n}\sum_{j=1}^{n}\sum_{k=1}^{n} |j-k| P_{jk} \quad (7)$$

The AQMR is the scale of the overall rural household income mobility, and the higher the value means the higher the mobility.

We arrange all sample rural households into five quantities according to the income levels and then create a 5*5 matrix.

For sample rural household income, we use the following formula to measure Gini coefficient:

$$G = \frac{1}{2n^2 \bar{x}} \sum_{i=1}^{n} \sum_{j=1}^{n} \left| x^i - x^j \right| \quad (8)$$

Where: $\bar{x}$ is the arithmetic mean income corresponding to x.

Fields (1999) defined the term “mobility” as “equalization of longer-term incomes”, i.e., the progressive index (P-value).

$$P = 1 - \frac{G(\bar{x}_1)}{G(x_i^0)} \quad (9)$$

In the above equation, $\bar{x}_1$ is the arithmetic income of rural households for a certain period; x_i^0 is the income of the number i rural household in the initial year; G (.) is the Gini coefficient. If P > 0, the average income distribution is more equal than the original distribution; if P < 0, the average income distribution is more unequal than the original year; if P = 0, the average income distribution remains the same as the initial year.

The P-value is also used to compare the extent of income distribution equality during different periods; if the P-value in the period i outweighs that in the period j, the average income distributions in the period i are more equal than that in the period j; if the P-value in the period i is less than that in the period j, the average income distributions in the period i are more unequal than that in the period j; if the P-value in the period i equals that in the period j, the average income distributions in the period i are as equal as that in the period j.

The characteristics, input of production factors, production structure (such as the ratio of off-farm employment) and policy factors such as the PFPs will affect the income of the farmers and these

parameters have some impact on rural household income mobility. We choose the AQIR and the AQMR of the sample counties as the dependent variables.

The AQIR and the AQMR are the change variables between the year of t and $t+1$ of the county *k*, thus we could consider the annual change in production factor inputs. With the implementation of the PFPs, rural households' farmland and forestland have experienced changes, resulting in restrictions on how the land may be used (Liu et al. 2010). Therefore, we choose the area enrolled in the PFPs of sample rural households to define these variables. In the meantime, the rural household head is the key decision-maker for rural household consumption and production. Generally speaking, the age of the rural household head is a key variable in affecting decision making (Liu et al. 2010). The size of tracts of forestland and plots of farmland also affects rural household income mobility. Thus rural household income mobility effect equation (10) may be defined as follows, and the definitions of the variables are listed in Table 3.

$$\begin{aligned} Y_{k(t+1)} &= \alpha_0 + \alpha_1(\ln \overline{perincome}_{k(t+1)} - \ln \overline{perincome}_{kt}) \\ &+ \alpha_2(\overline{wagerate}_{k(t+1)} - \overline{wagerate}_{kt}) + \alpha_3 \ln \overline{old}_{k(t+1)} + \alpha_4(\ln \overline{old}_{k(t+1)})^2 \\ &+ \alpha_5(\ln \overline{per\cos t}_{k(t+1)} - \ln \overline{per\cos t}_{kt}) + \alpha_6 \ln \overline{farm}_{k(t+1)} + \alpha_7 \ln \overline{for}_{k(t+1)} \\ &+ \alpha_8 \ln \overline{ITPP}_{k(t+1)} + \alpha_9 \ln \overline{SBDP}_{k(t+1)} + \alpha_{10} \ln \overline{SLCP}_{k(t+1)} \\ &+ \alpha_{11} \ln \overline{DCBT}_{k(t+1)} + \alpha_{12} \ln \overline{NFPP}_{k(t+1)} + \varepsilon_{k(t+1)} \end{aligned} \quad (10)$$

Where: y_{it} is AQIR or AQMR; $\overline{perincome}$ is the annual average income per capita (yuan/person) of the county *k*; $\overline{wagerate}$ is the ratio that the annual average off-farm income accounted for the total income of the county *k*; $\overline{per\cos t}$ is the annual average expenditure for land-based activities per mu of the county *j* (i.e., 15 mu = 1 hectare); and t is the year, 1, 2, 3, …, 12, 13, and 14； $\overline{ITPP}_{k(t+1)}, \overline{SBDP}_{k(t+1)}), \ln \overline{SLCP}_{k(t+1)}, \ln \overline{DCBT}_{k(t+1)} and \overline{NFPP}_{k(t+1)}$ is the annual average enrolled area of the ITPP, SBDP, SLCP, DCBT and NFPP of the county *k* in the year *t+1*, and *k* is the *kth* county.

It is worth noting that, as the rural household income mobility is presented at the county level, we could not calculate the income mobility for an individual rural household and, therefore, we use

annual averages of the county sampling households in equation (10) as the dependent variable. Hence, the total sample size for equation (10) is 195, based on a dataset covering 13 years and 15 sampling counties.

We performed a statistical analysis by employing an independent difference method, in order to compare the impact of the change in the independent variables on the income mobility. In view of the development stage of the PFPs in China, we divided the years 1995-2008 into four periods. As the NFPP and the SLCP were launched in 1998 and 1999, respectively, we chose 1995-1999 as Period I. Since the enrolled area under the SLCP reached its peak in 2003, we designated 2000-2003 as Period II. In 2007, the State Council of China announced a significant policy change for the SLCP, which resulted in a sharp reduction in the area enrolled under the SCLP to zero; therefore, we defined the years 2004-2006 as Period III. Finally, the years 2007-2008 constituted Period IV. While we used these periods to measure sample rural households' income mobility, we also calculated the income mobility by year during different intervals, for instance from 1995 to 1999, from 1999 to 2003 and from 2004 to 2008.

For the regression model of income mobility, i.e., equation (10), we have performed the Haussmann test to decide whether to use the random model or the fixed-effect model. In effect, we have concluded that the random model should be used instead of the fixed-effect model.

One other issue was whether or not households' participation in any of the PFPs is endogenously or self-selection decided, i.e., the problem of endogeneity bias. Liu et al. (2010) used the same dataset to test the presence of an endogeneity bias and their result suggested little effect of endogenous choice. In this respect, similar results were reported by Uchida et al. (2007) and Liu and Zhang (2006). In other words, rural households could choose to participate in a "take-it-or-leave-it" program only when their farmland or forest land are eligible for it. They will not have the option if their land is considered ineligible.

3. Data

The strained random sample model was adopted in this study. In light of the distributions of the rural households' income and the PFPs as well as our discussions with officials of provincial forestry

and other departments and local experts, we first selected 15 counties for our surveys. They are Zhangbei, Pingquan and Yixian in Hebei; Xiushui, Xingguo and Suichuan in Jiangxi; Zhen'an and Yanchang in Shaanxi; Nanbu, Nanjiang, Muchuan and Mabian in Sichuan; Pingguo and Huanjiang in Guangxi, and Pingyi in Shandong (see Figure 1). Each of these counties has participated in at least two of the PFPs with the exception of Pingyi County in Shandong Province being used as the baseline county for comparison purpose. For instance, Zhangbei County has participated in the DCBT and the SBDP, and Nanbu County has participated in the NFPP, the SLCP and the SBDP (see Table 1). As only Zhen'an and Huanjiang counties have two nature reserves, we selected only 5 sampling households, but did not list the WCNR in our table; however, we did analyze the effect of the WCNR on rural households' income mobility.

Figure 1. Distribution of study counties

Table 1. Participation of Sample Counties in the PFPs

Province	County	NFPP	SLCP	DCBT	ITPP	SBDP
Hebei	Zhangbei	○	○	★	○	★
	Pingquan	○	○	★	○	★
	Yi Xian	○	★	○	○	★
Jiangxi	Xiushui	○	★	○	★	★
	Suichuan	○	★	○	★	★
	Xingguo	○	★	○	○	★
Shaanxi	Yanchang	★	★	○	○	★
	Zhen'an	★	★	○	○	★
Sichuan	Mabian	★	★	○	○	★
	Muchuan	★	★	○	★	★
	Nanbu	★	★	○	★	★
	Nanjiang	★	★	○	○	★
Guangxi	Pingguo	○	★	○	★	★
	Huanjiang	○	★	○	★	★
Shandong	Pingyi	○	○	○	○	○

Note: NFPP, SLCP, DCBT, ITPP and SBDP represent, respectively, the Natural Forest Protection Program, the Sloping Land Conversion Program, the Desertification Combating Program around Beijing and Tianjin, Industrial Timber Plantation Development program and Shelterbelt Development Program in the Three Norths and the Yangtze River Basin. ★indicates that the sample county participates in the PFP; ○ indicates otherwise.

Sample villages and households were chosen randomly. Specifically, we chose the villages from the village list of a county and households from the household list of a village. Except for Zhangbei (among 270 sample households, we selected 90 households in each township) and Huanjiang, Pingguo, Yixian, Muchuan and Pingyi (of 135 sample households, we selected 45 households in each township) where three townships were selected, six townships were chosen in all other counties. Overall, 15 households were chosen in each sample village except for Zhangbei County (30 households were chosen). Altogether, we interviewed 3,375 households in 216 villages of 72 townships. Our initial survey was conducted in 2004 as part of our program monitoring and assessment efforts supported by the Asian Development Bank and the Chinese Ministry of Finance. To understand the microeconomic shifts over time, we asked interviewees to recall their production activities and other relevant information back to 1995. Then, in 2005, 2006, 2007 and 2008, we

repeated our surveys. As such, we were able to assemble a panel dataset covering 14 years (1995-2008), which has a longer and more continuous coverage than almost any other datasets used by others to assess the impacts of the six PFPs in China. In order to help interviewees describe their production and consumption behaviors, we designed the questionnaires in terms of specific production and consumption activities, and asked multiple family members to recall their household activities in each year, and cross-checked the responses by consulting with village resource persons and statistical data and information of case study counties, townships and villages. All these steps served to ensure high quality of the data collected.

However, our surveys did not contain complete information from some households. This is because a few of them moved away from the sample villages, errors occurred to some interviews, or certain families failed to clearly recall what had happened to them in the previous year(s). These factors led to the outcome of a slightly unbalanced panel over time. To measure rural households' income mobility, we need a balanced panel dataset. We decided to remove those observations with incomplete information and/or incomplete interviews, resulting in a balanced panel of 2,070 households for this study.

It is evident from Table 2 that, over the study period, more and more households were involved in the PFPs. Since the launching of these PFPs in 1998, the number of households that were not involved with the PFPs declined from 1,507 in 1998 to 508 in 2008. While some participated in multiple PFPs, others did not participate in any of them. While 33 households participated in both the NFPP and the SLCP in 1999, the figure increased to 656 by 2008. Meanwhile, 9 households were involved in the SLCP, NFPP and SBDP in 2008 (see Table 2). More specifically, a large number of households took part in the NFPP and the SLCP, but only a few were involved in the SBDP and even fewer in the ITPP. By the end of 2008, the sample households that participated in the NFPP, SLCP, DCBT, ITPP and SBDP were 904, 979, 283, 16 and 86, respectively.

The NFPP and the SLCP were initiated in Sichuan and Shaanxi provinces in 1998 and 1999, respectively; and Jiangxi Province and the Guangxi Zhuang Autonomous Region were included in the SLCP in 2001 and 2002, respectively. Both the SLCP and the DCBT were launched in Hebei Province in 2000.

Table 2. Evolution of Sample Households' Participation in the PFPs

Year	SLCP	NFPP	DCBT	ITPP	SBDP	SLCP & NFPP	SLCP & ITPP	SLCP & SBDP	NFPP & SBDP	DCBT & SBDP	ITPP & SBDP	SLCP, NFPP & ITPP	SLCP, NFPP, & SBDP	NONE
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	2070
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	2070
1997	0	0	0	0	1	0	0	0	0	0	0	0	0	2069
1998	0	562	0	0	0	0	0	0	1	0	0	0	0	1507
1999	270	529	0	0	0	33	0	0	1	0	0	0	0	1237
2000	38	444	0	0	0	459	0	0	1	0	0	0	0	1128
2001	50	399	0	0	0	504	0	0	1	0	0	0	0	1116
2002	163	330	131	0	0	573	0	0	1	3	0	0	0	869
2003	257	242	246	0	1	660	0	0	1	4	0	1	0	658
2004	276	254	263	0	1	648	0	0	1	6	0	1	0	620
2005	274	231	282	8	39	669	0	10	1	0	0	1	2	553
2006	268	226	283	9	63	673	0	19	1	0	0	2	2	524
2007	298	222	277	13	53	677	2	15	1	4	1	2	2	503
2008	291	236	277	12	51	656	2	19	1	6	0	2	9	508

The case study counties are located in the east; the west, the north and the south of China (see Figure 1). Although rural households' total income in some counties is lower than that of the national average (such as Zhangbei County and Mabian County), in some counties, rural households' income is the same as the national average (such as Yixian County) or higher than that of the national average (Pingyi County and Muchuan County). This means that these samples of rural households are representative of rural China.

Total income and cash outlay of sample households were deflated and converted to the 1994 constant yuan, using the rural consumer price index and rural industrial product price index from the Chinese Statistical Yearbooks, published by the China National Statistical Bureau (http://www.stats.gov.cn). Average annual total household income has been increasing since 1995, with the amount being 3,078 yuan, 5,775 yuan and 11,077 yuan in 1995, 2003 and 2008, respectively. The difference between the minimum and maximum income was extended, with the maximum household income being 38,422 yuan, 84,236 yuan and 192,676 yuan in 1995, 2003 and 2008, respectively (see Table 2). The weight of off-farm income was 43%, 53% and 59% in 1995, 2003 and 2008, respectively. The level of production costs for land-based activities has been increasing, being 524 yuan, 714 yuan and 1,563 yuan in 1995, 2003 and 2008, respectively. With the implementation of the PFPs, farmland area per household decreased from 8.3 mu in 1995 down to 5.8 mu in 2003 and to 5.7 mu in 2008. Meanwhile, forestland area per household rose from 9.9 mu in 1995 to 14.4 mu in 2003 and 18.6 mu in 2008. Area of other land types per household fluctuated during the study period. The area enrolled in the SLCP and the NFPP is largest among the PFPs; the area enrolled in the SLCP increased from 3 mu in 2003 to 4.1 mu in 2008; during the same period, the area enrolled in the NFPP increased from 0.9 mu to 3.7 mu; and the area enrolled in the DCBT also increased by 0.2 mu. The area enrolled in the SBDP has been up from 0.05 mu to 0.73 mu, and the area enrolled in the ITPP did not show significant change, from 0.00 mu to 0.15 mu (see Table 2).

The income levels of the sample rural households grew gradually and the average income per household was 4,442 yuan in 1995 (in 1994 constant price) and then increased to 12,109 yuan (in 1994 constant price). The structure of income has experienced significant changes. The

income from cropland was the main source of income before 2005, in that the ratio of the income from cropland declined from 69% in 1995 to 41% by 2004. The off-farm income became the main source of income in 2005 and 2006, with the ratio being 50.3% and 50%, respectively. Furthermore, the ratio of subsidy from the PFPs in total income increased, as the ratios rose from 0.3% to 2.9%, 8.9% and 8.3% in 1995, 2000, 2005 and 2006, respectively.

Average household size has expanded from 3.6 persons in 1995 to 4.2 persons in 2008. The age of household head has increased over time as well (see Table 3).

Table 3. Summary Statistics of Household Data in 1995, 2003 and 2008

Year	Variable definition		Mean	SD	Min	Max
1995	Total income (yuan)	*toincome*	3078.11	3013.22	17.42	38422.39
	Off-farm income (yuan)	*wage*	1323.33	2634.21	0.00	38167.94
	Household size (person)	*popula*	3.56	1.20	1.00	8.00
	Age of household head (year)	*old*	37.68	10.96	11.00	74.00
	Expenditure (yuan)	$\cos t$	524.37	473.42	0.00	8016.91
	Farmland area (mu)	*farm*	8.27	9.53	0.00	86.00
	Forestland area(mu)	*for*	9.90	24.27	0.00	680.00
	Other land area(mu)	*otherland*	0.45	3.24	0.00	95.40
	Area enrolled in ITPP(mu)	*ITPP*	0.00	0.00	0.00	0.00
	Area enrolled in SBDP(mu)	*SBDP*	0.00	0.00	0.00	0.00
	Area enrolled in SLCP(mu)	*SLCP*	0.00	0.00	0.00	0.00
	Area enrolled in DCBT(mu)	*DCBT*	0.00	0.00	0.00	0.00
	Area enrolled in NFPP(mu)	*NFPP*	0.00	0.00	0.00	0.00
2003	Total income (yuan)	*toincome*	5775.28	5203.41	74.88	84235.88
	Off-farm income (yuan)	*wage*	3075.84	4737.62	0.00	79037.62
	Household size (person)	*popula*	3.90	1.32	1.00	9.00
	Age of household head (year)	*old*	45.68	10.96	19.00	82.00
	Expenditure (yuan)	$\cos t$	714.33	708.99	0.00	11427.05

	Farmland area (mu)	*farm*	5.77	6.33	0.00	86.00
	Forestland area(mu)	*for*	14.40	25.81	0.00	680.00
	Other land area(mu)	*otherland*	2.76	10.66	0.00	103.40
	Area enrolled in ITPP(mu)	*ITPP*	0.00	0.05	0.00	2.10
	Area enrolled in SBDP(mu)	*SBDP*	0.05	1.04	0.00	28.50
	Area enrolled in SLCP(mu)	*SLCP*	3.02	7.33	0.00	102.30
	Area enrolled in DCBT(mu)	*DCBT*	0.77	3.90	0.00	66.40
	Area enrolled in NFPP(mu)	*NFPP*	0.85	21.22	0.00	960.00
2008	Total income (yuan)	*toincome*	11077.19	12815.13	66.52	192675.60
	Off-farm income (yuan)	*wage*	6495.21	9072.81	0.00	122399.00
	Household size (person)	*popula*	4.15	1.52	1.00	9.00
	Age of household head (year)	*old*	50.64	11.16	23.00	84.00
	Expenditure (yuan)	$\cos t$	1526.62	5466.36	0.00	123461.80
	Farmland area(mu)	*farm*	5.66	6.65	0.00	60.50
	Forestland area(mu)	*for*	18.64	29.29	0.00	500.00
	Other land area(mu)	*otherland*	1.99	8.99	0.00	88.20
	Area enrolled in ITPP(mu)	*ITPP*	0.15	2.73	0.00	100.00
	Area enrolled in SBDP(mu)	*SBDP*	0.73	5.77	0.00	126.70
	Area enrolled in SLCP(mu)	*SLCP*	4.06	9.48	0.00	104.00
	Area enrolled in DCBT(mu)	*DCBT*	0.95	3.66	0.00	49.40
	Area enrolled in NFPP(mu)	*NFPP*	3.74	13.51	0.00	221.00

4. Empirical results

In this section, we report the empirical results of the Gini coefficient, income mobility – AQIR and AQMR, and estimates of the regression model of income mobility.

4.1 Gini coefficient

By using equation (8), we calculated the Gini coefficient from 1995 to 2008. Figure 2 indicates that the Gini coefficient went down from 0.45 in 1995 to 0.35 in 2006, but it rebounded in

2007 and 2008; similar trends have been observed for China's rural households during the period (see Ministry of Agriculture 2009).

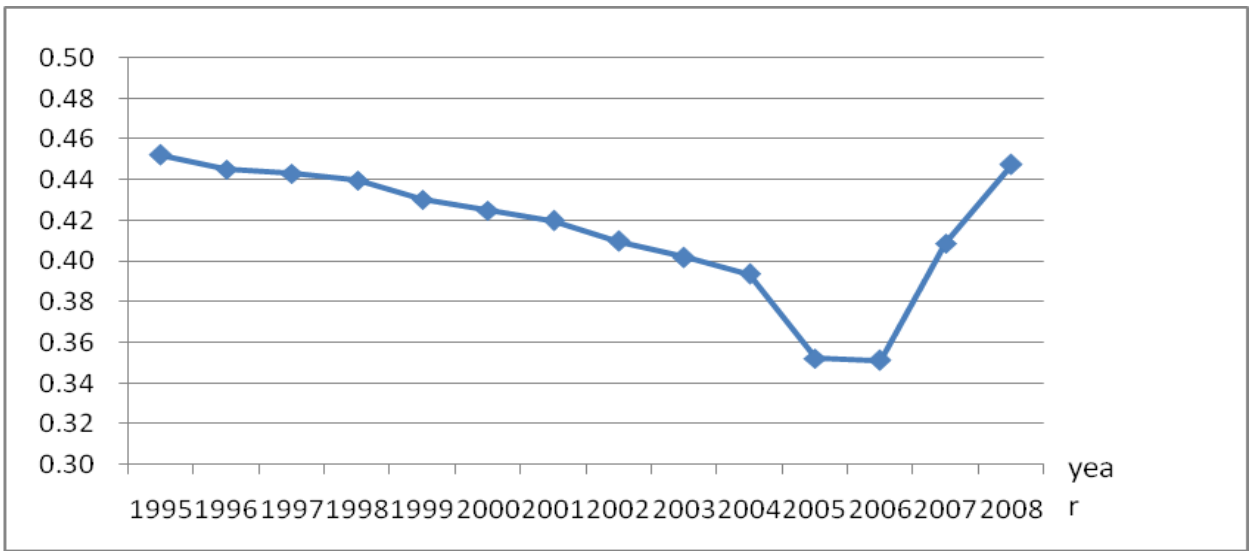


Figure 2. Gini coefficients of the sample household

This implies that the rural households' income inequality first narrowed, and then extended. The Gini coefficient did not change much from 1995 to 1998. During the period from 1999 and 2006, the Gini coefficient fell from 0.44 in 1998 to 0.35 in 2006, but after 2006, the Gini coefficient has rebounded (Figure 2). The Gini coefficient for the case study county became smaller from the launch of these PFPs in 1998 to 2005 or 2006. For instance, it reduced by 0.12 in Nanbu County, indicating that there are linkages between the PFPs and the income equality and the income mobility.

4.2 Income mobility

We calculated the AQIR and AQMR of the case study provinces and all samples by year and by period (see tables 4 and 5).

Table 4. AQIR and AQMR

Region	Period	AQIR	AQMR
Sichuan	(1995~1999) ~ (2000~2003)	0.51	0.59
	(2000~2003) ~ (2004~2006)	0.44	0.76

	(2004~2006) ~ (2007~2008)	0.30	1.14
	(1995~1999) ~ (2000~2008)	0.35	0.92
Jiangxi	(1995~1999) ~ (2000~2003)	0.53	0.56
	(2000~2003) ~ (2004~2006)	0.31	1.12
	(2004~2006) ~ (2007~2008)	0.30	1.16
	(1995~1999) ~ (2000~2008)	0.37	0.90
Hebei	(1995~1999) ~ (2000~2003)	0.52	0.60
	(2000~2003) ~ (2004~2006)	0.39	0.91
	(2004~2006) ~ (2007~2008)	0.33	1.12
	(1995~1999) ~ (2000~2008)	0.40	0.89
Shaanxi	(1995~1999) ~ (2000~2003)	0.49	0.6
	(2000~2003) ~ (2004~2006)	0.36	0.99
	(2004~2006) ~ (2007~2008)	0.38	0.98
	(1995~1999) ~ (2000~2008)	0.35	0.97
Shandong	(1995~1999) ~ (2000~2003)	0.63	0.42
	(2000~2003) ~ (2004~2006)	0.63	0.51
	(2004~2006) ~ (2007~2008)	0.28	1.30
	(1995~1999) ~ (2000~2008)	0.42	0.74
Guangxi	(1995~1999) ~ (2000~2003)	0.51	0.69
	(2000~2003) ~ (2004~2006)	0.55	0.58
	(2004~2006) ~ (2007~2008)	0.29	1.24
	(1995~1999) ~ (2000~2008)	0.40	0.87
All samples	(1995~1999) ~ (2000~2003)	0.54	0.57
	(2000~2003) ~ (2004~2006)	0.42	0.84
	(2004~2006) ~ (2007~2008)	0.33	1.10
	(1995~1999) ~ (2000~2008)	0.39	0.88

As discussed above, four periods have been designated, i.e., Period I (1995-1999), Period II (2000-2003), Period III (2004-2006) and Period IV (2007-2008). We calculated the average rural household income within the given period before calculating the AQIR and AQMR. Except for Shaanxi Province (with income mobility from Period III to Period IV (AQIR=0.38) being greater

than that from Period II to Period III (AQIR=0.36), for other provinces and all samples, the income mobility demonstrated a decreasing trend. For all samples, the calculations of the AQIR from

Period I to Period II, from Period II to Period III, and from Period III to Period IV are 0.54, 0.42 and 0.33. For the same periods, the AQMR values are 0.57, 0.84 and 1.10, respectively (see Table 4). Generally speaking, income mobility has been active.

Table 5. AQIR and AQMR

Region	Period	AQIR	AQMR
Sichuan	1995~1999	0.93	0.48
	1995~2003	0.80	0.90
	1995~2008	0.59	1.44
	1999~2003	0.90	0.66
	1999~2008	0.59	1.38
	2003~2008	0.61	1.36
Jiangxi	1995~1999	0.92	0.47
	1995~2003	0.80	0.86
	1995~2008	0.56	1.45
	1999~2003	0.89	0.67
	1999~2008	0.58	1.45
	2003~2008	0.59	1.43
Hebei	1995~1999	0.86	0.72
	1995~2003	0.78	0.93
	1995~2008	0.64	1.30
	1999~2003	0.80	0.86
	1999~2008	0.63	1.35
	2003~2008	0.63	1.28
Shaanxi	1995~1999	0.89	0.62
	1995~2003	0.73	1.00
	1995~2008	0.61	1.34
	1999~2003	0.82	0.79

	1999~2008	0.66	1.24
	2003~2008	0.63	1.24
Shandong	1995~1999	0.94	0.48
	1995~2003	0.87	0.70
	1995~2008	0.53	1.52
	1999~2003	0.90	0.46
	1999~2008	0.61	1.35
	2003~2008	0.55	1.37
Guangxi	1995~1999	0.88	0.58
	1995~2003	0.78	0.90
	1995~2008	0.58	1.40
	1999~2003	0.82	0.81
	1999~2008	0.59	1.41
	2003~2008	0.63	1.36
All samples	1995~1999	0.90	0.54
	1995~2003	0.80	0.87
	1995~2008	0.59	1.39
	1999~2003	0.87	0.70
	1999~2008	0.60	1.36
	2003~2008	0.62	1.32

In terms of income mobility by year, income mobility of all case study provinces and all samples (with the exception of Shaanxi Province) tends to be similar. Income mobility from 2003 to 2008 was higher than that from 1995 to 1999 and from 2000-2003. The AQIR from 2003 to 2008 for Sichuan, Jiangxi, Hebei, Shaanxi, Guangxi and all samples was calculated to be 0.61, 0.59, 0.63, 0.63, 0.55, 0.63 and 0.62, respectively. The sample rural households' income mobility was higher than that from 1995 to 1999 and from 1999 to 2003. In the meantime, the income mobility from 1999 to 2003 (AQMR=0.70 for all samples) was higher than that from 1995 to 1999 (AQMR=0.54 for all samples). Long-term income mobility is higher than that of the short-term, for example AQIR=0.93, 0.80 and 0.59 from 1995 to 1999, 2003 and 2008.

4.3 Effects of PFPs on sample rural households' income mobility

On the basis of the endogenenity test and Haustman test for random or fixed-effect model selection, we chose the random model for analyzing the effects of the PFPs on sample rural households' income mobility. The empirical regression results are presented in Table 6.

Table 6. Regression Results of Sample Households' Income Mobility and PFPs

Variable	AQIR	AQMR
$\ln \overline{perincome_{k(t+1)}} - \ln \overline{perincome_{kt}}$	-0.26*** （0.09）	0.51*** （0.18）
$\overline{wagerate_{k(t+1)}} - \overline{wagerate_{kt}}$	-0.40** （0.18）	0.88** （0.36）
$\ln \overline{old_{k(t+1)}})$	24.06*** （6.99）	-51.98*** （14.18）
$\ln \overline{old_{k(t+1)}} \times \ln \overline{old_{k(t+1)}}$	-3.27*** （0.92）	7.04*** （1.87）
$\ln per\cos tk_{i(t+1)} - \ln per\cos t_{kt}$	-0.09*** （0.03）	0.18*** （0.07）
$\ln \overline{farm_{k(t+1)}}$	-0.05*** （0.02）	0.07** （0.03）
$\ln \overline{for_{k(t+1)}}$	0.02* （0.01）	-0.01 （0.02）
$\ln \overline{ITPP_{k(t+1)}}$	-0.05*** （0.01）	0.11*** （0.02）
$\ln \overline{SBDP_{k(t+1)}}$	-0.002 （0.008）	0.002 （0.02）
$\ln \overline{SLCP_{k(t+1)}}$	-0.02*** （0.006）	0.03** （0.01）
$\ln \overline{DCBT_{k(t+1)}}$	-0.01 （0.01）	0.01 （0.02）
$\ln \overline{NFPP_{k(t+1)}}$	0.01*** （0.004）	-0.02* （0.01）
cons	-43.34 （13.23）	95.87 （26.84）

R^2	0.56	0.56

* Significant at 0.10 level;

** Significant at 0.05 level and

*** Significant at 0.01 level. Standard errors are in parentheses.

Table 6 indicates that the annual differences and annual wage rates have negative effects on the AQIR and positive effects on the AQMR, significant at the 0.05 level. The impact of the age of the household head and the age squared of the household head on the AQIR and the AQMR are significant at the 0.01 level.

The level of annual production cost differences for land-based activities has a negative effect (-0.09) on the AQIR and a positive effect (0.18) on the AQMR, which is significant at the 0.01 level. Farmland area has a similar impact on the AQMR or the AQIR as that of annual production cost differences. Forestland area has a mixed effect on the AQIR (0.02) and the AQMR (-0.01), which is significant at the 0.10 level or insignificant.

Higher annual income per capita and wage rate differences, production cost for land-based activities and an increase in farmland area tend to push up sample households' income mobility, and the impacts of these variables on the AQIR are negative and positive on the AQMR; all coefficients are significant at the 0.01 or 0.05 level. Forestland area has less or insignificant impact on rural household income mobility (see Table 6).

The impacts of the PFPs are mixed. The coefficients of the area enrolled in the SLCP on the AQIR and the AQMR are -0.02 and 0.03, significant at the 0.01 and 0.05 level, respectively. The impact of the area enrolled in the ITPP was found to be higher compared with that of the area enrolled in the SLCP, as the coefficients for the AQIR and the AQMR are -0.05 and 0.11, significant at the 0.01 level. The impact of the area enrolled in the NFPP is similar as those of the SLCP and the ITPP, as the coefficients of the area enrolled in the NFPP on the AQIR and the AQMR are 0.01 and -0.02, significant at the 0.01 and 0.10 level, respectively (see Table 6).

The implementation of the ITPP and the SLCP has pushed up rural household income mobility, whereas the launch of the NFPP caused rural household income mobility to fall. The

empirical results indicate that the DCBT and the SBDP had no significant impact on rural household income mobility.

4.4 Income mobility and long-term income inequality

We calculated P-value by using equation (10), and the results are presented in Table 7.

Table 7. P-value for Different Case Study Provinces and Periods

Period		P-value
All samples	1995-1996	0.02
	1995-1997	0.03
	1995-1998	0.04
	1995-1999	0.06
	1995-2000	0.08
	1995-2001	0.10
	1995-2002	0.11
	1995-2003	0.13
	1995-2004	0.15
	1995-2005	0.21
	1995-2006	0.25
	1995-2007	0.29
	1995-2008	0.32

Region	Period	P-value
Sichuan	1995-1999	0.04
Jiangxi		0.05
Hebei		0.06
Shaanxi		0.10
Shandong		0.13
Guangxi		0.02
Sichuan	1999-2003	0.08
Jiangxi		0.11
Hebei		0.09
Shaanxi		0.12
Shandong		0.06
Guangxi		0.03
Sichuan	2003-2008	0.27
Jiangxi		0.34
Hebei		0.18
Shaanxi		0.22
Shandong		0.08
Guangxi		0.24

Table 7 shows that P-value has become larger with the longer time span, increasing from 0.02 for the period between 1995 and 1996 to 0.32 for the period from 1995 to 2008. P-value varies from one case study province to another. Specifically, P-value for Sichuan, Jiangxi, Hebei, Shaanxi, Shandong and Guangxi during the period from 1995 to 1999 is 0.04, 0.05, 0.06, 0.10, 0.13 and 0.03, respectively. P-value of these case study provinces was highest during the period

from 2003 to 2008 and lowest during the period from 1995 to 1999 (see Table 7). These empirical results indicate that income mobility has contributed to long-term income equality.

5. Discussion and conclusions

We employed a dataset of 2,070 sample households from 15 counties of six provinces or autonomous region to conduct this analysis. The sample households' income inequality first narrowed and then expanded during the study period. Income mobility has contributed to long-term income equality. While income mobility varied for case study provinces and periods, the highest income mobility appeared after 2003, and the lowest income mobility appeared before the launch of the PFPs. Production factor inputs and household characters have affected income mobility. The effects of the area enrolled in PFPs on rural households are mixed. It appears that larger area enrolled in the ITPP and the SLCP pushed up rural households' income mobility, and enrollment of larger area in the NFPP constrained rural households' income mobility, and the size of enrollment in the DCBT and the SBDP seems to have little effect on villagers' income mobility. Thus, the PFPs have reduced the rural households' income inequality (P-value).

As we have discussed above, there is evidence to suggest that certain mechanisms of the PFPs caused rural households' income mobility. First of all, the areas enrolled and the starting points in the PFPs differed from one program area to another, which affected rural households' income mobility. Sample households from Sichuan and Shaanxi provinces have been involved in the NFPP since 1998 while those from other provinces have not. And sample households from Pingyi County, Shandong Province did not involved any PFPs since 1995. For the SLCP, Sichuan, Jiangxi, Hebei, Shaanxi and Guangxi began to participate in the program in 1999, 2001, 2002, 1999 and 2002, respectively.

After the launch of the PFPs, production factor inputs increased (see Table 3). Both labor inputs for land-based activities and off-farm activities have been increasing since 1995, and also the expenditure for land-based activities has increased **from 524.37 yuan per rural household in 1995 to 1526.62 yuan per capita**. Our empirical results indicate that the rates of increase in terms of labor input and production cost for land-based activities of those households participating

in the SLCP are 21.9% and 21.2% higher than those households that did not participate in the SLCP from 1999 to 2008. These production input differentials caused the income mobility to vary. The coefficients of the production factors are positive and significant at 0.01, 0.05 and 0.10 level, respectively (Liu et al. 2010). However, there are fairly large differences in the production factors by income cluster, because poor villagers' weight of off-farm employment of total labor is much lower than that of the rich, whereas rich villagers' expenditure for land-based activities is much higher than that of the poor.

In accordance with the NFPP policy, all forestland should be enrolled in the NFPP regions. Table 8 indicates that more area enrolled in the NFPP for the poorer and the poor, because the area enrolled in the NFPP of the poorer, the poor, the middle, the rich and the richer is 2.16 mu, 1.98 mu, 2.11 mu, 1.89 mu and 1.31 mu in 1999, and increased to3.77 mu, 4.54 mu, 3.79 mu, 3.32mu and 3.39 mu in 2008, respectively. Table 9 shows that the poor and the poorer have been involved the NFPP to a greater degree, as the number of the poorer and the poor was 439, while the number of the rich and richer was 279 in 2003.

Table 8. Area Enrolled in PFPs in 1999, 2003 and 2008 by Income Cluster (unit: mu)

Year	Income cluster	SLCP	DCBT	NFPP	ITPP	SBDP	labor for land-based activities	off-farm employment	expenditure for land-based activities
1999	the poorer	0.50	0.00	2.16	0.00	0.00	256.25	42.41	451.21
	the poor	0.58	0.00	1.98	0.00	0.00	237.12	65.87	520.55
	the middle	0.60	0.00	2.11	0.00	0.00	256.77	91.34	549.45
	the rich	0.86	0.00	1.89	0.00	0.03	235.00	137.21	688.39
	the richer	0.59	0.00	2.31	0.00	0.00	265.56	259.71	859.61
2001	the poorer	0.96	0.00	4.37	0.00	0.00	240.88	55.50	483.30
	the poor	1.58	0.00	4.13	0.00	0.00	235.02	72.69	552.28
	the middle	1.39	0.00	4.18	0.00	0.03	230.26	121.21	642.37
	the rich	1.54	0.00	2.69	0.00	0.00	238.75	184.68	745.84
	the richer	1.35	0.00	3.44	0.00	0.00	273.30	318.61	983.85
2003	the poorer	2.34	0.60	4.02	0.00	0.15	221.34	55.81	523.95

	the poor	3.74	0.75	4.32	0.01	0.04	236.90	99.00	565.62
	the middle	3.39	0.78	4.08	0.00	0.00	217.64	140.54	658.39
	the rich	3.10	0.97	3.49	0.00	0.03	240.81	223.93	768.35
	the richer	2.53	0.77	2.91	0.00	0.04	267.15	366.65	1055.37
2006	the poorer	2.66	0.59	3.95	0.06	0.17	236.30	65.14	474.02
	the poor	3.23	0.91	4.66	0.07	0.05	237.67	130.97	632.82
	the middle	3.64	1.20	3.89	0.01	0.15	226.55	186.90	665.76
	the rich	5.70	0.79	3.68	0.07	0.64	243.01	273.38	777.65
	the richer	3.67	1.15	2.64	0.05	2.05	251.36	394.69	1269.10
2008	the poorer	2.27	1.03	3.77	0.02	0.84	185.09	113.81	693.07
	the poor	4.96	1.14	4.54	0.05	0.89	189.23	160.82	876.04
	the middle	4.94	0.84	3.79	0.04	0.58	194.10	256.59	1128.24
	the rich	4.30	1.01	3.32	0.48	0.58	187.90	357.88	1419.56
	the richer	3.83	0.74	3.39	0.18	0.74	177.53	457.66	3516.16

With the implementation of the NFPP, commercial logging is forbidden and timber processing industries have been under the control of the governmental agencies. As a result, the poor and the poorer lost their income sources generated from these industries. Although these rural households' production behaviors have been changing, the rich and the richer could have more opportunities compared with the poor and the poorer. For example, the rich and the richer have invested in land-based activities and more labor inputs for off-farm employment. Therefore, the implementation of the NFPP has constrained rural households' income mobility.

Table 9. Number of Rural Households Enrolled in the PFPs by Income Cluster

Year	Cluster	SLCP	DCBT	NFPP	ITPP	SBDP
1999	the poorer	78	0	153	0	0
	the poor	70	0	120	0	0
	the middle	56	0	97	0	0
	the rich	56	0	97	0	1
	the richer	43	0	108	0	0
2001	the poorer	128	0	243	0	0
	the poor	129	0	196	0	0
	the middle	117	0	182	0	1
	the rich	90	0	147	0	0
	the richer	90	0	136	0	0
2003	the poorer	188	49	234	0	3
	the poor	194	51	205	1	1
	the middle	182	59	186	0	0
	the rich	194	52	159	0	1
	the richer	160	39	120	0	1
2006	the poorer	206	58	235	3	6
	the poor	205	59	220	2	7
	the middle	196	67	165	1	8
	the rich	192	49	153	3	26
	the richer	165	50	131	2	38
2008	the poorer	184	76	199	2	14

	the poor	208	57	202	1	16
	the middle	213	48	190	2	20
	the rich	191	58	144	7	19
	the richer	183	44	169	4	17

The average government subsidies are higher than the net benefit generated from the original sloping cropland (Liu and Wu 2010). The larger area enrolled in the SLCP can be explained by the higher net benefit that rural households derived. The size of enrollment in the SLCP of different income clusters changed from one year to another. The area enrolled in the SLCP by the poorer, the poor, the middle, the rich and the richer has increased by a factor of 3.7, 5.5, 4.7, 2.6 and 3.3 from 1999 to 2003, respectively, while these stakeholders' area enrolled in the SLCP has increased by -0.03 time, 0.33 time, 0.45 time, 0.39 time, and 0.52 time from 2003 to 2008 (see Table 8). For the SLCP, the area enrolled by the poor and the middle was much higher than that of other income groups, which has something to do with the policy arrangement of the large household management approach for implementing the program (see Table 8). And the number enrolled by the poor and the poorer was 382, while the figure enrolled by the rich and the richer was 194 and 160, respectively.

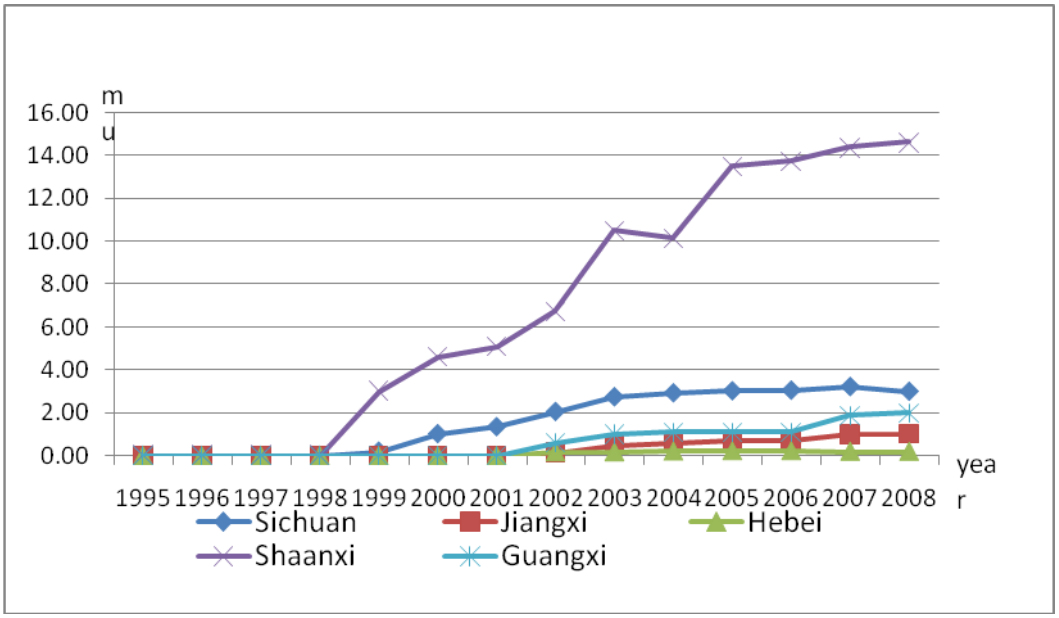


Figure 3. Area enrolled in the SLCP by province

The average area per household in these provinces in 2008 was 3.1 mu, 0.9 mu, 0.3 mu, 14.7 mu and 1.7 mu (see Figure 3) in Sichuan, Jiangxi, Hebei, Shaanxi, Guangxi respectively. In the meantime, the ratio of sample rural households in Shaanxi, Jiangxi, Guangxi, Sichuan and Hebei was 99.1%, 30.4%, 35.9%, 59.7% and 45.9%. Government subsidies under the SLCP accounted for a much higher percentage of the poor and the poorer villagers' total income than that of the rich and the richer (see Table 10). These factors have contributed to the rural households' income mobility.

Table 10. Weight of SLCP Government Subsidy of Rural Household Total Income by Income Cluster

Income cluster	the poorer	the poor	the middle	the rich	the richer
1998	0.00	0.00	0.00	0.00	0.00
1999	3.04	2.86	2.37	2.58	0.99
2000	7.84	6.75	4.66	3.86	1.85
2001	9.31	6.66	4.11	3.47	1.79
2002	11.71	9.04	8.20	6.43	2.53
2003	16.19	12.80	10.74	7.68	3.76
2004	14.51	13.87	8.68	8.05	5.80
2005	18.90	11.34	9.79	9.15	4.15
2006	17.89	10.51	8.79	7.98	3.48
2007	19.91	12.56	8.56	5.03	2.77
2008	17.78	12.99	8.24	4.59	1.86

The area enrolled in the ITPP differs among the income clusters (see Table 8). The difference in government incentive allocation among the rural households has played a role in causing rural households' income mobility.

Furthermore, the size of enrolment in the DCBT and the SBDP seems to have little effect on rural households' income mobility. In the meantime, governmental subsidies for those households participating in the DCBT were reversed due to losses caused by the switch of animal husbandry from open grazing to pen raising, and also almost all rural households have been enrolled in the DCBT in the program areas (the sample size of the DCBT program area in Zhangbei County and

Pingquan County being 295, and 283 sample rural households having been involved in the program), which help keep rural households' income constant. The SBDP was planned in accordance with the ecological functions; therefore, the area enrolled in the SBDP in terms of the number of households in the program areas is similar (see Table 8).

Other factors are also important to rural households' income mobility besides these PFP. Due to the fact that our paper focuses on the impact of the PFPs on rural households' income mobility, we did not explicitly analyze the effects of other factors on rural households' income mobility.

The implementation of the PFPs has affected households' income mobility, although these effects are mixed. The income mobility of rural households has contributed to long-term income equality. In this study we focus on short-term income mobility in China's rural area. However, it needs to be pointed out that income mobility reduces income disparity to a certain extent. The long-term effect of these PFPs on income mobility and long-term income inequality remains to be examined in the future. Long et al. (2006) and others raised concerns about the sustainability of these PFPs and short-term subsides. The Government of China has announced some new policy initiatives concerning the PFPs. Accordingly, the governmental agencies have invested in improving farmland productivity and resettlements in the SLCP regions. Overall, our findings suggest that the impact of the five PFPs on rural households' income is positive, which is conducive to long-term income equality.

Special acknowledgments

We appreciate the assistance of the research team members of ‘‘Poverty Reduction in the Priority Forestry Programs’’ and “The Effects of Priority Forestry Programs on Rural Household Income and Poverty Reduction Status in China” (No. 10-RG-12095-Liu) in collecting the household data. We are thankful to the three anonymous referees of the journal for their constructive comments. We are grateful for the financial supports from Technical Assistance (TA-4307) of the Asian Development Bank from 2004 to 2006, Ministry of Finance of the Peoples' Republic of China from 2004 to 2012, and the PEP (Poverty and Economic Policy), Canada from 2010 to 2012 (No. 10-RG-12095-Liu). Any remaining errors are solely our own.

References

Alesina, A., Tella, R.D., MacCulloch, R., 2004. Inequality and happiness: are Europeans and Americans different? Journal of Public Economics, 88, 2009-2042.

Atkinson, A.B., Bourguignon, F., Morrison, C., 1992. Empirical Studies of Earnings Mobility (Switzerland). Harwood Academic Publishers.

Chakravarty, S.R., Dutta, B., Weymark, J.A., 1985. Ethical indices of income mobility. Social Choice and Welfare, 2, 1-21.

China National Statistics Bureau, 2009. Year Book of China Statistics. China Statistics Publishing House.

Cowan, T., Johnson, R., 2008. Agriculture Conservation Program: A Scorecard. CRS Report for Congress.

Dragoset, L.M., Fields, G.S., 2007. Validating U.S. earnings mobility measures (Electronic version). Washington, DC: United States Census Bureau.

FAO, 2009. The State of the World's Forests 2009. FAO, Rome, 6-15.

Fields, G.S., 2001. Distribution and Development. A New Look at the Developing World, London: The MIT Press.

Fields, G.S., 2007. Does Income Mobility Equalize Longer-Term Incomes? New Measures of An Old Concept, Working Paper.

Fields, G.S., Ok, E., 1999. The measurement of income mobility: an introduction to the literature, In： J. Silber (ed.), Handbook on Income Inequality Measurement, Kluwer Academic Publishers, Dordrecht and New York.

Fields, G.S., Cichello, P.L., Freije, S., et al, 2003. For Richer or for Poorer? Evidence from Indonesia, South Africa, Spainand Venezuela, Journal of Economic Inequality, 1(1), 67-99.

Fields, G.S., Leary, J.B., Ok, A.E., 2002. Stochastic Dominance in Mobility Analysis, Economics Letters, 75(05), 333-339.

Friedman, M., 1962. Capitalism and Freedom, Chicago: University of Chicago Press.

Gaiha, R., 1988. Income mobility in rural India. Economic Development and Cultural Change, 36(2), 279-302.

Gardiner, K., Hills, J., 1999. Policy implications of new data on income mobility, The Economic Journal, 453, 91-111.

Gottschalk, P., 1997. Inequality, income growth, and mobility: The basic facts. Journal of Economic Perspectives, 11(2), 21-40.

Gan, G., Li, H., Luo, H., 2005. Sloping Land Conversion to Forestland – the issues, reasons and policy suggestions, China Rural Observation, 3, 72-79.

Guo, Y., Yao, S., 2007. The positive analysis of the effect of Sloping Land Conversion to Forestland on Rural households' income in Wuqi County. Agricultural Technology Economics, 26(8), 100-104.

Hu, X., 2005. The rural economic structure change after the implementation of Sloping Land Conversion to Forestland and Grassland. Chinese Rural Economics. 5. 63-70.

Jarvis, S., Jenkins, S.P., 1998. How much income mobility is there in Britain? The Economic Journal, 108, 428-443.

Kapitány, Z.S., Molnár, G.Y., 2004. Inequality and income mobility in Hungary, 1993-1998. Europe-Asia Studies, 56(8), 1109–1129.

Khor, N., Pencavel, J., 2006. Income mobility of individuals in China and the United States, IZA Discussion Paper.

Li, L., Liu, L., Tang, W., 2004. The effect of the Sloping Land Conversion to Forestland on farmers' income and rural economy, Rural Economy, 3, 50-51.

Liu, C., et al., 2010. An estimation of the effects of China's priority forestry programs on farmers' income. Environmental Management, 45(3), 526-540.

Liu, C., Wu, B., 2010. Grain for Green Program in China: Policy Making and Implementation? Brief Series—Issue 60, University of Nottingham China Policy Institution.

Liu, C., Zhang, W., 2006. Impacts of Conversion of Farmland to Forestland Program on Household Income: Evidence from a Sand Control Program in the Vicinity of Beijing and Tianjin, China Economic Quarterly, 23(6), 273－290.

Long, H.L et al, 2006. Land Use and Soil Erosion in the Upper Reaches of the Yangtze River: Some Socio-economic Considerations on China's Grain-for-Green Program. Land Degradation & Development, 17(6), 586-603.

Maasoumi, E., Trede, M., 2001. Comparing income mobility in Germany and the United States using generalized entropy mobility measures. The Review of Economics and Statistics, 83(3), 551-559.

Ministry of Agriculture of China, 2008. China Agriculture Yearbook 2008. China Agriculture Publishing House.

Ministry of Agriculture of China, 2009. China Agriculture Yearbook 2009. China Agriculture Publishing House.

Nee, V., 1996. The emergence of a market society: Changing mechanisms of stratification in China. American Journal of Sociology, 101(4), 908-49.

Nee, V. et al., 1997. Markets and Inequality in the Transition from State Socialism. Midlarsky I. M. ed. Inequality, Democracy, and Economic Development. Cambridge University Press, 202-235.

OECD, 1997. The Environmental Effects of Agricultural and Diversion Schemes, Paris, OECD.

Peter, G., Huynh, M., 2006. Impact of Non-Classical Measurement Error on Measures of Earnings Inequality and Mobility, Boston College and Social Security Administration Processed.

Quan, H., 2008. Income inequality and income mobility: International comparison and its significances, Journal of Social Sciences, 2, 4-13.

Quan, H., 2005. Governmental power, income mobility and income distribution—A theory framework and China's experiences, Social Science. 5, 64-73.

Scherr, Yadav, 1996. Land Degradation in the Developing World: Implications for Food, Agriculture, and the Environment to 2020. Food, Agriculture, and the Environment Discussion Paper.

Shorrocks, A.F., 1978. Income inequality and income mobility. Journal of Economic Theory, 19(2), 376-393.

Shorrocks, A.F., 1982. Inequality decomposition by factor components. Econometric, 50(1), 193-211.

State Forestry Administration, 2002. China Forestry Development Report. Beijing: China Forestry Publishing House.

State Forestry Administration, 2003. China Forestry Development Report. Beijing: China Forestry Publishing House.

State Forestry Administration, 2008. China Forestry Development Report. Beijing: China Forestry Publishing House.

Sun, W., 2007. An analysis of income mobility in rural China. Statistics and Decision-Making, 23(8), 149-151.

Uchida, E., Xu, J., Xu, Z., et al., 2007. Are the poor benefiting from China's land conservation program? Environment and Development Economics, 12(4), 593-620.

Wang, H., 2005. The household income mobility and its equalizing long-term income in China, Economic Research Journal, 1, 56-66.

Wang, J., Liang Y., 2007. A Survey on the current development of basic education in poor rural areas in Northwest China and its implications on policy-making. Peking University Education Review, 2, 147-156.

Wodon, Q., 2001. Income mobility and risk during the business cycle: Comparing adjustments in labor markets in two Latin-American countries, Economics of Transition, 9(2), 449-461.

Xu, J., Tao, R., Xu, Z., 2004. Sloping Land Conversion Program: Cost-effectiveness, Structural Effect and Economic Sustainability, China Economic Quarterly, 14(4), 143-166.

Yi, F., Xu, J., Xu, Z., 2006. The Re-Analysis of the Sloping Land Conversion to Forestland on Economic Activities, Chinese Rural Economy, 10, 28-36.

Yin, H., Li, S., Deng, Q., 2006. The urban individual income mobility in China, Economics Research, 10 , 30-43.

Yin, R., Yin, G., 2009. China's Ecological Restoration Programs: Initiation, Implementation, and Challenges. Yin R. S. ed. An Integrated Assessment of China's Ecological Restoration Programs. Springer Dordrecht Heidelberg London New York, 1-19.

Yin, R., Xu, J., Li, Z., Liu, C., 2005. China's Ecological Rehabilitation: Unprecedented Efforts, Dramatic Impacts, and Requisite Policies. China Environment Series, 6, 17-32.

Yitzhaki, S., Wodon, Q., 2004. Mobility, Inequality, and Horizontal Equity, in Professor John Bishop (ed.) Studies on Economic Well-Being: Essays in the Honor of John P. Formby (Research on Economic Inequality, Volume 12), Emerald Group Publishing Limited, 179-199.

Zhao, L., Wang, L., 2006. The effect of the Sloping Land Conversion to Forestland on rural households' income in Guyuan County. Forest Inventory and Planning. 6, 89-92.

Zhao, Y., 2008. The Income Mobility and Income Gap. Northern Economy, 1, 73-74.

Zheng, J., Bigsten, A., Hu, A., 2008. Can China's growth be sustained? A productivity perspective. World Development, 37, 874-888.

Zhu, S., Zhang, S., Tao, W., Wu, D., Xie, X., Yue, P., 2005. Identification and analysis of the factors influencing farmers' choices to replant crops in the SLCP Program, China Population, Resources and Environment, 5, 108-112.

APPENDIX 1: A Description of China's Priority Forest Programs

Severe natural disasters in the late 1990s intensified an environmental debate in China and resulted in the Government of China's initiation of several high-profile programs, notably, the Natural Forest Protection Program (NFPP) in 1998 and the Sloping Land Conversion Program (SLCP) in 1999 (Yin et al. 2005). Following successful piloting during 1998-1999, the NFPP was formally launched in 2000, with an initial investment of 96.4 billion yuan for the following decade (Yin and Yin 2009). A key component of the NFPP was the enforcement of logging bans over some 30 million ha of natural forests in the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River. In other areas, harvest restrictions were imposed. The SLCP was piloted in Sichuan, Shaanxi and Gansu provinces in 1999. The primary goal of the program was to convert 14.6 million ha of sloping and desertified farmland into forest and grass coverage between 2001 and 2010. When it was formally launched in 2002, the SLCP was expanded to 25 provinces, with an original budget of 225 billion yuan (Yin and Yin 2009). In addition to the above two mega-programs, a number of other initiatives of ecological restoration and forest expansion have been consolidated into the following four programs: the Desertification Combating Program around Beijing and Tianjin (DCBT), the Shelterbelt Development Program in the Three-North Regions (i.e., the Northwestern, North-central, and Northeastern regions of China) and the Yangtze River Basin (SBDP), the Wildlife Conservation and Nature Reserve Program (WCNR), and the Industrial Timber Plantation Program (ITPP). Along with the NFPP and the SLCP, these programs comprise the six priority forest programs (PFPs), which have been implemented for the purpose of restoring China's damaged ecosystems, increasing farmers' income, and boosting domestic timber supply.

The different policy arrangements and changes in implementing these six PFPs are summarized in Table A below.

Table A. Key Policy Measures of China's Priority Forest Programs

Program	Key Policies
Sloping Land Conversion Program (SLCP), covering 25 provinces during 2001-2010	• Sloping or desertified cropland is converted into ecological and/or economic forest, and grassland; ecological forest should account for 80% of total converted land. • The central government subsidizes farmers in the form of seeds or seedlings, grain, and cash. • Subsidies last 8 years for ecological forest, 5 years for economic forest, and 2 years for grassland. The annual cash subsidy is 300 yuan/ha, and the annual grain subsidy is 1500 kg/ha in the Yellow River basin and 2250 kg in the Yangtze River basin. • The central government also makes fiscal transfers to compensate for the entailed losses to local fiscal revenues. • Estimated total investment is 225 billion yuan. • Switch animal husbandry from open gazing to pen raising. • In 2007, the State Council decided that the second round subsidy would be taken, but the subsidy would be cut by half, i.e., the annual subsidy was to become 1050 yuan per ha in the Yellow River basin, and 1575 yuan per ha in the Yangtze River basin. The annual cash subsidy is 300 yuan per ha. The subsidy period was another five or eight years for the ecological forests or economic forests, respectively. Meanwhile, the sloping land conversion to forest or grass coverage would be terminated since 2007 and afforestation on the barren forestland would continue.
Natural Forest Protection Program (NFPP), covering 17 provinces during 2000-2010	• Complete ban on commercial logging in the upper Yangtze and middle Yellow River basins and sharp reduction in commercial harvests in other program areas. • Shutting down of certain processing facilities, compensating logging firms, and disposing displaced workers and equipment. • Promotion of afforestation and forest management wherever possible.

	• Strengthening administration and law enforcement, including forest protection. • Restricting the forest industry, and improving the efficiency of timber utilization. • Initial investment commitment is 96.4 billion yuan.
Shelterbelt Development Program (SBDP), covering all 31 provinces during 2001-2010	• Including shelterbelt programs in the Three Norths (northwest, north, and northeast), the Yangtze River basin, the Zhujiang River basin, and the Taihang Mountain Range. • Mobilization of public agencies, civil society, individuals to contribute to the shelterbelt development and tree planting. • Encouraging local government investment and local labor contribution, and adopting new silvicultural techniques. • Total planned investment is 70 billion yuan.
Desertification Combating around Beijing and Tianjin (DCBT), including Inner Mongolia, Hebei, Shanxi, Beijing, and Tianjin and 75 counties or banners during 2001-2010	• Converting desertified land into forestland and grassland by means of flexible and diversified measures based on the local conditions. • Changing herding and animal husbandry practices to control overgrazing and rehabilitate degraded grassland. • Developing irrigation projects, and resettling people away from fragile areas. • Extension of suitable production technology and energy sources. • Establishing desertification monitoring and dust storm forecasting systems. • Total projected investment is 57.7 billion yuan. • Switching animal husbandry from open grazing to pen raising. • In 2007, the State Council decided that the second round subsidy would be implemented, but the subsidy would be cut by half, i.e., the annual subsidy was to become 1050 yuan per ha in the Yellow River basin, and 1575 yuan per ha in the Yangtze River basin. The annual cash subsidy is 300 yuan per ha. The subsidy period was another five or eight years for the ecological forests or economic forests, respectively. Meanwhile, the sloping land conversion to

	forest or grass coverage would be terminated since 2007 and afforestation on the barren forestland would continue.
Industrial Timber Plantation Development Program (ITPP), covering 18 provinces during 2001-2015	• Market-driven and profit-orientated efforts for increasing domestic timber supply. • As high as 70% of the investment may come from subsidized National Development Bank loans, with 20% from direct government funding and 10% from other sources; in addition, certain tax incentive is provided. • Encouraging active participation by various enterprises – state or collectively owned, shareholder based, or fully private. • Planned area of establishment is 4.69 million ha by 2005, 9.2 million ha by 2010, and 13.33 million ha by 2015. • Projected total investment is 71.8 billion.

Sources: (Liu et al. 2010) and updated by the authors.