# Classification-based forest management program and farmers' income : evidence from collective forest area in southern China

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# Classification-Based Forest Management program and farmers' income: evidence from collective forest area in southern China

**Abstract**

**Purpose –** This article's purpose is to examine the effect of a Classification-Based Forest Management (CFM) program on farmers' income and determine whether its effect varies with the degree of farmers' concurrent occupations.

**Design/methodology/approach** – We use representative panel survey data from Longquan to explore the welfare effects of CFM on farmers. The analysis uses differences-in-differences with propensity score matching (PSM-DID) estimation techniques to deal with endogeneity problems when farmers make the decision to participate in CFM.

**Findings** – The results show that CFM has a positive effect on part-time forestry households (where forestry income accounts for between 5% and 50% of total income). In contrast, it has a negative impact on full-time forestry households (forestry income accounts for more than 50%), and no clear effect on non-forestry households whose forestry income is less than 5%. This research also shows that the positive effect of CFM on farmers' total income is mainly due to increase of off-farm income driven by CFM, while the negative effects consist of CFM's reduction of forestry income.

**Originality/value –** The extent of CFM's economic benefits to farmers is uncertain and largely unexplored. This paper analyzes the impact of CFM on income structure to explore the mechanisms explaining its effects on farmers' income. There are still challenges in ensuring the reliability and accuracy of CFM assessment. This paper collected natural experimental data, and used the estimation technology of PSM-DID to solve the possible endogeneity problems.

**Keywords** Farmers' income, CFM, PSM-DID, China

**Paper type** Research paper

## 1. Introduction

Halting the current loss and degradation of forests will help address two of the world's greatest and most interlinked global environmental challenges: biodiversity loss and climate change (Blackman and Bluffstone, 2021). However, wood is an important resource needed in economic development. Forest protection requires logging restrictions, which in turn affects development; that is, forest protection and economic development, especially in emerging and developing countries, are in a state of primitive contradiction (Mather, 2007). Among many possible solutions proposed to reduce these contradictions, the CFM (or functional zoning) method is becoming increasingly popular on a global scale (Kaya *et al.*, 2016; Hou *et al.*, 2017; Elizabeth *et al.*, 2021). This method converts a portion of forestland for commercial forest products to achieve economic benefits, preserving the other part of the forestland to obtain ecological benefits. In this way, we can weaken the singular function of forest management, mitigate conflicts between economy and ecology, minimize negative environmental impact originating from the forestry industry, and meet peoples' needs for wood (Yin, 1998; Hou *et al.*, 2017).

At present, many major forestry countries have implemented CFM (Bragg *et al.*, 2020). In China, CFM is a two-class system where the overall concept involves applying different management strategies to different categories of forestlands, namely, Commodity Forestlands (CoF) and non-commodity or Ecological Welfare Forestlands (EWF) (Dai *et al.*, 2009). The Chinese government officially started CFM in 2000 and designated 13.3 million hectares of EWF for CFM, accounting for 34.95% of the total forest area in China at that time (SFA (State Forestry Administration), 2004). EWF owners or managers initially received a subsidy of approximately 75 yuan per hectare per year, while logging on EWF land is prohibited. By the end of 2018, the area of EWF in China accounted for 52.43% of the total forest area (SFA, 2019), the compensation amount had risen to about 225 yuan per hectare per year, and the cumulative investment in the program had reached 162.88 billion yuan.

However, for such an important policy, there are very limited empirical studies on the economic impact of CFM on forest management entities across China and worldwide. Usually, due to environmental externalities, forests that perform ecological functions should be designated and managed by the government (Pattanayak *et al.*, 2010). Since the collective forestland tenure reform in China, some forestland management rights have been delegated to communities or farmers (Xu and Hyde, 2019; Xu *et al.*, 2021). This has led to a large number of forestlands in EWF managed by communities and farmers, and this type of forestland now accounts for 47.38% of the total EWF area (SFA, 2019). Considering this, we observe that CFM is a Forest Eco-compensation Program (FEP) formulated by the Chinese government, primarily covers communities and farmers, and its implementation extends across the entire country, making it a very large-scale program (Dai *et al.*, 2009). The literature on the impact of FEP on farmers' livelihoods in China mainly focuses on the Sloping Land Conversion Program (SLCP) and Natural Forest Protection Program (NFPP) (Uchida *et al.*, 2009; Yin *et al.*, 2018; Zhang *et al.*, 2020). However, caution is needed when extrapolating existing conclusions to the concerns of this study, as FEP's impact on farmers' income depends on the specific compensation strategy, the scale of participation, and the heterogeneity of farmers' income sources (Wunder, 2013; Liu *et al.*, 2014).

We applied the PSM-DID estimation technique to identify the causal effect of CFM on farmers' incomes. We find strong evidence showing that participation in the CFM program reduces the income of full-time forestry households, whose majority source of revenue is the forest. Concurrently, CFM increases the income of part-time forestry households, who have strong employment mobility in off-farm sectors. However, it has no significant effect on non-forestry households, whose main occupation and revenue are not derived from forestry. Specifically, analyzing the impact of CFM on farmers' income structure reveals that CFM reduces the forestry income of both full-time and part-time forestry households, but increases the off-farm income of part-time forestry households. These results indicate that when implementing CFM, it is necessary to pay attention to the heterogeneity of the impact of programs on various types of farmers, with special focus on full-time forestry households.

This paper makes four important contributions. First, this is the first study (to our knowledge) that empirically explores the CFM's effects on farmers' income. Second, our research pays attention to the heterogeneity of the CFM'S effects on the farmers' income. Due to the variety of income sources and working times among farmers, they will make various decisions when responding to national programs and policies, which will lead to different policy results (Pattanayak *et al.*, 2010; Wunder, 2013). Ignoring the heterogeneity of farmers will then result in an inaccurate understanding of the effect(s) of policy implementation. Third, we also analyze the CFM's impact on income structure, to explore the mechanisms explaining effects on income. Fourth, to solve the widespread selection bias in the evaluation of FEP, we collect natural experimental data and use the estimation technology of PSM-DID to solve possible endogeneity problems. However, there are still challenges in ensuring the reliability and accuracy of CFM assessment (Ferraro and Hanauer, 2014; Yin *et al.*, 2018). Farmers' participation in FEP is not random; there are many factors, observable and unobservable, that may affect farmers' decision-making, which will lead to selection bias and affect the reliability of policy results (Duflo and Pande, 2007; Yin *et al.*, 2018). Additionally, farmers may participate in multiple FEP at the same time (Zinda *et al.*, 2017; Liu *et al.*, 2014; Wang *et al.*, 2020). To ensure that CFM alone plays a role, we require farmers to only participate in CFM.

# 2. Background

As early as China's first RFL promulgation in 1984, China divided forests into five categories: economic forest, shelterbelt forest, timber forest, special-use forest, and fuel forest. Each forest category had a specific but narrow purpose for management (Richardson, 1990). Although the idea of CFM was developed during this period, due to the rigid demand for wood production all over the country, the Chinese government was flexible in its classification of forest categories, and the majority of forests in China were certified as timber forests (Dai *et al.*, 2011).

By the end of the 20th century, 50 years of excessive forest exploitation had led to severe ecological and environmental degradation throughout China, manifested as soil erosion, sandstorms, desertification, and flood (Li, 2001). Faced with such serious environmental problems, the Chinese government decided to better balance land use, economic growth, and forest production, to reach sustainable and ecological forestland usage (Wang *et al.*, 2007). When the RFL was revised in 1998, timber forests, economic forests, and fuel forests were classified as CoF, while shelterbelt and special-purpose forests were classified as EWF. RFL assigned CoF and EWF different logging and circulation systems, and proposed to establish a forest compensation fund to run and operate EWF (Dai *et al.*, 2009).

Clear EWF certification is the foundation for implementation of CFM. In 1999, China's SFA issued "A Memorandum of the National Forestland Classifications," explaining principles, methods and procedures to be used to classify forestland, and this classification scheme was officially implemented in 2000. However, the financial compensation needed to cover the national EWF lands was much higher than the national budget could afford (Liu, 2018). In 2003, the SFA revised the forest classification criteria again; accordingly, the whole nation started re-allocating its forestland (again) (Dai *et al.*, 2009).

After three years of pilot work, the SFA issued the "Methods of Checking the Key National-Level Ecological Welfare Forests" and "Central Finance Forest Ecological Benefit Compensation Fund Management Measures" in 2004 (SFA, 2004), which marked the formal establishment of a national forest compensation fund system, and fully implemented nationwide (Pan *et al.*, 2017). Since then, among the 267 million hectares of forestry land in China, 104 million hectares of EWF have been delimited, and 27 million hectares were selected to be covered by the National Forest Compensation Fund. The fund has reached 2 billion yuan, with an average subsidy of 75 yuan per hectare per year. In 2009, the SFA issued the newly revised "Methods of Checking the Key Ecological National-Level Welfare Forests" and "Central Finance Forest Ecological Benefit Compensation Fund Management Measures," which further enlarged the scope of central government subsidies and expanded the compensation area to 70 million hectares. In 2010, SFA increased its subsidies to the staff who took the direct responsibility for managing EWF, increased compensation standard from 75 yuan per hectare per year to 150 yuan. By 2012, China had designated 124 million hectares of EWF, of which the state-owned EWF was 71 million hectares, and the collective and individual-owned EWF was 53 million hectares (SFA, 2014). By 2013, China had again increased the amount of EWF compensation for collectives and individuals, and the EWF subsidy standard was increased to 225 yuan per hectare per year.

## 3. Theoretical analysis

We assume that the labor force of a representative farm household before the implementation of the program, is $L$, the area of commercial forest is $K$, and the labor force used by the farm household for forestry production is $l(K)$. It is generally believed that the of fragmented forestland's investment income is small, and the larger the forestland area, the higher the return of farmers' forestry production, that is, forestry production has a scale effect (Uchida *et al.*, 2009; Liu *et al.*, 2014; Zhu *et al.*, 2018). The labor used for off-farm sectors is $L-l(K)$, $l(K)^{'}>0$, that is, when the labor force is constant, increasing commercial forest area will increase the marginal output of labor. The output of farmers' forest products is $Q[K, l(K)]$, and we assume that the production function is strictly concave. The price of forest products is $P_1$. Then, the total income $I_0$ of the farmers at this time is expressed as:

$$I_0=P_1 Q[K, l(K)]+w[L-l(K)] \qquad (1)$$

After CFM is implemented, some or all of the commercial forests belonging to farmers will be classified as EWF that cannot be harvested. We assume that the area of EWF of farmers is $bK$, $0 \leq b \leq 1$. The compensation standard is $P_2$. The compensation income that farmers get is $P_2 bK$. Total income $I_1$ is:

$$I_1 = P_1 Q\{(1-b)K, l[(1-b)K]\} + w\{L - l[(1-b)K]\} + P_2 bK \qquad (2)$$

When the area of CoF declines, marginal output of labor will decrease, and when the marginal income from labor decreases, overall forestry income will also decline. The low compensation income usually cannot make up for the economic loss when farmers give up forestry production. Therefore, to maintain the level of utility brought by the original income, the forestry households' labor will be transferred to off-farm sectors. The wage level $w$ that farmers can get is related to the characteristics of farmers themselves. Research showed that when farmers gain a certain substantial amount of much work experience and information through off-farm employment, their working experience can help increase off-farm wages (Siikamäki *et al.*, 2015).

For full-time forestry households, which have been mainly engaged in forestry production, their unidimensional work experience makes it difficult to find off-farm employment at high salaries and therefore also to increase their off-farm income (Zinda *et al.*, 2017). Comparatively, part-time forestry households have more advantages when seeking jobs in off-farm sectors, so they can deal better with possible risks derived from CFM (Zhu *et al.*, 2018; Yin *et al.*, 2018).

The use of CFM will reduce the relative area of CoF and therefore also reduce forestry income, however it has little effect on promoting off-farm employment of full-time forestry households. Therefore, we propose:

*Hypothesis 1: CFM has a negative impact on the income of full-time forestry households.*

For part-time forestry households, the income derived from other off-farm employment is generally higher than the loss of giving up forestry production. Therefore, we propose:

*Hypothesis 2: CFM has a positive effect on the income of part-time forestry households.*

For non-forestry households, income does not come from forestry production. The labor force $l(K)$ originally used for forestry production is relatively small. The impact of CFM on forestry income and off-farm income is relatively limited. Therefore, the impact of CFM on the income of non-forestry households is relatively limited.

# 4. Data and Methods

## *4.1 Data Collection*

Using the quasi-experimental method, a field survey was conducted in Longquan, Zhejiang Province, China (Figure 1). Longquan is located in the southwest of Zhejiang Province, adjacent to Fujian Province. The landscape around Longquan is dominated by mountains, which account for 97.09%, while plains account for only 2.91%. The forest coverage rate of Longquan is 86.84%. In 2004, the year Longquan initiated CFM, 82,300 ha of forestland were delimited as EWF. In 2009, Longquan added 26,000 ha as new EWF area, so that the total EWF area reached 108,300 ha. By 2015, Longquan carried out the second round of expansion of CFM, adding 6,000 ha as new EWF area. The city's EWF area reached 114,300 ha, accounting for 43.03% of the city's total forest area of 265,600 ha.

Delimitation of EWF area in Longquan is conducted directly by the local municipal forestry bureau, without input from farmers (Dai *et al.*, 2009); that is, farmers only passively participate in the CFM program in Longquan. In our research, we consider the CFM program to be a quasi-natural experiment implemented by the government.

Longquan is a county with 19 towns under its jurisdiction, but all towns cannot be included in the sampling scope of this paper. We excluded towns in the Fengyang Mountain Reserve in Longquan, and those that had implemented SLCP, including Pingnan Town, Longnan Town, and Lanju Town. Samples of farmers in these areas may be disturbed by other FEPs. Therefore, we only conducted sampling in the towns of Anren, Baoxi, Zhulong, Chengbei, and Jinxi, which were involved in the second round of EWF expansion; 140 farmers in these towns were randomly selected as the treatment group. Alongside the selected list of 140 households, 1 to 2 households in each village that had never owned EWF before were selected as the reference group, for a total of 200 households. The survey includes datasets for two timespans, focusing on these two groups' production and livelihoods in 2013 (before the second expansion in 2015) and 2019 (after that expansion).

Since 2000, Longquan has carried out a number of ecological construction projects, such as NFPP and SLCP. NFPP is not conducted in the sample scope of this survey. The SLCP project in Longquan was completed in 2012. In this survey, we excluded farmers who had participated in SLCP, to eliminate other external effects; after excluding 21 invalid samples, 319 households were retained.

(Figure 1 here)

### *4.2 Empirical Methodology*

If CFM is an ideal natural experiment, that is, the treatment group and the control group are randomly assigned, DID may be the best method to evaluate CFM's impact on the income of farmers (Yin *et al.*, 2018). As we mentioned before, the government implemented CFM, leaving limited choices and initiatives to farmers, and CFM is in that sense a natural experiment implemented by the government. However, when delimiting the EWF areas, certain principles are still followed, such as "prioritize ecology, centralize forestry land" (Dai *et al.*, 2009). Therefore, although farmers have no right to choose whether their forestland will be classified as EWF, this outcome may still be affected by the observable characteristics of the forestland. If randomization is based on a series of observable variables based on which subjects have various probabilities of being selected, it leads to imperfect randomization (Duflo and Pande, 2007).

Consideration of the characteristics of forestland will affect randomness when implementing CFM, resulting in selection bias. Therefore, to relieve the endogeneity problems caused by selection bias, we adopt the PSM method, whose results can reduce sample selection bias; but this method also had obvious shortcomings, including failing to capture selection bias based on unobserved heterogeneity (Abadie, 2005). To better solve this problem, a DID method based on PSM was adopted to better assess difference in the program's average effect on household income (Heckman *et al.*, 1997).

A logit and probit model were used to estimate the propensity score, which was defined as the conditional probability of receiving treatment. Given this propensity score, each household participating in the program (the treatment group) was matched with one or more non-participants (control group) with similar characteristics. We refer to "Methods of Checking the Key National-Level Ecological Welfare Forests" (SFA, 2004) to select the criteria (i.e., covariates) used in PSM: total forestland area, number of forestland plots, proportion of timber forest, proportion of economic forest, proportion of bamboo forest, forestland distance from road, and forestland slope.

The empirical equation of DID is:

$$Y_{it} = \alpha + \beta_1 D_i \times T_t + \beta_2 D_i + \beta_3 T_t + \gamma X_{it} + \varepsilon_{it} \quad (1)$$

In formula (1), $Y_{it}$ is the total income of farmers; $D_i$ is a dummy variable ($D_i$=1 means that farmers have EWF, $D_i$=0 means that farmers do not have EWF); $T_t$ is a time dummy variable (before the implementation of CFM, $T_t$ takes 1; otherwise, it is 0); and $\beta_1$ is the coefficient of the interaction term $D_i \times T_t$, acting as the double difference estimator. Only when household *i* is in the treatment group after attending CFM, the interaction term is equal to 1. $X_{it}$ is a set of control variables, and $\varepsilon_{it}$ is a random error term.

With reference to Li *et al.* (2021), Liu *et al.* (2014) and Uchida *et al.* (2007), we select control variables from the characteristics of the head of the farmer household, political resources, labor endowment, and forest land resources. Specific control variables are household head' age, household head' education level, whether there are party members among family members, total labor force, total forestland area, total forestland number, proportion of timber forest, proportion of economic forest, proportion of bamboo forest, forestland quality, distance between forestland and road, and forestland slope.

***4.3 Variables and Descriptive Statistics***

The explained variable is the total income of farmers. To analyze how CFM affects the income of farmers, we also analyze the policy's impact on the income structure of farmers, namely forestry income and off-farm income. To find the differences between farm households engaged in different types of part-time work, we define households whose forestry income accounts for more than 50% as full-time forestry households, farmers whose forestry income accounts for between 50% and 5% as part-time forestry households, and farmers whose forestry income accounts for less than 5% as non-forestry households. Summary statistics of all variables included in the analysis are presented in Table I.

(Table I here)

## 5. Results and Discussion

### *5.1 Sample Selection Based on PSM*

In PSM, the characteristics of households and forestland that may affect farmers' participation in CFM are controlled, and the observation values that meet our assumption are chosen. The sample used in PSM is the survey data for 2013, before implementing CFM. Referring to Li *et al.* (2021), we use the kernel matching method for PSM. Local linear regression matching is used to verify the reliability of the empirical results, as a robustness test.

The common support of the propensity score is shown in Figure A.1 (in the Appendix). For every interval of propensity score, there exist observations from both control and treatment groups. Table A.I (in the Appendix) reports the extent of balancing of the variables after matching. It is observed that the standardized bias of most variables after matching is less than 10%, and the result of the *t*-test does not reject the null hypothesis (that there is no systematic difference between the treatment group and the control group). The results show that the overall bias and the median deviation become smaller after matching, indicating that the quality of the sample matching in this study is relatively high (Chatterjee and Pal, 2021).

### *5.2 The Effect of CFM on Farmers' Income*

Panel A in Table II reports the regression results with full-time forestry households as a sample. Consistent with our expectations, CFM has a significant negative impact on the total income of full-time forestry households. We observe that CFM has reduced the forestry income of full-time forestry households by 47.66%; however, it has no significant impact on the off-farm income of full-time forestry households. The classification of forestland as EWF is equivalent to reducing the commercial forest's area for farmers. Facing the program's impact to reduce commercial forest area, farmers can expand the scale of forestland management through circulation or implement more intensive management of forestland (Zhang *et al.*, 2020). However, smaller commercial forest area has higher operating costs, and it is difficult to generate scale income, which will reduce the enthusiasm of full-time forestry households to manage forests (Zhu *et al.*, 2018). By contrast, it appears that farmers need more external support to expand the scale of forestland. Especially after the reform of collective forestland tenure, the degree of forestland's fragmentation in collective forest areas has increased, and farmers face higher transaction costs to expand the scale of forestland through circulation (Xu *et al.*, 2021). Therefore, the forestry income of full-time forestry households decreases. This finding is similar to Liu *et al.* (2014). Regarding off-farm employment, CFM did not reflect the effect of increasing income but instead reduced the commercial forest area of farmers and shunted supporting labor for commercial forests to the off-farm sector. However, the mobility of off-farm employment of full-time farming household labor is relatively poor, so the crowding-out of forestry labor by CFM is weakened (Zhang *et al.*, 2020).

In Panel B, different from the regression results for full-time forestry households, CFM shows a strong promotion effect on the income of part-time forestry households. We observe that CFM has a negative impact on part-time forestry households' forestry income but a positive impact on off-farm income. This confirms Yin *et al.'s* (2018) finding that after participating in the SLCP, the off-farm income of farmers has greatly increased, concealing the reduction in overall income caused by the reduction in forestry income due to participation in the program. Part-time forestry households have a comparative advantage in off-farm employment. When the implementation of CFM leads to the fragmentation of forestland and reduces the benefits of forestry production, they are more likely to respond to program shocks by adjusting off-farm employment (Uchida *et al.*, 2009; Wang *et al.*, 2020). Therefore, in the face of program shocks, part-time forestry households mainly obtain higher total family income by optimizing the allocation of labor, reducing the scale of forestry production, and increasing off-farm income.

As seen in Panel C, we observe that CFM has no statistically significant impact on the total income of non-forestry households. One possible reason may be that for non-forestry households, dependence on forestry production is very small, and so the reduction of commercial forest area has little effect on their income. Moreover, current EWF compensation is relatively low, and the impact on the income of non-forestry households is, correspondingly, relatively limited. Our results are thus similar to those of Xu *et al.* (2004), who found that SLCP has little or no impact on households' income. They attributed this result to diversity and variability (risk) in farmers' income sources, which made the increase in income of a large part of the program participants likely to be transient.

Finally, Panel D shows the regression results using all farm households as a sample. A striking finding is that CFM has no significant impact on the total income of farmers. Similarly, CFM did not have a significant impact on the forestry income or off-farm income of any farmers.

This means that currently, the overall effect of CFM on farmers' income increase is still very limited.

(Table II here)

Further, to improve the understanding of the CFM's impact on the income of farmers, we used Lowess to analyze the impact of EWF area changes on the income of farmers with EWF certification. Lowess is a non-parametric estimation method, which can avoid the setting error of the parameter estimation method due to the strong assumptions made regarding the model setting and furthermore can more intuitively show the non-linear relationship between variables. The result is shown in Figure 2.

Figure 2a reveals that when the EWF area is greater than 8 ha, the increase in the EWF area has a significant promotion effect on the total income of full-time forestry households. In contrast, when the area of EWF is less than 8 ha, the increase in EWF area has an unstable effect on the total income of full-time forestry households, and even shows an inhibitory effect when it is less than 3 ha. The reason is that when the area of EWF is less than 3 ha, the negative impact of EWF area on forestry income is relatively strong, however the promotion effect on off-farm income is not obvious. When the area of EWF exceeds 3 ha, the positive effect of EWF area on off-farm income has the upper hand, and the total income of farmers also increases. It should be noted that when the EWF area exceeds 26 ha, the growth rate of the total income of farmers is much higher than the growth rate of off-farm income. This may be due to the high total amount of EWF subsidies, which can directly increase the total income of farmers and may generate certain investment income. These results suggest that we should provide support measures for full-time forestry households who have obtained EWF certification, especially small-scale full-time forestry households, to help them transition into off-farm economic activity.

Figure 2b shows that when the EWF area is less than 4 ha, as the EWF area increases, although the forestry income of part-time forestry households continues to decline, their off-farm income increases rapidly, which makes their total income increase rapidly. When the EWF certified area reaches 9.5 ha, the off-farm income of part-time forestry households begins to decline, and forestry income and total income gradually stabilize. This is because part-time forestry households have not completely abandoned forestry production, and their off-farm employment is not stable. The increase in the total amount of EWF subsidies can ease the budget constraints on forestry production, and part-time forestry households may invest EWF subsidies and part of their labor in forestry production. Similar to pure forestry households, when the EWF certified area increases to 23 ha, the total income of part-time forestry households also increases rapidly, and its growth rate also exceeds the growth rate of off-farm income.

Figure 2c indicates that as the area of EWF increases, the off-farm income of non-forestry farming households also continues to increase, and the total income with it. However, since non-forestry farming households have little dependence on forestry income, forestry income is not affected much. It is worth mentioning that when the EWF certified area is less than 6 ha, off-farm income and total income increase rapidly. A possible reason is that non-forestry farming households have a comparative advantage in off-farm employment compared with part-time forestry households. When EWF certification reduces the income of forestry production, non-forest households will release more labor to invest in off-farm production sectors, making off-farm income grow rapidly.

(Figure 2 here)

### *5.3 Robustness Test*

To verify the reliability of the empirical results, we conduct robustness tests using three methods: (1) We apply a different matching method through local linear regression matching in PSM, following the same procedure as our specific models to reestimate the effect of CFM on sample rural households' income. We find that the coefficient's signs and significance are consistent with the previous empirical results. (2) We choose the survey data of per capita total income to measure total income for the robustness test. We find that the coefficients and signs of the double difference estimator are basically consistent with those in Table IV, indicating that the empirical results are robust.

## 6. Conclusion

The analysis shows that superficially, CFM has no effect on the income of Chinese farmers. However, when subdividing farmers into different groups by time investment, a different picture emerges. There is an income increase in part-time forestry households deriving from CFM, but a significant income decreases in full-time forestry households. We found that CFM will reduce the forestry income of full-time forestry households, however also that it cannot increase off-farm income to compensate for the income loss. For part-time forestry households, CFM also has a negative impact on their income; however, part-time forestry households can participate extensively in off-farm employment, making it possible to increase their total family income. Additionally, for non-forestry households, due to their low dependence on forestry production, neither off-farm income nor forestry income will be impacted by CFM.

We cannot ignore this result, as people may doubt the sustainability of this policy when EWF compensation does not quickly increase. As the Chinese government puts more emphasis on the forests' ecological functions, EWF in China will continue to expand in the future, while areas used for forestry production will be reduced (Hyde and Yin, 2019; Hou *et al.*, 2017). From the current situation of CFM, it is obvious that simply giving compensation payments to farmers lacks consideration of farmers' livelihood models and transformation. One possible innovation is to provide work opportunities, for example, forest fire prevention patrol teams, to laborers who cannot go outside to find jobs. Increasing marketing linkage to increase sales and income of forest products could be another option. Moreover, promotion of forestland circulation should also be speeded up, to provide a more efficient platform for farmers to optimize the allocation of forestland resources (Xu *et al.*, 2021).

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# Appendix

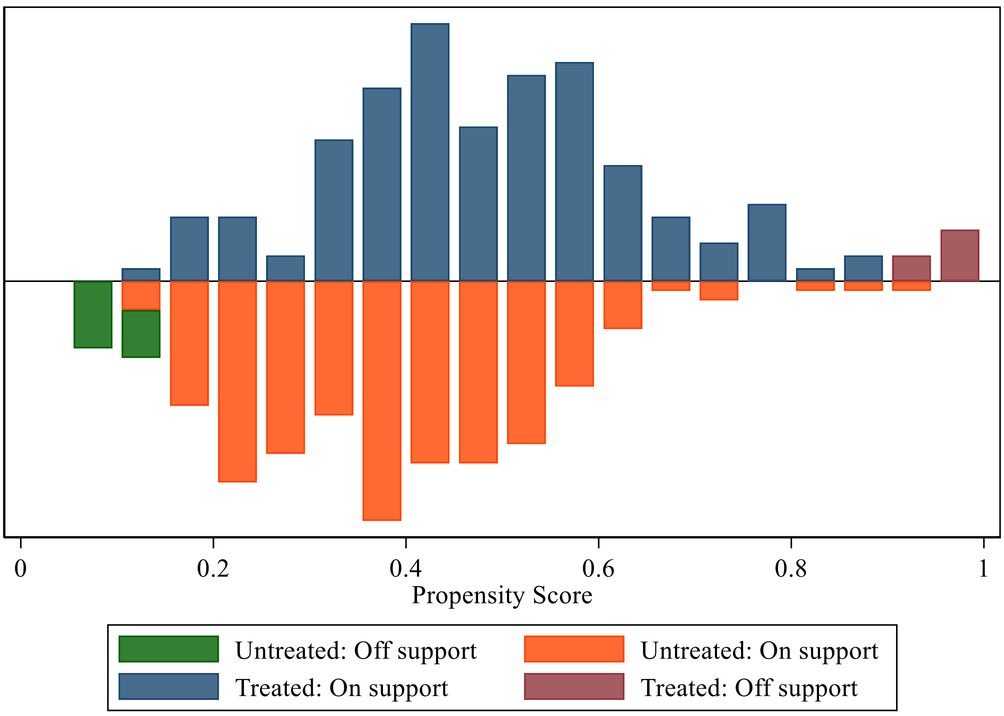

Figure A.1 Common value range of propensity matching score (take kernel matching as an example)

Table A.I The extent of balancing of the variables after matching

| | Mean | | %bias | *t*-test | |
|---|---|---|---|---|---|
| Variable | Treated | Control | | *t* | *p*>\|*t*\| |
| Forest area | 10.57 | 12.21 | -6.7 | -0.70 | 0.487 |
| Number of forestland plots | 3.73 | 3.91 | -7.6 | -0.52 | 0.605 |
| Proportion of timber forest | 0.52 | 0.50 | 5.2 | 0.41 | 0.681 |
| Proportion of economic forest | 0.05 | 0.06 | -2.0 | -0.22 | 0.830 |
| Proportion of bamboo forest | 0.23 | 0.23 | 1.3 | 0.11 | 0.911 |
| Forestland distance from road | 0.68 | 0.57 | 8.5 | 0.72 | 0.473 |
| Forestland slope | 36.50 | 36.01 | 3.3 | 0.28 | 0.783 |