Tenure Decentralization and Forest Productivity & Quality: Evidence from Northeast China

Tingyu CUI[1] Chen FANG[1] Yushuai ZHANG[2]
(1 School of Economics and Management, Tsinghua University; 2 National School of Development, Peking University)

Abstract: The new round of Collective Forest Tenure Reform (CFTR) initiated in China in 2003 is a forest land reform following the household responsibility system reform. To evaluate the impact of forest tenure reform on the sustainable development of China's forest resources, this study innovatively uses Gross Primary Productivity (GPP) as the core observation variable to directly observe the policy's stimulative effect on forest productivity. The use of GPP replaces the existing research method that indirectly assesses the impact through forestry income and input derived from household surveys. Our research focuses on the forest area in Northeast China during 2000 ~ 2016. The results show that after CFTR, with forest farmers obtaining the right to manage collective forests, the GPP of collective forest areas in the Northeast increased by an average of 3.6% approximately. Subsequent placebo tests and PSM-DID regression results serve as robustness checks on the baseline regression, further confirming the significant positive contribution of CFTR. This paper also further analyzes the heterogeneity of the reform effect in terms of population density and land cover types, showing that collective forest lands with higher population densities enjoy stronger CFTR effects.

Keywords: Collective Forest Tenure, Reform, Gross Primary Productivity, Northeast China Forest

1. Introduction

Forests are a significant resource in China. Adopting reasonable forestland management can promote sustainable development and fully leverage the carbon sequestration value of forest ecosystems (Noss, 2001). China's collective forest land covers approximately 130 million hectares, accounting for about 58% of the total forest area, with nearly 90% of the country's forest resources distributed in mountainous areas. However, China's collective forest areas have faced issues such as deforestation and low enthusiasm among farmers for forest management and protection. The academic community generally believes that these issues are caused by unclear property rights and frequent adjustments (Liu et al., 2017). Therefore, reforming collective forest lands is of significant importance. To improve the productivity and operational efficiency of collective forests and enhance the welfare of the forest area population, the Chinese government began to progressively implement a new round of Collective Forest Tenure Reform (CFTR) starting in 2003. CFTR, with the main content of “clarifying property rights, reducing taxes and fees, liberalizing operations, and standardizing transactions”, can be deemed as the second land reform after the initial agricultural reforms in 1978 (Jintao Xu & William F. Hyde, 2019). It aims to maintain the collective ownership of forest lands while transferring the management tenure to farmers. Farmers gain ownership, disposal rights, and profit rights over the collective forests, thereby motivating them to improve the management of collective forests, increasing their income while achieving forest protection and development.

Figure 1 shows the trend changes in Gross Primary Productivity (GPP) of collective and state-owned forests in Northeast China. Before CFTR, the average GPP of collective forests was lower than that of state-owned forests, possibly because the latter are mostly natural forests with higher biodiversity. However, because of the characteristics of collective forests, which are more influenced by human intervention compared to natural forests, improvements in the management of collective forests can to some extent stimulate their forest productivity. According to Figure 1, after the forestry rights reform, the GPP of collective forests began to grow rapidly and started to exceed the GPP of state-owned forests in the seventh year following the implementation of the reform.

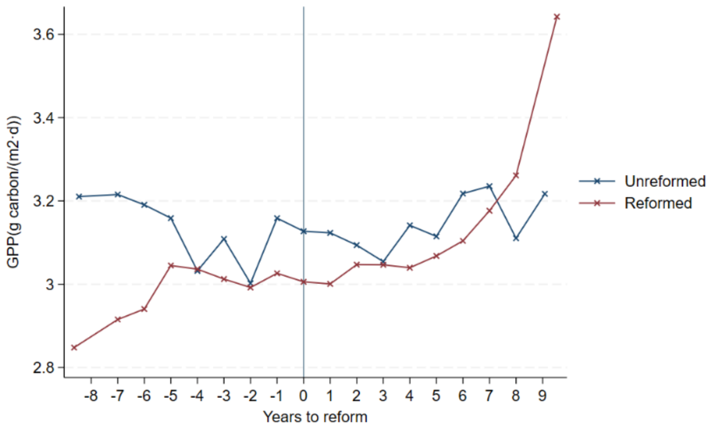


Figure 1. Trends in GPP of Reformed and Unreformed Forest Land

This study designed DID econometric models to estimate the average impact of CFTR, including staggered DID with two-way fixed effects, and stacked DID model. We apply those two DID regression and event study as baseline identification, evaluating the effectiveness of CFTR. The results indicate that after the CFTR, the average GPP of collective forests increased by more than 3%, and the effect of the reform exhibits a certain degree of lag, which may stem from the relatively slow growth process of forests. The empirical strategies and findings are described in more detail below.

2. Importance of this Study

Our main dependent variable is GPP, which is derived from remote sensing data, homogeneous over a large spatial scale, easy to analyze, and can ensure a certain degree of accuracy. This parameter can also measure the ecological quality of forests, including forest health, forest structure, and the effectiveness of forest ecological services. Compared to existing studies based on household survey data, our use of remote sensing data products is conducive to observing the long-term effects of forest rights reform. It also avoids the impact of policy fluctuations themselves on the effectiveness of CFTR, that is, households' reservations about investing in productive factors due to doubts about the stability and continuity of the policy.

This research concentrates on CFTR in Northeast China for several reasons. Firstly, the Northeast boasts the largest expanse of state-owned natural forests in the country, with collective forests also occupying a substantial portion. This area contributes 14.7% to the national forest land, establishing it as a forerunner in the implementation of CFTR. The insights gained from the forest management practices in the Northeast can offer valuable guidance for similar reforms across other forest lands in China. Secondly, the past few years have witnessed remarkable enhancements in the Northeast in terms of vegetation greening, forest cover, and overall forest quality. This progress positions the region among the top performers in forest resource development nationwide (Yu et al., 2021). An additional objective of our study is to explore the extent to which these advancements can be ascribed to the impact of forest rights reform.

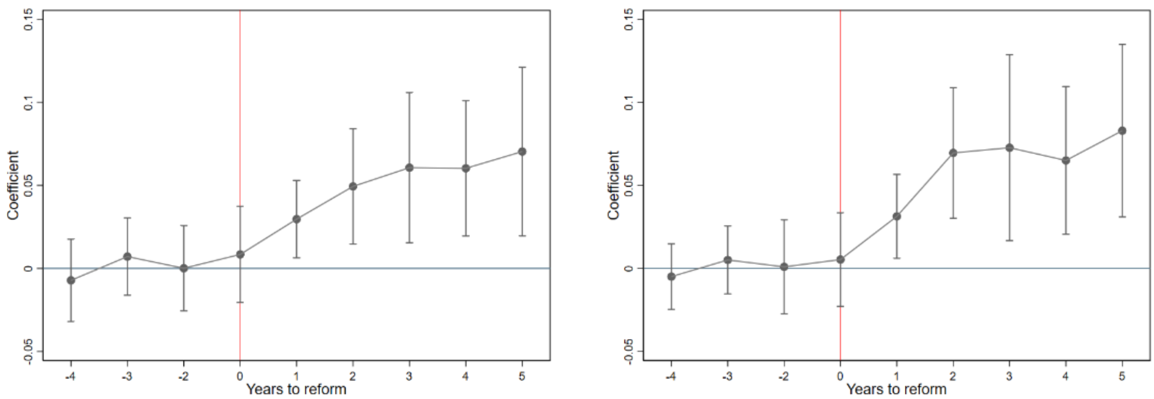
3. Data & Methods

The GPP data (unit: g carbon/(m2d)) used in this study were obtained from NASA's Earth Data official website, with a grid resolution of 5 arcminutes × 5 arcminutes (about 7 km × 7 km) in the Northeast China. To classify different land cover types, this study used the 30-meter global land cover data GlobeLand30, a global land cover database developed by the National Geomatics Center of China. We collect the implementation time of CFTR from county-level government work reports, official news reports, and other official channels. In order to identify which forest lands are treated in CFTR, we used the areas of forest industry enterprises and natural forests under the direct jurisdiction of the government as non-forest reform areas. Covariates are natural and social indicators, including temperature and precipitation provided by National Tibetan Plateau Data Center, and population density data (unit: people/km2) from WorldPop. We extract remote sensing image data into panel data based on a unified latitude and longitude grid, and then conduct empirical research using staggered DID and stacked DID models.

4. Results

Panel A. Two-way fixed effects

Panel B. Stacked DID



Notes: Panel A is estimated using equation (1), Panel B is estimated using equation (2). Scatter plots with error bars of 95% CI.

Figure 2. Dynamic Effects of CFTR

Table 1. Baseline Estimates

Independent variables	Dependent variable: Log (GPP)			
	Two-way FE		Stacked DID	
	(1)	(2)	(3)	(4)
Reform×Manf	0.032***	0.034***	0.055***	0.043***
	(0.009)	(0.010)	(0.010)	(0.010)
Controls	Yes	Yes	Yes	Yes
Grid FE	Yes	Yes	Yes	Yes
Year FE	Yes			
Group-by-year-to-reform FE			Yes	Yes
Year×month FE		Yes		Yes
Observations	645,774	645,774	4,044,533	4,044,533
R-squared	0.911	0.933	0.851	0.918

Notes: The dependent variable is the natural logarithm of GPP.. Robust standard errors in parentheses, clustered at the county level in column 1 and 2, clustered at the group level in columns 3 and 4. *** p<0.01, ** p<0.05, * p<0.10

Figure 2 displays the dynamic effects of the forest tenure reform policy on the GPP of forests in the Northeast China, with Panel A and B representing the dynamic effects of the two-way fixed effects and the stacked DID, respectively. Based on the results in Figure 2, we can infer that the treatment and control groups satisfied the parallel trends assumption before CFTR. After the implementation of the forest tenure reform, the GPP of the collective forest area significantly increased compared to the control group, and eventually diverged from the non-reform area within the 95% CI. Within the first year after the reform, the GPP of the collective forest area increased by about 2.5%, and continued to rise in the following two years, with the positive effect of the forest tenure reform reaching about 6.5% in the third year, and then roughly stabilizing. The gradual increase in the GPP improvement of the collective forest over time after the policy implementation may be due to the long process of forest productivity. The dynamic effect of the stacked DID in Panel B is similar to that in Panel A, especially the coefficient estimates for the year following the reform and earlier. However, after the second year of the forest tenure reform, the estimation results of the stacked DID begin to be overall about 1% higher than those of the two-way fixed effects.

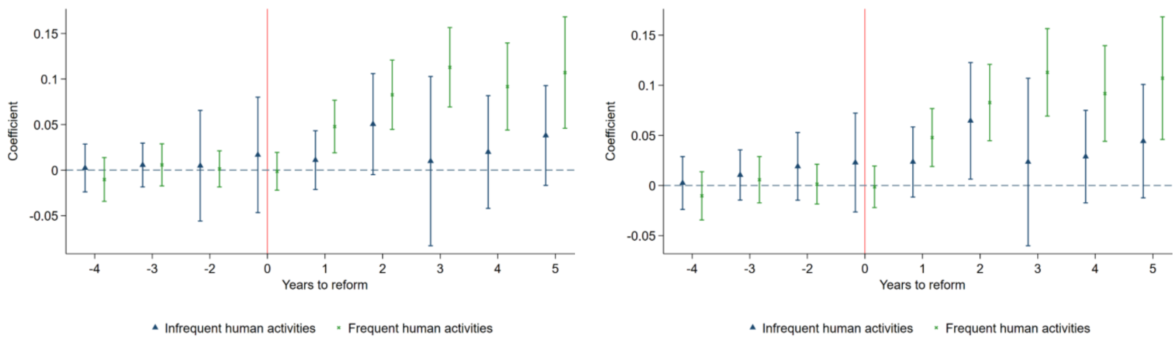
Table 1 demonstrate a significant positive contribution of CFTR to the GPP of collective forest areas. In the two-way fixed effects model, the results in columns 1 and 2 show that after the implementation of forest tenure reform policy, the GPP of collective forest areas in the northeast increased by 3.2% and 3.4%, approximately. In the stacked DID model, columns 3 and 4 show that the average treatment effect of CFTR on the GPP of collective forests is 5.5% and 4.3%, with the estimates from the stacked DID model being generally larger than those from the two-way fixed effects model. Recent studies suggest that dispersed policy timings and heterogeneity might cause bias into the two-way fixed effects estimates of staggered DID models (Athey & Imbens, 2022; Baker et al., 2022; Goodman-Bacon, 2021). The differences in results between the two models in Table 1 may initially hint at issues of heterogeneity in the real-world mechanisms of forest tenure reform.

This paper conducts a series of robustness checks on the basis of the benchmark regression. On the one hand, we randomized the reform timing for placebo tests, obtaining Wald Statistics from Estimates with Placebo Reform Years. The peak of Wald Statistics occurs within two years after the actual reform, which is consistent with expectations. Moreover, the placebo policy effect rapidly decreases when the reform timing is randomly advanced or delayed for a longer period. This distribution result also confirms the significant positive effect of forest tenure reform on the GPP of collective forests in the northeast from a counterfactual perspective.

On the other hand, based on the benchmark identification models of equations (1) and (2), we conduct regression analysis again after Propensity Score Matching (PSM) based on the multidimensional information of the sample. The covariates in the PSM process are the averages of temperature, precipitation, and population density from April to October between 2000 and 2016. The regression results after PSM matching are similar to those in Figure 2 and Table 1, with differences only in the Stacked DID model compared to columns 3 and 4 of Table 1. After PSM, the regression coefficients of Stacked DID decrease and become closer to those of the two-way fixed effect model. This suggests that factors involved in the matching process, such as natural conditions and population density, may affect the effect of forest tenure reform. Hence, we speculate that the larger estimation gap between the two models in Table 1 may originate from heterogeneity caused by factors such as natural conditions and population density. This heterogeneity might stem from the differences between collective and state-owned forest areas delineated in the early days of the People's Republic of China. In fact, compared to natural forest areas, collective forest areas are more likely to be located around population centers, making the discussion on heterogeneity due to population factors particularly important.

Panel A. Dynamic Effects of CFTR on Groups Based on Human Activities (Group Set 1)

Panel B. Dynamic Effects of CFTR on Groups Based on Human Activities (Group Set 2)



Notes: Panel A and B are estimated using equation (2), grouping based on human activities, measured by population density. Two Groups in Panel A are divided with a boundary of 15 (people per km^2). The groups of frequent human activities in Panel A and B are the same, while the population density in the group of infrequent human activities in Panel B is less than 15 but no less than 1 (person per km^2).

Figure 3. Dynamic Effects of CFTR of Different Groups based on Population Density

Table 2. Heterogeneous Effect Based on Population Density

Dependent variable: Log (GPP)

	Stacked DID			
Pop. Density	[0, 5]	(5, 15]	(15, 125]	>125
Independent variables	(1)	(2)	(3)	(4)
manf_reform	-0.010	0.009	0.062***	0.072***
	(0.009)	(0.008)	(0.013)	(0.008)
Controls	Yes	Yes	Yes	Yes
Grid FE	Yes	Yes	Yes	Yes
Group-by-year-to-reform FE	Yes	Yes	Yes	Yes
Observations	1,199,750	1,175,020	1,244,489	1,172,890
R-squared	0.963	0.963	0.961	0.962

Notes: The dependent variable is log of GPP. Robust standard errors in parentheses, clustered at the group level. Columns 1-4 are grouped according to the population density interval (people/km^2). *** p<0.01, ** p<0.05, * p<0.10

The results from Figure 3 and Table 2 demonstrate that the effect of forest tenure reform on the GPP of collective forest lands exhibits significant population heterogeneity. In forest land groups with higher population density, the average effect of forest tenure reform is larger and more significant. In other words, the frequency of human activity is higher in these areas, implying that in collective forest areas with higher population densities, there is a greater likelihood of more intensive management of forest lands by the forestry population. The regression coefficients in columns 3 and 4 of Table 2 are also higher, with the average effect of forest tenure reform in collective forest areas with a population density greater than 125 (people/km2) being about 31% higher than the policy effect of this reform across all collective forest areas. Conversely, in forest areas with lower population density, the average effect of forest tenure reform is not only lower but often not significantly different from zero. In the first and second columns of Table 2 which include areas of lower population density, the effect of forest tenure reform is not significant. This suggests that forest tenure reform may be constrained by population distribution conditions, with the reform potentially struggling to exert a greater policy effect in sparsely populated forest areas.

One of the focuses of forest tenure reform is the devolution of forest land management rights, and the farmers who obtain these rights need to invest human capital in planting, maintaining, and harvesting activities on the forest land. The analysis of population density heterogeneity in collective forest areas may reveal a potential mechanism of the reform—forest tenure reform, by devolving management rights in collective forest areas, could mean more frequent forest management activities in areas with more population, thereby achieving higher forestry productivity, or better policy effects, in those regions.

5. References

Athey, S., & Imbens, G. W. (2022). Design-based analysis in Difference-In-Differences settings with staggered adoption. *Journal of Econometrics*, *226*(1), 62–79. https://doi.org/10.1016/j.jeconom.2020.10.012

Baker, A. C., Larcker, D. F., & Wang, C. C. Y. (2022). How much should we trust staggered difference-in-differences estimates? *Journal of Financial Economics*, *144*(2), 370–395. https://doi.org/10.1016/j.jfineco.2022.01.004

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, *225*(2), 254–277. https://doi.org/10.1016/j.jeconom.2021.03.014

Jintao Xu & William F. Hyde. (2019). China's second round of forest reforms: Observations for China and implications globally. *Forest Policy and Economics*, *98*, 19–29. https://doi.org/10.1016/j.forpol.2018.04.007

Liu, C., Wang, S., Liu, H., & Zhu, W. (2017). Why did the 1980s' reform of collective forestland tenure in southern China fail? *Forest Policy and Economics*, *83*, 131–141. https://doi.org/10.1016/j.forpol.2017.07.008

Noss, R. F. (2001). Beyond Kyoto: Forest Management in a Time of Rapid Climate Change. *Conservation Biology*, *15*(3), 578–590. https://doi.org/10.1046/j.1523-1739.2001.015003578.x

Yu, L., Xue, Y., & Diallo, I. (2021). Vegetation greening in China and its effect on summer regional climate. *Science Bulletin*, *66*(1), 13–17. https://doi.org/10.1016/j.scib.2020.09.003