ECONOMIC EFFECT OF PILOT POLICIES FOR FORESTRY CARBON TRADING IN FUJIAN PROVINCE, CHINA: BASED ON THE PSM-DID MODEL

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Abstract. This paper uses the Propensity Score Matching-Difference in Differences (PSM-DID) model to study the impact of the implementation of forestry carbon trading pilots in Fujian Province, China, on the local economic development, and conducts heterogeneity tests from three aspects: population density, the development level of the forestry economy, and fiscal capacity. The research conclusions are as follows: (1) Overall, the implementation of forestry carbon trading pilot policies in Fujian Province significantly promotes local economic development. (2) Heterogeneity analysis shows that in areas with high population density, forestry carbon trading pilots have a greater impact on economic development than in areas with low population density; In areas with developed forestry economy, the pilot of forestry carbon trading has a greater impact on economic development than in areas with underdeveloped forestry economy; In areas with strong fiscal capacity, the pilot policy of forestry carbon trading has a greater impact on economic development than in areas with weak fiscal revenue and expenditure.
Keywords: *forest carbon sink, PSM-DID model, economic performance, carbon trading pilot, fiscal capacity*

Introduction

Since the Industrial Revolution, human activities have become increasingly frequent, and productivity has rapidly developed. At the same time, the use of fossil fuels for production relying on machinery and equipment has emitted large amounts of greenhouse gases such as carbon dioxide into the atmosphere, leading to increasingly serious global climate change problems (Brienen et al., 2020; Wang et al., 2024a; Li et al., 2024a). The issue of global climate change has become a huge challenge for human society. A new round of energy revolution is emerging, and more and more countries are continuously reducing their dependence on fossil fuels and taking the path of green and low-carbon development (Wang et al., 2023a). There are currently two main ways to achieve carbon reduction targets: one is to control carbon sources, that is, to reduce greenhouse gas emissions, mainly carbon dioxide, in social production activities; and the other is to increase the carbon sink of the ecosystem, that is, to use various means to absorb and fix carbon dioxide, in order to reduce the content of carbon dioxide in the air. As the largest terrestrial carbon pools, forest ecosystems play a unique role in addressing climate change (Heinrich et al., 2021; Launiainen et al., 2022; Raihan et al., 2021). The global forest ecosystem can absorb up to 2.6 billion tons of carbon dioxide annually, accounting for two-thirds of the entire terrestrial ecosystem and equivalent to one-third of the total carbon emissions from fossil fuels. Moreover, the cost of forest carbon sinks is much lower than that of industrial carbon reduction (Li et al., 2024b). In

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1992, the United Nations Framework Convention on Climate Change (UNFCCC) explicitly stated the need to maintain and enhance forest carbon sinks; In 1997, the Kyoto Protocol proposed afforestation and reforestation, as well as sustainable management of forests, as important measures to address climate change; The 2015 Paris Agreement requires all parties to take action to protect and enhance forest carbon sinks, reduce carbon emissions caused by deforestation and forest degradation. In 2021, at the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), 141 countries, including China, committed to achieving sustainable forest management, forest conservation and restoration, and strengthening coordination of various international funding channels to reverse forest loss and degradation. It can be seen that the important role of forest carbon sinks in addressing climate change is beyond doubt.

China is the world's largest energy consumer, and there are certain difficulties in reducing carbon emissions on a large scale (Li et al., 2024c). There is a certain contradiction between achieving dual carbon goals through carbon reduction and economic growth, and carbon sinks can alleviate this contradiction to a certain extent (Li et al., 2024d). Carbon sinks not only have ecological, economic, and social benefits, but also have the characteristics of high efficiency, safety, and stability (Alaniz, et al., 2022). At present, China has identified consolidating its existing forest carbon sequestration capacity, continuously increasing forest area and forest stock, and enhancing ecosystem carbon sequestration as important ways to achieve carbon neutrality. According to the data of the ninth national forest resource inventory, the area of plantation in China has reached 79.5428 million ha, which is the largest country in the world. For every 100 million m^3 increase in forest stock, an average of 160 million tons of carbon dioxide can be fixed. It can be seen that China has enormous potential for forest carbon sequestration, and increasing the amount of forest carbon sequestration is an important strategy to achieve the dual carbon goals.

Given that forest carbon sinks have the function of carbon sequestration and emission reduction, forest carbon trading has been actively carried out both domestically and internationally to fully leverage the important role of forest carbon sinks as an ecological product in mitigating climate change (Doelman et al., 2020; Li et al., 2024e). The power source of carbon trading comes from the emission reduction commitments in the Kyoto Protocol, and three trading mechanisms have been established: International Emissions Trading (IET), Joint Implementation Mechanism (JI), and Clean Development Mechanism (CDM). Countries choose the appropriate trading mechanism based on their actual development situation, and thus the marketization process of carbon sinks begins. The international carbon market can be divided into mandatory carbon market and voluntary carbon market. The carbon trading market in China is mainly a voluntary market, which is a supplement to the carbon emission trading market. Currently, its trading rules, scope, and methods are all dependent on the carbon emission trading market. International carbon trading projects mainly include the United Nations Clean Development Mechanism (CDM), Verified Carbon Standard (VCS), and Gold Standard (GS). Domestic carbon trading projects mainly include the Chinese Certified Emission Reduction (CCER) and China Green Carbon Foundation (CGCF). Local level carbon trading projects mainly include Fujian Forestry Certified Voluntary Emission Reduction, Guangzhou Carbon Inclusive Certified Voluntary Emission Reduction, Beijing Certified Emission Reduction, and Guizhou Province Single Plant Carbon Poverty Alleviation Project. The CCER project started in March 2012. In March 2017, in order to standardize voluntary greenhouse gas emission reduction trading and prepare for the official launch of the national carbon emission trading market, the CCER project was temporarily suspended, new projects were no longer approved, and old projects could still continue to be traded. During this period, there were 2871 approved projects and 861 registered projects nationwide. Regarding carbon trading, currently both domestically and internationally, the focus is mainly on forest carbon trading. China's forest carbon trading is in its infancy and has great potential for development. *Figure 1* is a graphical summary of this article.

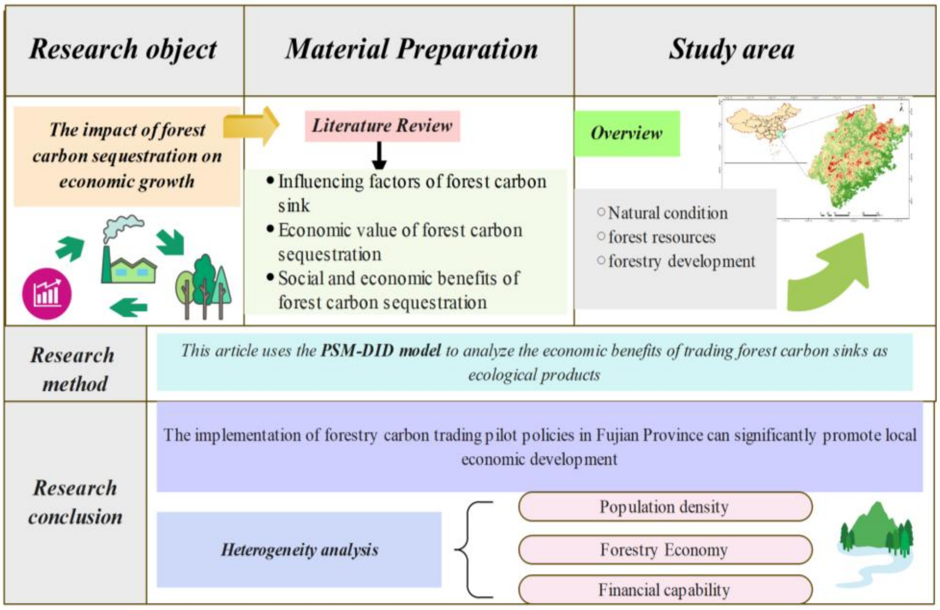

Figure 1. *Graphical summary of this article*

The marginal contribution of this article lies in: firstly, based on existing literature, this article takes forest carbon sinks as the research object and studies the economic benefits of forest carbon sinks from an economic perspective, providing a theoretical basis for the further development of forest carbon sinks. With the establishment of the carbon emission market, forest carbon sinks have gradually been included in this trading system. Carbon sink trading through market mechanisms can achieve forest ecological value compensation. It is important to study the economic benefits that carbon sink projects bring to the region. Secondly, this article takes the forestry carbon trading pilot in Fujian Province as an example and uses the PSM-DID model to study its impact on the local economic development level. Heterogeneity analysis is conducted from three aspects: population density, forestry economic development level, and fiscal capacity, in order to explore a high-quality and sustainable forest carbon development model. The trading volume and volume of forest carbon sinks in Fujian Province are among the top in the country, and the exploration of diversified development models for forest carbon sinks is also in a leading position in the country. Therefore, choosing Fujian Province as an example to analyze the economic benefits of forest carbon sinks is typical and can provide reference and inspiration for the development of forest carbon sinks in other regions of the country. The purpose of this study is to understand the role of forest carbon trading projects in local economic development. The conclusion of the article

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can not only provide feasible paths and breakthroughs for local governments to achieve green and low-carbon development, but also provide corresponding evaluation basis for local governments to implement forest carbon trading projects, and provide decision-making basis for the rational formulation of forest carbon development plans, thereby promoting the diversified development of forest carbon industry and the green development of local economy.

Literature review

The influencing factors of forest carbon sink

As an ecological resource, the development of forest carbon sinks is first affected by the natural environment. Ercanli (2018) found from the perspective of forests themselves that diversified forest structures have a positive impact on the amount of forest carbon sinks. In addition, forest age (Liu et al., 2021; Ribaj and Mexhuani, 2021), climate (Wu et al., 2018; Liu et al., 2019), and deforestation (Valade et al., 2017; Wang et al., 2024b) all have an impact on forest carbon sinks (Lin and Ge, 2020). On the one hand, the sustainable development of forest carbon sinks relies on human management, financial and technological support; On the other hand, human production activities and economic and social development inevitably have an impact on the ecological environment, which in turn affects the ability of forests to absorb carbon dioxide. Therefore, the development of forest carbon sinks will also be affected by socio-economic development. Zhang et al. (2020) found from a socio-economic perspective that economic development, industrial structure, and land use structure all have varying degrees of impact on forest carbon sinks. Du et al. (2021) and Liu et al. (2012) studied the influencing factors of forest carbon sinks from the perspective of spatial spillover, and believed that the development of forest carbon sinks is not only affected by urbanization rate, energy consumption structure, and technological management level, but also by surrounding areas, and will have an impact on the forest carbon sinks in surrounding areas. Therefore, jointly formulating forest carbon sink development strategies with surrounding areas can effectively promote the development of forest carbon sinks.

The market demand for forest carbon sinks and the supply willingness of forest carbon sink operators will to some extent affect the development of forest carbon sinks. When the market demand is high, forest carbon sink operators will increase the supply willingness of forest carbon sinks, thereby increasing the input of factors for forest carbon sink development, which is conducive to the improvement of forest carbon sink capacity; On the contrary, it may have a negative impact on the development of forest carbon sinks. Therefore, scholars have conducted research from the perspective of forest carbon supply and demand, and believe that market participants such as enterprises, governments, institutions, and farmers will all have an impact on the supply and demand of forest carbon (Song and Peng, 2019). Specifically, the environmental concept, partners, emission reduction costs, and policy support of managers are the core factors that affect the willingness of emission control enterprises to demand forest carbon sinks (Zou et al., 2020). Media publicity, risk-taking, carbon sink market expectations, offset ratios, etc. also have an impact on the willingness of enterprises to demand forest carbon sinks to a certain extent (Pan et al., 2020; Li et al., 2024f; Deng et al., 2021); The public's understanding of forest carbon sequestration and climate change is the main factor affecting the willingness of the public to demand forest carbon sequestration (Wang et al., 2024c; Chen and Gao, 2021). In terms of supply willingness,

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Huang et al. (2017) based on the survey data of forest farmers in Wenzhou City, Zhejiang Province, believed that gender, having undertaken carbon sequestration afforestation projects, enjoying afforestation subsidies, and recognizing the advantages of reducing forest carbon sequestration will affect farmers' supply willingness of forest carbon sequestration. Scholars have also found that carbon sink prices, risk preferences, forest resource scale, social capital, and other factors can also affect the willingness to supply forest carbon sinks.

The economic value of forest carbon sequestration

With the signing of the Kyoto Protocol in 1997, the economic value of forest carbon sinks began to be valued by the international community. Subsequently, with the establishment of the carbon emission market, the economic value of forest carbon sinks has received increasing attention from people. Carbon sinks can generate revenue and increase people's additional income through trading in the market (Parajuli et al., 2015; Chen and Wang, 2019; Wang et al., 2024d). At the same time, developing forest carbon sinks can also solve the employment problem of some impoverished people, which is conducive to the development of poverty alleviation. The economic value assessment of carbon sinks is the conversion of the economic benefits generated as indicator values to determine the value of carbon sink services that an ecosystem can provide. An important factor determining the economic value of forest carbon sinks is the carbon sink price, but due to the public good and externalities of forest carbon sinks, their price cannot be completely determined by the market. The carbon sink price in the market is currently not fixed, and both parties mainly determine the transaction price through negotiation.

Currently, the economic value assessment methods for forest carbon sinks mainly include afforestation cost method, carbon tax law, mean method, market value method, willingness to pay method, etc. Due to different scholars' research objects, factors considered, and measurement methods, there are also certain differences in the forest carbon sink prices obtained. Due to the fact that most developed countries use carbon taxes to limit carbon dioxide emissions, scholars calculate the economic value of forest carbon sinks by using the carbon tax price as the carbon sink price (Daigneault et al., 2020). Zhang and Peng (2021) evaluated the economic value of forest carbon sinks in Beijing using the carbon tax law and found that the average annual increase in forest carbon sink economic value in Beijing over the past 15 years was 24.91 million USD, and it has been continuously growing. The calculation of the economic value of forest carbon sinks is ultimately aimed at determining the value of carbon sink services that can be provided, providing a basis for market transactions, and the forest carbon sink trading market has also been preliminarily established. Therefore, Bañolas et al. (2020) use the market value method to determine the economic value of forest carbon sinks. In addition, literature has calculated the economic value of China's forest carbon sinks based on the National Accounts System and comprehensive indicator method, and found that the annual growth rate of China's forest carbon sink economic value is 2.18% (Zhang et al., 2016). Overall, when scholars calculate the economic value of forest carbon sinks, they mostly choose a certain province (city) or region as the research object, and the calculation methods vary; But the research conclusions all indicate that China's forest carbon sinks have great economic value and are in a continuous growth trend, reflecting the increasing value of forest carbon sink services in the context of climate change in China.

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The social and economic benefits of forest carbon sequestration

Carbon sinks not only have enormous ecological benefits, but also economic and social benefits (Lin and Ge, 2019). With the further development of forest carbon trading projects, scholars have conducted research on the social and economic benefits of forest carbon trading projects. The implementation of forest carbon trading projects can not only improve the ecological environment and enhance local infrastructure, but also provide employment opportunities and increase income for farmers, which can help alleviate poverty (Grassi et al., 2017). Phan et al. (2018) conducted a study on the ecosystem service payment project in Vietnam and found that after introducing the project, not only did forest coverage increase, but the average income of households participating in the project also increased by 45%. Li (2022) found that farmers who participate in forest carbon sequestration management and simultaneously obtain project forest land management rights, forest ownership, and partial verified emission reduction benefits have an average annual income increase of 5422 USD. However, some scholars believe that forest carbon trading projects have limited effect on increasing farmers' income levels (Nielsen et al., 2018), while Diswandi (2017) argues that due to the long implementation cycle and investment return rate of forest carbon trading projects, their effect on increasing farmers' income lags behind and may not increase their income in the short term, but can alleviate poverty in the long term. Overall, only based on endogenous development drivers and the self-development ability of impoverished populations can the development and design of forest carbon trading projects better achieve the goals of addressing climate change and alleviating poverty (Zhang and Huang, 2019).

Hu (2020) no longer limited themselves to farmers' income, but studied the impact of carbon sequestration afforestation projects on local economic development from a relatively larger perspective. They found that the longer the implementation cycle of carbon sequestration afforestation projects, the greater the promotion effect on economic development. Wu et al. (2021) took the Guangdong Province Carbon Sequestration Afforestation Project as an example and found that carbon sequestration afforestation projects can also promote local economic development, and their economic benefits have been significantly demonstrated in the sixth year after project implementation. This indicates that forest carbon trading projects have a long implementation cycle and have a relatively small impact on local economic development in the short term, but in the long run, their economic benefits are becoming increasingly evident. Scholars have also studied the wealth effect of forest carbon sequestration projects from the perspective of social capital, and believe that high social capital farmers who participate in forest carbon sequestration projects receive higher benefits than low social capital farmers. Cao et al. (2017) conducted research on the economic value of carbon sequestration afforestation projects themselves. Through analysis of the bamboo afforestation project in Tongshan County, Hubei Province, they found that the cumulative emission reduction of the project reached 131128tCO_2e, with a carbon sequestration value of 1.728 million USD. It has enormous value in both ecological and economic benefits.

By reviewing existing literature, it can be concluded that both domestic and international research data and conclusions indicate that forest carbon sinks have ecological, economic, and social benefits, and play a crucial role in mitigating climate change. This fully demonstrates the importance of studying forest carbon sinks. The existing research results have laid the foundation for the study in this article, but there are still some shortcomings. Firstly, in terms of research perspective, existing literature mainly focuses on the quantitative measurement of forest carbon sinks, the economic value, influencing factors, and socio-economic benefits of forest carbon sinks, and mainly conducts research from a single perspective. Secondly, in terms of research methods, when conducting empirical studies on forest carbon trading projects, most scholars analyze them through questionnaire surveys, which are easily influenced by personal subjective factors and have certain limitations in the research results. Finally, in terms of research scale, existing literature on forest carbon sequestration is mostly based on a certain province or region, and most studies on forest carbon trading projects focus on the role of the implementation of forest carbon trading projects in increasing farmers' income, with the main focus on farmers and neglecting their role in overall economic development.

Research areas

Natural condition

Fujian Province is located in the southeast coast of China, and the terrain is mainly mountainous and hilly. The mountainous and hilly area accounts for more than 80% of the total area of the province, most of which are part of the Wuyi Mountains. There are numerous rivers and dense water systems in the province. In addition, the coastline of Fujian Province is 3572 km long, winding and long, with many bays and islands. It has a good deep-water coastline and abundant port resources. In terms of climate, Fujian Province belongs to the subtropical maritime monsoon climate, with warm and humid climate, abundant sunshine, and abundant rainfall. The annual average temperature is between 17-21°C, and the annual average rainfall is between 1400-2000 mm, which is suitable for the growth and development of various plants.

Overview of forest resources

Due to its superior climate and terrain conditions, Fujian Province has abundant forest resources and enormous potential for developing forest carbon sinks. The main types of trees in Fujian Province are coniferous forests and broad-leaved forests. The area of broad-leaved mixed forests accounts for 32.7% of the province's forest area, which is the largest among all tree species, followed by Chinese fir, which accounts for 22.36% of the total area. From 2012 to 2022, Fujian Province has completed 1.19 million ha of afforestation, 1.253 million ha of mountain closure for afforestation, 1.74 million ha of forest nurturing, 0.20 million ha of national reserve forest construction, and 0.11 million ha of precise improvement in forest quality. Fujian Province has nine prefecture-level cities (Fuzhou City, Xiamen City, Quanzhou City, Zhangzhou City, Putian City, Ningde City, Longyan City, Sanming City, Nanping City) and one Pingtan Comprehensive Experimental Zone under its jurisdiction. All nine cities and one district in the province have been rated as national forest cities, and all counties (cities) have been rated as provincial forest cities. According to the ninth forest resource inventory data (https://www.forestry.gov.cn/) and the announcement from the Fujian Provincial Forestry Bureau (https://lyj.fujian.gov.cn/), the forest area in Fujian Province is 8.116 million ha, of which tree forests account for 76.6% and artificial forests cover 3.856 million ha; The forest stock volume is 729.3763 million m^3, ranking seventh in the country, and the unit area stock volume of deciduous forests is 116.922 m^3 ha^{-1}, ranking fifth in the country; The forest coverage rate is 66.8%, ranking first in the country for 42 consecutive years.

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Figure 2 shows the research overview of Fujian Province. The high and low represent the height above sea level of Fujian Province. The highest height above sea level in Fujian is 2153 m, and the lowest is -36 m.

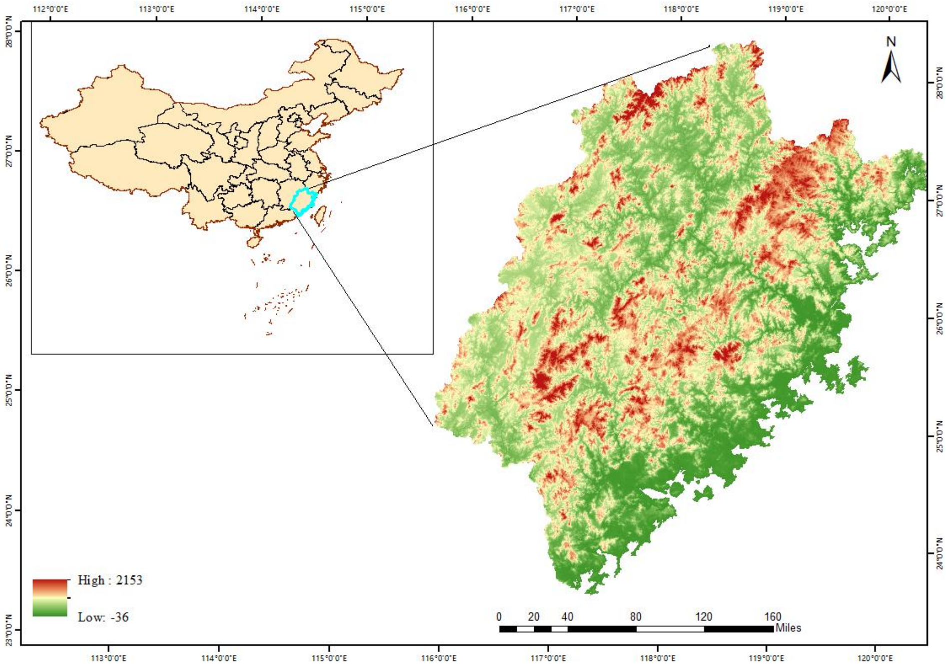

Figure 2. *Overview map of the research area*

Table 1 shows the relevant data of nine forest resource inventories in Fujian Province. From *Table 1,* it can be seen that since the first forest resource inventory, the forest area in Fujian Province has been continuously increasing. Except for the negative growth in the second forest resource inventory, the forest coverage has been positively increasing in all other times, and the forest stock volume has been positively increasing except for the negative growth in the second and third forest resource inventories. Compared to the first forest resource inventory, the forest area in Fujian Province increased by 71.67%, forest coverage increased by 37.7%, and forest stock increased by 132.9% in the ninth forest resource inventory, with the largest growth rate. In addition, in terms of growth rate, the forest area and forest coverage in Fujian Province had a relatively high growth rate before the fifth forest resource inventory, and were generally higher than the growth rate of forest stock volume; After the fifth forest resource inventory (1994-1998), the growth rates of forest area and forest coverage were lower than the forest stock volume. After the fifth forest resource inventory, the quality of forest resources in Fujian Province has improved. The forest stock volume indirectly reflects the forest carbon sink situation. The above situation indicates that the overall forest quality in Fujian Province is continuously improving, and the forest carbon sink capacity has been enhanced. This is related to a series of relevant policies implemented in Fujian Province and the continuous deepening of forest carbon sink development.

Figure 3 shows the forest coverage rate of various cities in Fujian Province. The average forest coverage rate in China is approximately 23.04%. From the graph, it can be seen that the forest coverage rates of nine cities in Fujian Province are far higher than the national average, with Longyan City, Sanming City, and Nanping City all having

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forest coverage rates of over 70%, indicating abundant forest resources; And only Fuzhou, Quanzhou, and Xiamen have forest coverage rates below 60%. This may be due to the fact that these three cities are the main economic development centers in Fujian Province, mainly focused on economic development, which puts them in a relatively disadvantaged position in the process of forest resource cultivation and development, with forest coverage rates lower than other cities. The area with the lowest forest coverage rate is Xiamen City, at 42.07%; The highest is Longyan City, reaching 79.39%, 37.32 percentage points higher than Xiamen City, ranking first in Fujian Province for 40 consecutive years. Longyan City is a national forest city, national garden city, national forest tourism demonstration city, national ecological civilization construction pilot area, and national greening model city. It has unique advantages in forest resource management and development, with good forest resource protection and huge potential and advantages in forest carbon sink development.

Table 1. *Nine forest resource inventory data in Fujian Province (the data is sourced from the forest resource inventory report released by the China Forestry Administration)*

Time	Forest area /10000 hm^2	Growth rate /%	Forest coverage (%)	Growth rate /%	Forest stock volume /100 million m^3	Growth rate /%
1973-1976	472.75	-	48.50	-	3.13	-
1977-1981	486.40	0.03	37.00	0.24	2.88	-0.08
1984-1988	547.05	0.12	41.18	0.11	2.81	-0.02
1989-1993	656.22	0.20	50.10	0.22	3.33	0.19
1994-1998	735.37	0.12	60.52	0.21	3.65	0.10
1999-2003	764.94	0.04	62.96	0.04	4.44	0.22
2004-2008	766.65	0.002	63.10	0.002	4.84	0.09
2009-2013	801.27	0.05	65.95	0.05	6.08	0.26
2014-2018	811.58	0.01	66.80	0.01	7.29	0.20

From 1981 to 1984, China did not conduct a census, and there was a gap between the two censuses

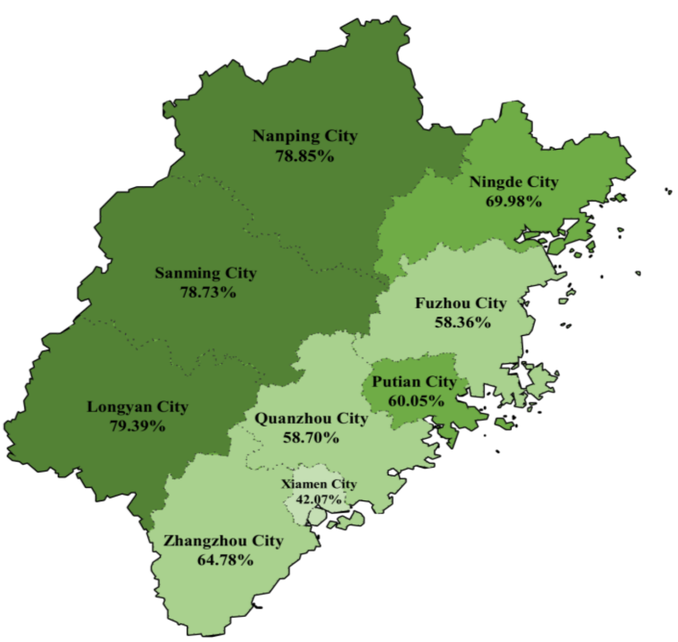

Figure 3. *Forest coverage rate of various cities in Fujian Province*

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Overview of forestry development

Fujian is one of the first regions in China to initiate the reform of the collective forest tenure system, and it is also the province with the fastest forestry development speed in the country. *Figure 4* shows the trend of changes in the total forestry output value and growth rate of Fujian Province from 2010 to 2020. From the perspective of the total output value of the forestry industry, the total output value of forestry in Fujian Province is in a continuous growth trend and exceeded 72.49 billion USD in 2017. In 2010, the total output value of forestry was 24.26 billion USD, which increased to 96.56 billion USD. by 2020, an increase of 298.09%. This indicates that in recent years, Fujian Province's emphasis on the development of forest carbon sinks has also driven the deepening development of its forestry industry. From the perspective of growth rate, except for 2011, the growth rate of the total forestry output value in Fujian Province fluctuated within 21% in all other years. In 2011, there was a significant increase in the total output value of forestry in Fujian Province. This may be due to the fact that 2011, as the beginning year of the 12th Five Year Plan, entered a new stage of forestry development in Fujian Province. In order to promote the development of forestry cooperative economic organizations throughout the province, the "Guidelines for the Application of Some Forestry Special Fund Projects in 2011" were issued, which promoted the development of forestry economy; Then, in 2011, Fujian Province exceeded the afforestation area by 0.47 million ha, and the afforestation output value was 4.7 times that of 2010.

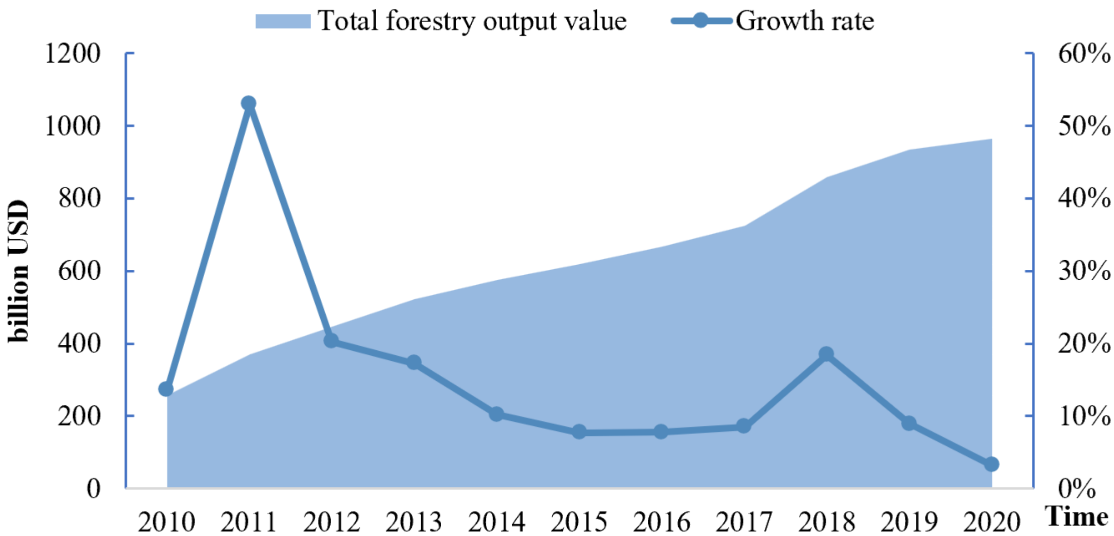

***Figure 4.** Changes in the total output value and growth rate of forestry in Fujian Province*

Figure 5 shows the output value and proportion of the first, second, and third industries of forestry in Fujian Province. The primary industry of forestry mainly includes tree breeding and seedling cultivation, afforestation, wood and bamboo harvesting, planting and collection of economic forest products, planting of flowers and other ornamental plants, and breeding and utilization of terrestrial wildlife; The secondary industry of forestry mainly includes wood processing and manufacturing of wood, bamboo, rattan, brown, and reed products, manufacturing of wood, bamboo, and rattan furniture, papermaking and paper products made from wood, bamboo, and reed

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pulp, manufacturing of forest chemical products, manufacturing of wood handicrafts and wooden cultural and educational sports equipment, and processing and manufacturing of non-wood forest products; The tertiary industry of forestry mainly includes forestry production services, forestry tourism and leisure services, forestry ecological services, forestry professional technical services, forestry public management, and other organizational services. From *Figure 5,* it can be seen that the forestry secondary industry dominates the composition of the forestry industry in Fujian Province, with a much higher output value than the primary and tertiary industries, accounting for over 50%. However, since 2014, the proportion of the secondary industry has continued to decline. The output value of the primary forestry industry was more than three times higher than that of the tertiary industry from 2010 to 2017, and began to be lower than that of the tertiary industry in 2018. The proportion of output value of the tertiary industry in forestry has been continuously increasing since 2011 and surpassed that of the primary industry in 2018. From the above changes in the forestry industry structure, it can be seen that the forestry industry structure in Fujian Province has undergone significant optimization and upgrading, with the proportion of the tertiary industry continuously increasing, indicating that Fujian's forestry is shifting towards sustainable development.

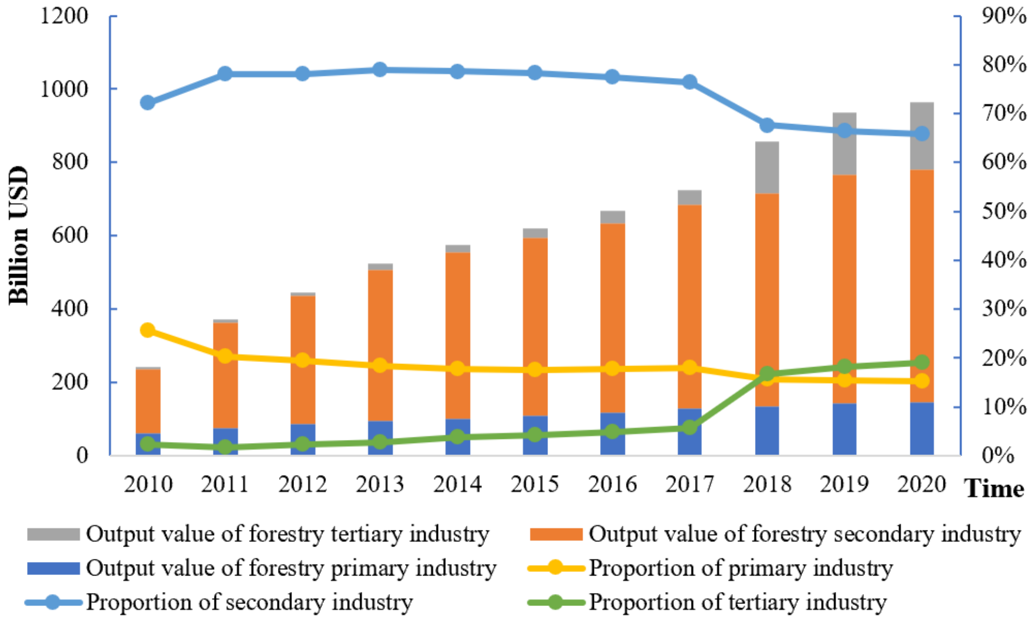

Figure 5. *Output value and proportion of the first, second, and third industries of forestry in Fujian Province from 2010 to 2020*

Development of forest carbon sequestration

As the first provincial-level ecological civilization demonstration zone and national ecological civilization experimental zone in China, Fujian Province has good policy advantages, development foundation, and practical experience in ecological environment protection and green low-carbon development. Its forest carbon sink development is also in a leading position in the country. Firstly, in terms of total forest carbon sequestration, as mentioned earlier, from 2005 to 2020, the forest carbon

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sequestration in Fujian Province was higher than the national average, ranking sixth in the country. In 2005, the forest carbon sink in Fujian Province was 522.99 million tons, and by 2020, it had increased to 9100.9 million tons, a growth rate of 74.02%, indicating that the forest carbon sink in Fujian Province has achieved good development. Secondly, in terms of forest carbon sequestration methodology, Fujian Province actively carries out a special survey on forest carbon sequestration. Based on the types and biological characteristics of trees in the province, more than 400 forest plots are selected for investigation to understand the forest carbon sequestration background and construct a carbon sequestration measurement and monitoring system accordingly. In 2016, the “Methodology for Forest Carbon Sequestration Project to Stop Commercial Logging” developed by experts organized by Fujian Province has been registered. Again, in terms of forest carbon trading, since its establishment as a national ecological civilization pilot zone in 2016, Fujian Province has actively explored the development of forest carbon projects and the construction of carbon trading markets. In 2017, 20 counties (cities, districts) and forest farms were selected to carry out carbon trading pilot sites, achieving significant results in forest carbon trading. According to the “Reply to Proposal No. 20221112 of the Fifth Session of the 12th Provincial Political Consultative Conference” released by the Fujian Forestry Bureau. Fujian Province has cumulatively traded 3.508 million tons of forestry carbon credits, with a transaction amount of 7.49 million USD, ranking among the top in both trading volume and transaction amount in the country. Finally, in terms of forest carbon sink development models, Fujian Province actively and continuously explores diversified carbon sink financial development models to promote the in-depth development of carbon sinks, fully utilize market mechanisms, and combine financial development, injecting vitality into achieving carbon peak and carbon neutrality goals.

Policy background and mechanism of action

Policy background

In the context of global climate change, how to coordinate the relationship between economic development and ecological environment protection is a global issue, and the emergence of carbon sinks provides a new perspective for alleviating the contradiction between economic development and ecological protection. With the signing of the Kyoto Protocol and the Paris Agreement, the role of forest carbon sinks in addressing climate change has been widely recognized by the international community. On the one hand, forest carbon sinks can reduce carbon dioxide in the air, purify the air, and improve the ecological environment; At the same time, measures such as afforestation and prohibition of indiscriminate logging can be taken in various regions to develop forest carbon sinks, which can achieve ecological restoration, prevent soil erosion, and protect biodiversity. On the other hand, developing forest carbon sequestration projects can convert ecological value into economic value, bring employment opportunities to the local area, increase economic income, improve infrastructure, and contribute to social stability. To this end, China has taken a series of measures to develop forest carbon sinks. The Interim Measures for the Management of Greenhouse Gas Resource Emission Reduction Trading, released in 2012, officially allowed forestry carbon sink projects to enter; The Guiding Opinions on Promoting Forestry Carbon Trading issued by the State Forestry Administration in 2014 proposed to improve forestry carbon trading projects, promote voluntary forestry carbon trading, and explore forestry carbon trading under carbon

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emission trading; In December 2021, China released its first national standard for forestry carbon sequestration, the “Guidelines for the Approval and Verification of Forestry Carbon Sequestration Projects”, which is the first forestry carbon sequestration national standard issued by China since the proposal of the dual carbon target. As of the end of 2020, there were a total of 137 forest carbon sequestration projects in China, including 99 CCER projects (China Certified Emission Reduction Mechanism), 33 VCS projects (International Certified Carbon Reduction Standards), and 5 CDM projects; Among them, the CCER project has a trading volume of about 2 million tons, the VCS project is expected to reduce emissions by 9.5 million tons, and the CDM project is expected to reduce emissions by over 40 million tons. On this basis, China has also launched multiple regional forestry carbon sequestration projects, such as the Beijing Forestry Carbon Sequestration Project, the Fujian Forestry Carbon Sequestration Project, the Guangdong Carbon Inclusive Verified Voluntary Emission Reduction Project, and the Guizhou Single Plant Forestry Carbon Sequestration Project.

Fujian has abundant forest resources and significant ecological advantages, with enormous potential for forest carbon sequestration. It can be seen that Fujian Province has great potential and unique advantages in achieving carbon peak and carbon neutrality through forest ecosystem carbon sinks. In order to fully implement the series of decisions and deployments of the 18th National Congress of the Communist Party of China on ecological civilization construction, coordinate social, economic, and ecological development, and promote green development, Fujian Province proposed the “Fujian Province Forestry Carbon Trading Pilot Plan” in 2017, selecting 20 counties (cities, districts) and forest farms including Shunchang, Yong’an, Luoyuan, Anxi, Yangkou State owned Forest Farm, and Wuyi State owned Forest Farm to carry out forestry carbon trading pilot projects, focusing on improving forest quality, increasing forest carbon sinks, and actively promoting forest carbon trading. The pilot carbon sequestration projects mainly include carbon sequestration afforestation, forest management carbon sequestration, and bamboo forest management carbon sequestration projects. Verified forestry carbon sequestration projects can be traded in the pilot carbon market in Fujian. Since the establishment of the carbon trading market in 2016, Fujian Province has included Fujian forest carbon sinks in market trading, which is one of the national forest carbon trading pilot projects. Emission control enterprises can offset carbon emissions by purchasing forest carbon sinks, and innovatively proposed that Fujian forest carbon sinks can offset up to 10% of the carbon emissions of emission control enterprises and up to 5% of the carbon emissions of other industries. As of April 2022, Fujian Province has cumulatively traded 3.508 million tons of forestry carbon credits, with a transaction amount of 7.49 million USD, ranking among the top in both trading volume and transaction amount in the country. It can be foreseen that the pilot construction of forestry carbon trading in Fujian Province will have significant and far-reaching impacts on various aspects of local economic development. Therefore, this article chooses Fujian Province as the research object to analyze the economic benefits of forest carbon sequestration.

Mechanism of action

Actively conducting forest carbon trading through market mechanisms is an effective means of transforming “green mountains and clear waters” into “golden mountains and silver mountains”, which can bring new economic growth points to the local area. Firstly, developing forest carbon sinks can bring employment opportunities to local forest farmers, and local residents can participate in various forms of carbon sink forest project

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construction, enriching the income sources of forest farmers and increasing residents' income (Stringer, 2012; Ferraro et al., 2015). During the initial implementation of the forest carbon sequestration project, a large amount of temporary labor is required for afforestation land consolidation, tree planting, fertilization, and weeding; As the project continues to be implemented, the management of carbon sequestration forests will generate long-term labor demands. Therefore, the implementation of forest carbon trading pilots can provide a large number of job opportunities, improve local employment rates (Carton and Andersson, 2017), contribute to social stability, and create a favorable social environment for the sustained and healthy development of the local economy. In addition, the implementation of forest carbon trading pilot can bring advanced technology and management experience to the local area (Ken et al., 2020), and local residents have the opportunity to participate in various afforestation and forestry skills training, which is conducive to improving local human capital and promoting regional economic development (Benessaiah, 2012). Secondly, pilot forest carbon trading can improve local economic development conditions, attract investment, and promote sustained and stable regional economic development. On the one hand, the implementation of carbon trading pilot policies means that government fiscal expenditures will increase, and infrastructure construction such as roads and small-scale water conservancy equipment will gradually improve, greatly improving local agricultural production conditions and promoting local agricultural economic development. On the other hand, market-oriented trading mechanisms can guide social capital to flow to pilot areas and provide financial support for local industrial development. Finally, the pilot program for forest carbon trading is conducive to breaking the traditional economic development mode dominated by agricultural production in the local area, and to a certain extent, promoting the transformation of production methods in the pilot areas. In the market-oriented trading mechanism of forest carbon sequestration, the pilot project of carbon sequestration trading can not only promote the development of the forest carbon sequestration industry, but also promote the development of the wood processing industry. Previous studies have shown that reasonable logging can effectively enhance forest carbon sequestration capacity. Therefore, in the management of carbon sequestration forests, forest farmers can scientifically harvest trees based on their rotation period, and develop processing trade on this basis to process wood, increase product added value, and promote the development of the wood industry. At the same time, in the pilot areas of carbon trading, we will horizontally expand the scope of forest carbon industry, vertically extend the forest carbon industry chain, carry out ecological planting, intensive breeding, forest health and other industries, develop ecotourism, and promote the development of local service industry.

Based on the above analysis, this article proposes the following hypothesis:

H1: Pilot policies for forestry carbon trading can promote local economic growth.

The effect of forest carbon trading pilot policies on regional economic growth may vary depending on differences in population density, forestry economic development level, and local fiscal revenue and expenditure levels between regions. The higher the density and activity of economic activities in areas with high population density, the more likely they are to generate internal economies of scale and localized economies. Based on this, workers can specialize in their own areas and achieve rapid development in specialized production. The afforestation and forestry activities mainly aimed at increasing forest carbon sinks have strict land preparation requirements and technical specifications, and mechanized production is difficult to meet the requirements, requiring a large amount of manual operation. Therefore, in areas with high population

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density, there is a relatively sufficient labor force that can promote the rapid development of carbon trading pilot projects. In addition, industries derived from the forest carbon sink industry, such as wood processing, forest by-products, and forest ecotourism services, cannot achieve large-scale and intensive production without a large amount of labor input. Therefore, areas with high population density can effectively improve the development level of forest carbon sequestration industry, thereby promoting regional economic development.

The level of forestry economic development has a significant impact on the implementation of pilot policies for forestry carbon trading. Due to differences in forest resource endowments and uneven distribution of factor inputs between counties, there are significant disparities in the level of forestry economic development between counties. To a certain extent, areas with high levels of forestry economic development indicate that the region has abundant forest resources, relatively high levels of forest management and experience, relatively complete forestry infrastructure, and a relatively complete industrial chain. Such regions can quickly and effectively digest and absorb various knowledge and technologies brought by the pilot policies of forest carbon trading, promote the high-quality development of the forest carbon industry, and thus promote local economic development.

Finance, as an effective means for the government to allocate resources, can promote regional economic development by changing the structure of fiscal expenditure. The implementation of the pilot policy for forest carbon trading cannot be separated from the financial support of the local government. Areas with high local fiscal expenditures indicate that the government has invested heavily in local economic development, with corresponding investments in infrastructure, science and technology. Relatively complete infrastructure can accelerate the flow of production factors and facilitate the smooth implementation of forest carbon trading projects. At the same time, the government’s investment in technological innovation will promote the emergence of new technologies and processes, which can to some extent promote the development of forest carbon sequestration technology and improve the technological level of forest carbon trading pilot areas. In addition, government spending on ecological construction and protection will ultimately drive the construction of forest carbon trading projects, promote the development of the forest carbon industry, and ultimately drive regional economic development.

Based on the above analysis, this article proposes the following hypothesis:

H2: In areas with high population density, the pilot policy of forestry carbon trading has a stronger impact on economic development.

H3: In areas with high levels of forestry economic development, pilot policies for forestry carbon trading have a stronger impact on economic development.

H4: In areas with high levels of local fiscal expenditure, the pilot policy of forestry carbon trading has a stronger impact on economic development.

Research design

Model design

This article examines the effect of the pilot policy of forestry carbon trading in Fujian Province on the local economic development level. The policy can be regarded as a quasi-natural experiment. By comparing the results between the pilot and non-pilot areas of forestry carbon trading, the implementation effect of the policy can be

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estimated. The Difference in Difference (DID) method is commonly used to evaluate the implementation effectiveness of policies, which can effectively avoid endogeneity issues and alleviate problems such as omitted variable bias (Zou et al., 2022). The double difference model considers the differences in data results before and after the policy implementation. By controlling for the differences between the treatment group and the control group before and after the policy implementation, the changes that occur after the policy implementation are comparable. By observing the magnitude of the increment after the difference, the effectiveness of the policy can be evaluated.

Directly using DID for estimation may lead to sample selection bias issues, and the premise of using DID is that the treatment group and control group must satisfy the parallel trend assumption. However, whether from the perspective of classical economic convergence theory or the economic development reality of carbon trading pilot areas and other non-pilot areas, this assumption may not be met. Liu et al. (2015) and Ji (2020) believe that Propensity Score Matching (PSM) can effectively solve this problem. Therefore, this article refers to the research of these scholars and combines PSM for further study. The basic idea of propensity score matching method is to calculate the propensity score of the sample in the study through Logit or Probit models, find a control group that is as similar as possible to the observable variables of the experimental group based on the calculated propensity score, and then perform paired analysis. Propensity score matching can not only effectively reduce the impact of sample selection bias on research results, but also largely eliminate the confounding bias of observable factors such as control variables on the examined variables (Wang et al., 2023b). However, propensity score matching is difficult to overcome endogeneity issues caused by omitted variables. Combining DID and PSM can effectively solve endogeneity and sample selection bias problems, and achieve effective identification and evaluation of policy implementation effects.

Based on the above analysis, this article uses PSM-DID to analyze the effect of forestry carbon trading pilot policies on local economic growth. The model is set as follows:

$$\mathrm{pgdp}_{it} = \alpha_0 + \alpha_1 \mathrm{policy} + \alpha_2 X_{it} + \gamma_i + \mu_t + \varepsilon_{it} \tag{Eq.1}$$

Among them, pgdp_{it} represents the per capita GDP of county i at time t; α_0 is a constant term; The policy is $\mathrm{post}_{it} \times time_{it}$, where post_{it} represents the policy dummy variable. $\mathrm{post}_{it} = 1$ is the pilot area for implementing forestry carbon trading, which is included in the experimental group. $\mathrm{post}_{it} = 0$ is the non-pilot area, which is included in the control group; $time_{it}$ represents a time dummy variable, with $time_{it} = 0$ before the implementation of the forestry carbon trading pilot policy and $time_{it} = 1$ after the policy implementation; X_{it} represents the control variable; γ_i represents individual fixed effects; μ_t represents the fixed time effect, which is used to control for macroeconomic factors and policy changes that can affect all counties in a specific year; ε_{it} is a random interference term.

Indicator selection

(1) Explained variable. The dependent variable of this chapter is the level of regional economic development, measured by the per capita GDP of each county (city, district) according to the common practice in the literature.

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(2) Core explanatory variables. The core explanatory variable of this chapter is the forestry carbon trading pilot policy, represented by the interaction term between time and policy dummy variables. The pilot policy for forestry carbon trading in Fujian Province began to be implemented in 2017, so 2017 is taken as the policy timeline. If the county (city, district) is designated as a pilot area starting from 2017, it will be assigned a value of 1; Otherwise, assign a value of 0.

(3) Control variables. (1) Population size. This article uses the logarithm of the population of each county (city, district) to measure the population size. (2) Degree of industrialization. This article measures the degree of industrialization by the proportion of the secondary industry to the GDP of the county. (3) The level of fiscal revenue and expenditure. This article uses the logarithm of fiscal expenditure and fiscal revenue to measure the structure of fiscal revenue and expenditure. (4) Fixed assets investment. This paper uses the proportion of fixed assets investment in county GDP to measure the level of fixed assets investment. (5) The level of financial development. This article uses the proportion of various loan balances of county-level financial institutions to the county-level GDP to measure the level of financial development (6) capital accumulation. This article measures capital accumulation by the proportion of residents' savings deposits to the county's GDP. *Table 2* provides an explanation of the relevant variables.

Table 2. *Variable description*

Category	Name	Explanation
Dependent	Economic development level (pgdp)	Per capita GDP in counties
Explanatory variables	Pilot policy for forestry carbon sequestration trading	Since 2017, it has been designated as a pilot area and assigned a value of 1; otherwise, assign a value of 0
Control variable	Population size (lnpeo)	Logarithmic number of population in each county (city, district)
	Industrialization level (ind)	Secondary industry/county-level GDP
	Fiscal expenditure (lnexp)	The logarithm of fiscal expenditure amount
	Fiscal revenue (lninc)	The logarithm of fiscal revenue amount
	Fixed assets investment (fix)	Fixed assets investment/county GDP
	Financial development level (fin)	Balance of various loans from county-level financial institutions/county-level GDP
	Capital accumulation (save)	Resident savings deposit balance/county GDP

Data sources

In 2017, Fujian Province selected 18 counties (cities, districts) and 2 state-owned forest farms to carry out forestry carbon trading pilot projects. Considering the continuity and availability of research data, 18 counties (cities, districts) were selected as the experimental group and the remaining counties as the control group during the sample period from 2010 to 2020. According to the *Notice of the General Office of the People's Government of Fujian Province on Issuing the Pilot Scheme for Forestry Carbon Trading in Fujian Province*, 27 counties did not participate in the pilot policy of forestry carbon trading, namely, including Minhou, Lianjiang, Minqing, Yongtai,

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Pingtan, Yunxiao, Zhangpu, Zhao'an, Dongshan, Nanjing, Pinghe, Huian, Yongchun, Kinmen, Xianyou, Gutian, Pingnan, Shouning County, Zherong, Pucheng, Guangze, Songxi, Mingxi, Qingliu, Ninghua, Datian, and Wuping; 30 districts did not participate, including Gulou, Taijiang, Cangshan, Jin'an, Mawei, Changle, Siming, Haicang, Huli, Jimei, Tong'an, Xiang'an, Xiangcheng, Longwen, Longhai, Changtai, Licheng, Fengze, Luojiang, Quangang, Chengxiang, Hanjiang, Licheng, Xiuyu, Jiaocheng, Yanping, Sanyuan, Shaxian, Xinluo, and Yongding. Considering that some counties (cities, districts) have undergone changes during the research period, they will be excluded in this study; Due to significant data gaps, Kinmen County was also excluded and finally collected and organized into 57 county-level sample data. After PSM matching, 558 sample observations were finally obtained. The data in the article mainly comes from the *"China County Statistical Yearbook"* published in March 2022 and the statistical yearbooks of various cities in Fujian Province over the years. Some data comes from the statistical yearbooks and bulletins of various counties (cities, districts) over the years, and some missing data is supplemented by the mean method. The descriptive statistics of each variable are shown in *Table 3*.

Table 3. *Descriptive statistics*

Variables	Count	Mean	SD	Min	Max
pgdp	558	5.768	2.662	1.258	15.69
policy	558	0.127	0.334	0	1
lnpeo	558	3.535	0.576	2.330	5.023
ind	558	0.470	0.0980	0.204	0.798
lnexp	558	2.993	0.595	1.300	4.549
lninc	558	1.973	0.799	0.00995	4.264
fix	558	0.863	0.408	0.0904	2.227
fin	558	0.553	0.302	0.187	5.624
save	558	0.435	0.120	0.219	0.869

Empirical analysis

(1) Balance test

PSM requires that there is no significant difference in observable variables between the experimental group and the control group before the implementation of the forestry carbon trading pilot policy. Therefore, before conducting PSM-DID estimation, a balance test needs to be performed on the matched data. If the balance test fails, further analysis cannot be carried out. This paper selects population size, industrialization degree, fiscal expenditure, fiscal revenue, fixed assets investment, financial development level and capital accumulation as covariates, and uses 1:1 nearest neighbor matching as the experimental group to match the control group; And the Logit model is used to estimate the propensity score, and the control group with the closest propensity score is the paired group of the experimental group. The results of PSM balance test are shown in *Table 4*. From the table, it can be seen that after PSM matching, the absolute values of the standard deviations of all variables significantly decreased, and the deviations were all within 10%. The distribution tended to be consistent, and there was no systematic bias, indicating that the selected matching variables and methods were

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reasonable. At the same time, the p-values after matching were not significant, indicating that there was no significant difference in the variables between the experimental group and the control group after matching, and the two groups of samples had good comparability after matching.

Table 4. *Balance test results of propensity score matching*

Variable sample	Sample	Experimental group mean	Control group mean	Standard deviation (%)	t-Value	p-Value
lnpeo	Before matching	3.425	3.729	-50.7	-5.67	0.000
	After matching	3.429	3.407	3.7	0.38	0.704
ind	Before matching	0.481	0.472	9.1	1.02	0.306
	After matching	0.479	0.482	-3.2	-0.32	0.746
lnexp	Before matching	2.921	3.199	-43.3	-4.85	0.000
	After matching	2.922	2.924	-0.3	-0.03	0.973
lninc	Before matching	1.880	2.293	-46.0	-5.07	0.000
	After matching	1.884	1.902	-2.0	-0.22	0.825
fix	Before matching	0.896	0.821	19.1	2.20	0.029
	After matching	0.893	0.918	-6.3	-0.62	0.534
fin	Before matching	0.547	0.589	-15.1	-1.58	0.114
	After matching	0.547	0.528	7.2	0.99	0.324
save	Before matching	3.425	3.729	-50.7	-5.67	0.000
	After matching	3.429	3.407	3.7	0.38	0.704

(2) Benchmark regression

Table 5 shows the benchmark regression results of the forestry carbon trading pilot policy on local economic growth. Model (1) is a regular OLS regression without fixed effects, Model (2) is a regression with only regional fixed effects, and Model (3) is a double fixed effects model with both regional and temporal fixed effects. From *Table 5,* it can be seen that the coefficient of the policy is significantly positive at the 10% level, indicating that the pilot policy of forestry carbon trading in Fujian Province does have a promoting effect on the local economic development level, and H1 has been confirmed.

(3) Robustness test

(1) Replace the matching method. In the previous section, 1:1 nearest neighbor matching was used to match the experimental group with the control group. To verify the robustness of the results, kernel matching method was chosen as the robustness test. As shown in *Table 6,* Model (1) is the regression result using kernel matching, and it was found that the coefficient of policy was still significantly positive at the 10% significance level, indicating the robustness of the benchmark regression conclusion in the previous section.

(2) Replace the dependent variable. The forestry economy was the first to be affected and had a significant impact on the implementation of the pilot policy for forestry carbon trading. Therefore, the county-level forestry output value (FECO) was used instead of the county-level per capita GDP to measure the level of regional economic development. As shown in *Table 6,* Model (2) presents the regression results of forestry

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output value as the dependent variable. It can be seen that after replacing the dependent variable, the coefficient of policy is significantly positive at the 5% significance level, indicating the robustness of the benchmark regression conclusion in the previous section.

Table 5. *Analysis of benchmark regression results*

Variable	(1)	(2)	(3)
policy	1.239***	1.266***	0.194*
	(6.36)	(7.04)	(1.76)
lnpeo	-3.800***	8.697***	-4.352**
	(-21.53)	(3.06)	(-2.42)
ind	5.523***	-0.811	2.346***
	(6.48)	(-0.51)	(2.63)
lnexp	3.911***	4.905***	-0.265
	(14.94)	(15.47)	(-1.01)
lninc	0.433**	-0.461	0.349*
	(2.06)	(-1.47)	(1.95)
fix	-1.140***	-1.945***	-0.576***
	(-5.84)	(-7.96)	(-4.00)
fin	-0.572***	-0.031	-0.131
	(-2.64)	(-0.15)	(-1.18)
save	-3.556***	-6.934***	-9.236***
	(-5.98)	(-6.43)	(-15.47)
_cons	6.732***	-43.432***	24.609***
	(8.23)	(-3.78)	(3.22)
Regional fixed effects	No	Yes	Yes
Fixed time effect	No	No	Yes
R^2	0.712	0.860	0.960
N	558	558	558

***, **, * respectively indicate significance at the 1%, 5%, and 10% levels, with t-values in parentheses, the same applies below

(4) Heterogeneity analysis

(1) Population density. Due to the implementation of the forestry carbon sequestration pilot policy requiring a large amount of labor, areas with high population density can provide sufficient labor for the implementation of the pilot policy, but it may put some pressure on the environmental carrying capacity, which is not conducive to the implementation of the pilot policy. Therefore, the effects of forestry carbon trading pilot policies on economic development levels may vary in areas with different population densities. To study the economic benefits of forestry carbon trading pilot policies in areas with different population densities, population density was measured by the proportion of permanent population to the area of each county (city, district). Referring to the research of Cui and Jiang (2019), the median classification method was used to classify samples above the median population density as high population density areas and samples below the median population density as low population density areas.

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The regression results are shown in *Table 7*. Model (1) shows the regression results for high-population-density areas, while Model (2) shows the regression results for low-population-density areas. From *Table 7,* it can be seen that the coefficient of policy is significantly positive in high population density areas, and positive but not significant in low-population-density areas. The pilot policy of forestry carbon trading has a more prominent effect on local economic growth in areas with higher population density. H2 has been validated.

Table 6. *Robustness test*

Variable	Replace the matching method	Replace the dependent variable
policy	0.193*	0.553**
	(1.74)	(2.37)
lnpeo	-4.298**	-15.829***
	(-2.37)	(-4.17)
ind	2.313**	6.790***
	(2.54)	(3.60)
lninc	0.347*	0.436
	(1.93)	(1.15)
lnexp	-0.277	-0.302
	(-1.05)	(-0.54)
fix	-0.569***	-0.052
	(-3.93)	(-0.17)
fin	-0.129	1.013***
	(-1.16)	(4.32)
save	-9.305***	-0.583
	(-15.40)	(-0.46)
_cons	24.479***	61.246***
	(3.18)	(3.80)
Regional fixed effects	Yes	Yes
Fixed time effect	Yse	Yes
R^2	0.960	0.949
N	555	558

(2) The level of development of forestry economy. The implementation of forestry carbon trading pilot policies is directly related to the abundance of forest resources. The level of forestry economic development can to some extent reflect the local forest resource management situation. Therefore, the effect of forestry carbon trading pilot policies on the local economic development level may vary under different levels of forestry economic development. To investigate the differences in the effects of forestry carbon trading pilot policies on economic growth at different levels of forestry economic development, the county-level forestry output value was used to measure the level of forestry economic development. The median classification method was used to divide samples higher than the median forestry output value into regions with high forestry economic development levels, and samples lower than the median forestry output value into regions with low forestry economic development levels. The

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regression results are shown in *Table 8*. Model (1) shows the regression results for regions with high levels of forestry economic development, while Model (2) shows the regression results for regions with low levels of forestry economic development. From *Table 8,* it can be seen that the coefficient of policy is significantly positive in areas with high levels of forestry economic development, and positive but not significant in areas with low levels of forestry economic development. The pilot policy of forestry carbon trading has a more prominent effect on local economic development in areas with high levels of forestry economic development, and H3 has been verified.

Table 7. *Regression results of population density heterogeneity*

Variable	High population density	Low population density
policy	0.468**	0.043
	(2.00)	(0.35)
lnpeo	-5.340*	0.648
	(-1.72)	(0.27)
ind	0.307	3.779***
	(0.21)	(2.93)
lninc	0.594**	0.306
	(2.18)	(1.22)
lnexp	-0.379	-0.514
	(-0.92)	(-1.48)
fix	-0.947***	-0.567***
	(-3.91)	(-3.16)
fin	-0.714	-0.074
	(-1.42)	(-0.77)
save	-9.197***	-8.353***
	(-8.31)	(-11.40)
_cons	27.493**	4.082
	(2.34)	(0.53)
Regional fixed effects	Yes	Yes
Fixed time effect	Yse	Yes
R^2	0.916	0.957
N	279	279

(3) Financial capability. The smooth implementation of a new policy requires strong support from the local government, and fiscal expenditure is an important guarantee for the implementation of the forestry carbon trading pilot policy. Due to the relatively low level of economic development in counties and the lack of supporting infrastructure for the development of carbon sequestration as an emerging industry, it is necessary to continuously improve relevant infrastructure construction, such as road construction, water irrigation facilities, forest trails, forest fire prevention facilities, etc., in order to ensure the smooth implementation and sustainable development of pilot policies. These all require government financial support to achieve; In addition, research and development investment in related carbon sequestration technologies also requires financial support from the government. Therefore, the financial capacity of local

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governments will directly affect the implementation effect of forestry carbon trading pilot policies. To investigate the differences in the effects of forestry carbon trading pilot policies on economic development levels under different fiscal capacities, the proportion of fiscal expenditure to fiscal revenue was used to measure fiscal capacity. Drawing on the research of Gan and Zong (2021), the mean method was used to classify samples above the mean fiscal capacity as high fiscal capacity areas and samples below the mean fiscal capacity as low fiscal capacity areas. The regression results are shown in *Table 9*. Model (1) shows the regression results for regions with high fiscal capacity, while Model (2) shows the regression results for regions with low fiscal capacity. From *Table 9,* it can be seen that the coefficient of policy is significantly positive in areas with high fiscal capacity, and positive but not significant in areas with low fiscal capacity. The pilot policy of forestry carbon trading has a more prominent impact on local economic development in areas with higher fiscal capacity. H4 has been validated.

Table 8. *Heterogeneity regression results of forestry economic development level*

Variable	High level of forestry economic development	Low level of forestry economic development
policy	0.247** (2.09)	0.100 (0.50)
lnpeo	-0.719 (-0.34)	-1.381 (-0.45)
ind	4.132*** (3.22)	2.434* (1.82)
lninc	0.109 (0.46)	0.291 (0.99)
lnexp	-0.066 (-0.19)	-0.388 (-0.95)
fix	-0.205 (-1.07)	-0.989*** (-3.85)
fin	-0.112 (-1.17)	-0.775* (-1.67)
save	-11.771*** (-13.21)	-5.583*** (-6.26)
_cons	9.113 (1.25)	10.300 (0.93)
Regional fixed effects	Yes	Yes
Fixed time effect	Yse	Yes
R^2	0.958	0.905
N	279	279

Discussion

With the construction of the forest carbon trading market, forest carbon not only plays a role in carbon reduction, but also brings new economic growth points to local development. To study the impact of the implementation of carbon trading projects on local economic development, this article takes the forestry carbon trading pilot in Fujian

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Province as an example, uses the PSM-DID model to analyze the effect of the trading pilot on the local economic development level, and conducts heterogeneity analysis, laying the foundation for proposing policy recommendations for the deep development of forest carbon sinks in the following text.

Table 9. *Regression results of heterogeneity in fiscal capacity*

Variable	High fiscal capacity	Low fiscal capacity
policy	0.299^{*} (1.94)	0.017 (0.10)
lnpeo	-8.123^{***} (-3.16)	-4.070 (-1.40)
ind	1.880 (1.51)	2.457^{*} (1.89)
lninc	0.757^{**} (2.48)	-0.031 (-0.10)
lnexp	-0.449 (-0.92)	0.671 (1.46)
fix	-0.146 (-0.62)	-0.785^{***} (-4.07)
fin	-1.625^{***} (-3.31)	0.002 (0.02)
save	-7.215^{***} (-9.13)	-10.885^{***} (-10.07)
_cons	32.754^{***} (3.80)	20.462^{*} (1.91)
Regional fixed effects	Yes	Yes
Fixed time effect	Yes	Yes
R^2	0.933	0.942
N	260	298

The experimental results indicate that: Firstly, due to the “resource-asset-capital-fund” transformation path of forest carbon sequestration, the most direct benefit of implementing carbon trading pilot is the forest carbon sequestration income obtained through carbon market trading, which is consistent with the research conclusion of Cai et al. (2024) Carbon trading based on market mechanisms is conducive to promoting the transformation of forest “carbon tickets” into “banknotes”, creating new economic growth points for local economic development and bringing new development opportunities. On the one hand, the pilot development of forestry carbon trading requires a large amount of labor input, and the project construction period is long, which can create lasting and stable employment opportunities, broaden the employment channels for farmers deep in the mountains, promote rural labor to start businesses locally, and promote local economic development. On the other hand, the deepening development of the carbon sequestration industry can drive the construction of local infrastructure and cultural services, creating a favorable social environment for local economic development.

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Secondly, the impact of spatial population agglomeration on economic growth depends on the power balance between economies of scale and the diseconomies of scale brought about by agglomeration (Yang and Zhang, 2019). The research results of this article indicate that in counties with high population density, population agglomeration has formed a certain degree of economies of scale. These regions not only provide labor for forestry carbon trading pilot projects, but also promote the large-scale development of the carbon sink industry to a certain extent, thereby promoting local economic development. Although areas with low population density can provide a favorable ecological environment for implementing forestry carbon trading pilot policies, the insufficient supply of human capital factors, especially when implementing pilot policies requires a large amount of labor input, results in insignificant economic growth effects. In addition, the local forestry economic development level and government financial capacity also play an important role. Regions with higher levels of forestry economic development have rich management experience and financial support in forest resource management and related forestry industry development, which can promote the rapid and efficient implementation of local forestry carbon trading pilot policies and have certain advantages in extending the forest carbon industry chain. They have a relatively complete industrial chain and can quickly and effectively digest and absorb various knowledge and technologies brought by forestry carbon trading pilot projects. They also have comparative advantages in developing diversified forest carbon industries and can quickly absorb and introduce social capital to develop the carbon industry, driving local economic development. In this case, the carbon trading pilot policy can fully play its role in promoting local economic development.

Finally, government investment in infrastructure can not only promote the implementation of forestry carbon trading pilot policies, but also bring more market and employment opportunities for local economic development (Yang, 2021), promoting local economic development. At the same time, government subsidies for carbon sink participants can motivate relevant personnel to improve their work enthusiasm and promote the in-depth development of the carbon sink industry. Fiscal expenditure is an important guarantee for the implementation of carbon trading pilot policies, and the size of local government fiscal capacity will directly affect the effectiveness of carbon trading pilot implementation. Due to the fact that China’s forest carbon sink is still in its early stages of development, achieving sustainable and orderly development requires guidance from government policies and support from market mechanisms. The research conclusion of this article indicates that the implementation of forestry carbon trading pilot can promote local economic development. Therefore, it is necessary to fully explore new models of forest carbon industry development, promote diversified development of forest carbon industry, achieve a win-win situation of “ecology, economy, and society”, and truly realize that “green mountains and clear waters” are “golden mountains and silver mountains”.

Conclusions and policy implications

Conclusions

From the benchmark regression results, it can be seen that the pilot policy of forestry carbon trading in Fujian Province has a promoting effect on local economic development. The most direct benefit of the pilot implementation of carbon trading is the forest carbon income obtained through carbon market trading; Secondly, while managing forest carbon sinks, profits from additional products such as wood and fruits can also be obtained; It can also drive local economic development by developing industries such as forest tourism and ecological planting. Therefore, piloting carbon trading can promote local economic development from multiple aspects.

From the perspective of heterogeneity analysis, the pilot program of forestry carbon trading in Fujian Province has a better effect on local economic development in areas with high population density, high level of forestry economic development, and high local fiscal capacity. The construction of carbon trading pilot projects requires a large amount of labor, and in areas with high population density, more high-quality labor can be provided for the construction of carbon trading pilot projects; At the same time, population agglomeration has formed a certain degree of economies of scale. While promoting the pilot construction of carbon trading, it can also promote the diversified development of the carbon industry and drive local economic development. Regions with high levels of forestry economic development have abundant forest resources and relatively better experience and technology in forest resource management. They have a relatively complete industrial chain and can quickly and effectively digest and absorb various knowledge and technologies brought by forestry carbon trading pilot projects. They also have comparative advantages in developing diversified forest carbon industries and can quickly absorb and introduce social capital to develop the carbon industry, driving local economic development. Fiscal expenditure is an important guarantee for the implementation of carbon trading pilot policies, and the size of local government fiscal capacity will directly affect the effectiveness of carbon trading pilot implementation. Regions with high fiscal capacity can provide important funds for the infrastructure and subsequent development of carbon trading pilot projects, guide social capital to enter, promote the in-depth development of carbon trading pilot projects, and fully leverage the economic benefits of forest carbon sequestration in pilot areas. Due to the fact that China’s forest carbon sink is still in its early stages of development, achieving sustainable and orderly development requires guidance from government policies and support from market mechanisms.

Practical and managerial implications

This article starts from the aspects of technological support, social propaganda, and market construction, hoping to promote the deep development of forest carbon sinks through mutual interaction, restraint, and joint efforts, and help China efficiently achieve its carbon peak and carbon neutrality goals.

Firstly, intensify technological support for forest carbon sinks and improve the technological content of forest carbon sinks. The development of forest carbon sinks not only requires sound supporting policies, but also relies on innovative development of science and technology. On the one hand, the government should promote deep cooperation among enterprises, universities, research institutes, etc., to overcome key core technologies of forest carbon sequestration, research and enhance the potential of forest carbon sequestration and related technologies for carbon accounting, and at the same time increase China’s independent research and development efforts in low-carbon technologies, providing scientific research support and technical assistance for the development of forest carbon sequestration in China. On the other hand, we will strengthen the basic scientific research on forest carbon sinks, enhance cooperation and exchanges with relevant organizations and institutions at home and abroad in forest carbon trading mechanisms, forest carbon sink methodologies, and forest carbon sink

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potential exploration, and continuously improve the technical level and capabilities related to forest carbon sinks in China.

Secondly, strengthen the promotion of forest carbon sequestration and encourage multi-party participation in forest carbon sequestration construction. Forest carbon sequestration, as a new phenomenon, on the one hand, the public's understanding of forest carbon sequestration and related policies is insufficient, resulting in low participation of the general public in the development of forest carbon sequestration; On the other hand, achieving large-scale and intensive development of forest carbon sinks requires sufficient labor force. The research conclusion of this article also indicates that the implementation of forestry carbon trading pilot projects has a more significant promoting effect on local economic development in areas with high population density. Therefore, we should increase the promotion of forest carbon sequestration from all aspects and multiple perspectives, so that the public can better participate in the construction of carbon sequestration projects.

Finally, strengthen the construction of the forest carbon trading market and fully leverage the economic benefits of forest carbon sequestration. A sound carbon trading market is an important guarantee for fully realizing the economic benefits of forest carbon sequestration and promoting the market-oriented development of forest carbon sequestration. In this regard, it is necessary to improve the construction of China's forest carbon trading market, draw on successful carbon trading experiences at home and abroad, plan the market elements, institutional framework, and guarantee mechanism of carbon trading in advance, establish a scientific supervision and registration system, and build a government led, multi-party social participation, market-oriented operation mode of carbon trading market. Simultaneously integrating with the trading rules of China's carbon market, achieving unified deployment, operation, and supervision of the carbon emission trading market and carbon sink trading market, and improving the efficiency of carbon market operation. Different regions can also pre-position their markets and establish regional forest carbon trading markets based on the development of local forest carbon sinks and the requirements and characteristics of the forest carbon sink market. While actively promoting the development models of forest carbon sinks such as "one yuan carbon sink", "forestry carbon ticket", and "conference carbon neutrality", we encourage various regions to actively explore different forest carbon trading models and promote the in-depth development of forest carbon trading.

Limitations and future research suggestions

This article uses the PSM-DID model to conduct an in-depth analysis of the economic benefits of forest carbon sinks, and has passed a series of robustness tests. The research conclusions are also guaranteed to some extent. However, due to limited time and limited ability, some content cannot be comprehensive. Carbon sink is an important means to address climate change, and its cost is relatively low, which will not have a significant negative impact on the current economic development model. China has regarded it as an important strategy to address climate change. Therefore, many issues related to carbon sink deserve in-depth research.

(1) Expand the types of carbon sinks. Generally speaking, carbon sink refers to the process, activity, or mechanism by which plants absorb carbon dioxide through photosynthesis and fix it in vegetation and soil. However, in addition to plants, some

animals and microorganisms can also fix carbon dioxide. Due to space limitations, this article mainly selects forest carbon sinks as the research object, and in the future, the research scope can be expanded to ocean, grassland, soil, and wetland carbon sinks.

(2) Increase in-depth analysis. Due to the serious lack of data on pollution emissions at the county level, this article only studied the effect of forestry carbon trading pilot policies on economic growth. In the future, pollution emission data can be included in research to analyze the effect of forestry carbon trading pilot policies on green economic growth, in order to better analyze the green economic benefits brought by carbon sinks.

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Data availability. Data will be made available on request.

REFERENCES

[1] Alaniz, A. J., Carvajal, M. A., Marquet, P. A., Vergara, P. M., Meneses, L., Moreira-Arce, D. (2022): Analyzing the spatiotemporal patterns of forests carbon sink and sources between 2000 and 2019. – Earth's Future 10(11): e2021EF002560.

[2] Bañolas, G., Fernández, S., Espino, F., Haroun, R., Tuya, F. (2020): Evaluation of carbon sinks by the seagrass Cymodocea nodosa at an oceanic island: spatial variation and economic valuation. – Ocean & Coastal Management 187: 105112.

[3] Benessaiah, K. (2012): Carbon and livelihoods in Post-Kyoto: assessing voluntary carbon markets. – Ecological Economics 77: 1-6.

[4] Brienen, R. J., Caldwell, L., Duchesne, L., Voelker, S., Barichivich, J., Baliva, M., Ceccantini, G., Di Filippo, A., Helama, S., Locosselli, G. M., Lopez, L., Piovesan, G., Schöngart, J., Villalba, R., Gloor, E. (2020): Forest carbon sink neutralized by pervasive growth-lifespan trade-offs. – Nature Communications 11(1): 4241.

[5] Cai, W., Wang, Y., Lin, G., Huo, C., Sun, X., Wang, M. (2024): Value realization mechanism of forest carbon sink based on the transformation path of 'resource-asset-capital-fund'. – China Population, Resources and Environment 34(03): 60-67.

[6] Cao, X., Zhang, Y., Shi, X., Shan, Y. (2017): Study on the dynamic value of carbon sequestration of bamboo forestation project in ccer market and its sensitivity. – Resources and Environment in the Yangtze Basin 26(2): 247-256.

[7] Carton, W., Andersson, E. (2017): Where forest carbon meets its maker: forestry-based offsetting as the subsumption of nature. – Society & Natural Resources 30(7): 829-843.

[8] Chen, W., Wang, X. (2019): Study on the mechanism of sustainable development of forest carbon sink supply in Western China. – Forestry Economics 41(3): 79-86.

[9] Chen, Y., Gao, T. (2021): Promote the high-quality development of China's economy with Innovative fixed asset renewal. – Economic Review Journal 12: 50-57.

[10] Cui, G., Jiang, Y. (2019): The influence of environmental regulation on the behavior of enterprise environmental governance: based on a quasi-natural experiment of new environmental protection law. – Business and Management Journal 41(10): 54-72.

[11] Daigneault, A. J., Sohngen, B. L., Sedjo, R. (2020): Carbon and market effects of US forest taxation policy. – Ecological Economics 178: 106803.

[12] Deng, R., Zhang, A., Tang, Y. (2021): Impact of integrated development of the Yangtze River Economic Belt on urban ecological efficiency—an empirical analysis based on PSM-DID model. – Soft Science 35(9): 22-27.

[13] Diswandi, D. (2017): A hybrid Coasean and Pigouvian approach to payment for Ecosystem Services Program in West Lombok: Does it contribute to poverty alleviation? – Ecosystem Services 23: 138-145.
[14] Doelman, J. C., Stehfest, E., van Vuuren, D. P., Tabeau, A., Hof, A. F., Braakhekke, M. C., Gernaat, D. E. H. J., van den Berg, M., van Zeist, W. - J., Daioglou, V., van Meijl, H., Lucas, P. L. (2020): Afforestation for climate change mitigation: potentials, risks and trade-offs. – Global Change Biology 26(3): 1576-1591.
[15] Du, Z., Su, T., Ge, J., Wang, X. (2021): Towards the carbon neutrality: the role of carbon sink and its spatial spillover effects. – Economic Research Journal 56(12): 187-202.
[16] Ercanli, İ. (2018): Positive effect of forest structural diversity on aboveground stand carbon stocks for even-aged Scots pine (Pinus sylvestris L.) stands in the Sarıçiçek Forest, Northern Turkey. – Scandinavian Journal of Forest Research 33(5): 455-463.
[17] Ferraro, P. J., Hanauer, M. M., Miteva, D. A., Nelson, J. L., Pattanayak, S. K., Nolte, C., Sims, K. R. (2015): Estimating the impacts of conservation on ecosystem services and poverty by integrating modeling and evaluation. – Proceedings of the National Academy of Sciences 112(24): 7420-7425.
[18] Gan, Z., Zong, J. (2021): Does environmental regulation increase the actual tax burden of enterprises? A quasi-natural experiment based on the special emission limits of air pollutants. – Journal of Yunnan University of Finance and Economics 37(11): 75-93.
[19] Grassi, G., House, J., Dentener, F., Federici, S., den Elzen, M., Penman, J. (2017): The key role of forests in meeting climate targets requires science for credible mitigation. – Nature Climate Change 7(3): 220-226.
[20] Heinrich, V. H., Dalagnol, R., Cassol, H. L., Rosan, T. M., De Almeida, C. T., Silva Junior, C. H., Campanharo, W. A., House, J. I., Sitch, S., Hales, T. C., Adami, M., Anderson, L. O., Aragão, L. E. (2021): Large carbon sink potential of secondary forests in the Brazilian Amazon to mitigate climate change. – Nature Communications 12(1): 1785.
[21] Hu, Y., Zeng, W. (2020): Does the carbon sink afforestation project promote local economic development: an empirical study of PSM-DID based on panel data of counties in Sichuan Province. – China Population, Resources and Environment 30(2): 89-98.
[22] Huang, Z., Chen, Z., Chen, Q., Huang, S. (2017): Analysis of influencing factors of forestry households' carbon sequestration forest management intention: an empirical test of the pilot areas of carbon sequestration afforestation. – Ecological Economy 33(4): 34-37+42.
[23] Ji, X. (2020): Research on the impact of Central China's rising strategy on urban environmental quality—an analysis based on PSM-DID method. – Inquiry into Economic Issues 8): 157-169.
[24] Ken, S., Entani, T., Tsusaka, T. W., Sasaki, N. (2020): Effect of REDD + projects on local livelihood assets in Keo Seima and Oddar Meanchey, Cambodia. – Heliyon 6(4).
[25] Launiainen, S., Katul, G. G., Leppä, K., Kolari, P., Aslan, T., Grönholm, T., Korhonen, L., Mammarella, I., Vesala, T. (2022): Does growing atmospheric CO2 explain increasing carbon sink in a boreal coniferous forest? – Global Change Biology 28(9): 2910-2929.
[26] Li, C., Lei, T., Wang, L. (2024a): Examining the emission reduction effect of carbon emission trading and carbon tax synergism and their impact mechanisms to reduce the carbon emission of company: based on 247 listed companies of China. – Technology Analysis & Strategic Management. DOI: 10.1080/09537325.2024.2346807.
[27] Li, C., Li, K., Wang, L. (2024b): The influence effect of regional carbon emission reduction under the perspective of fiscal decentralization: government intervention or market mechanism? – Managerial and Decision Economics. DOI: 10.1002/mde.4181.
[28] Li, C., Wang, Y., Wang, L. (2024c): Exploring the path and synergistic effects of "green intelligence integration" for improving industrial carbon emission efficiency: comparative empirical study of China's five major urban agglomerations. – Environment, Development and Sustainability. DOI: 10.1007/s10668-024-05606-1.

[29] Li, C., Wang, Y., Zhang, G., Wang, L. (2024d): How willing is the public to spread green behavior? Evidence from the voluntary provision experiment of public goods. – Current Psychology. DOI: 10.1007/s12144-024-06637-7.
[30] Li, C., Yang, X., Wang, L. (2024e): The impact of renewable energy development on regional carbon emission reduction: based on the spatio-temporal analysis of 30 provinces in China. – Environmental Management. DOI: 10.1007/s00267-024-01995-1.
[31] Li, C., Zhao, Q., Wang, L. (2024f): The impact mechanism and effect evaluation of digital economy development on regional carbon emission reduction: evidence from provincial panel data in China. – International Journal of Environment Resource. DOI: 10.1007/s41742-024-00651-0.
[32] Li, Y. (2022): The Impact of Participating in Forestry Carbon Sink Projects on the Income of Forest Farmers. – Issues of Forestry Economics 42(3): 253-261.
[33] Lin, B., Ge, J. (2019): Carbon sinks and output of China's forestry sector: an ecological economic development perspective. – Science of the Total Environment 655: 1169-1180.
[34] Lin, B., Ge, J. (2020): How does institutional freedom affect global forest carbon sinks? The analysis of transfer paths. – Resources, Conservation and Recycling 161: 104982.
[35] Liu, C., Ma, Y., Xie, Q. (2019): Research on China's financial situation and real economy development—Monthly data from China 2000-2017. – Systems Engineering-Theory & Practice 39(11): 2723-2738.
[36] Liu, R., Zhao, R. (2015): Western development: growth driven or policy traps: a study based on PSM-DID method. – China Industrial Economics 6: 32-43.
[37] Liu, S., Zhou, T., Wei, L., Shu, Y. (2012): The spatial distribution of forest carbon sinks and sources in China. – Chinese Science Bulletin 57: 1699-1707.
[38] Liu, S., Zhang, X., Zhou, Y., Yao, S. (2021): Spatiotemporal evolution and influencing factors of carbon sink dynamics at county scale: a case study of Shaanxi Province, China. – International Journal of Environmental Research and Public Health 18(24): 13081.
[39] Nielsen, M. R., Theilade, I., Meilby, H., Nui, N. H., Lam, N. T. (2018): Can PES and REDD+ match Willingness to Accept payments in contracts for reforestation and avoided forest degradation? The case of farmers in upland Bac Kan, Vietnam. – Land Use Policy 79: 822-833.
[40] Pan, R., Shen, Y., Yang, H., He, Y. (2020): Research of forest carbon sink demand in China. – Issues of Forestry Economics 40(1): 14-20.
[41] Parajuli, R., Lamichhane, D., Joshi, O. (2015): Does Nepal's community forestry program improve the rural household economy? A cost–benefit analysis of community forestry user groups in Kaski and Syangja districts of Nepal. – Journal of Forest Research 20: 475-483.
[42] Phan, T. H. D., Brouwer, R., Hoang, L. P., Davidson, M. D. (2018): Do payments for forest ecosystem services generate double dividends? An integrated impact assessment of Vietnam's PES program. – PloS ONE 13(8): e0200881.
[43] Raihan, A., Begum, R. A., Mohd Said, M. N., Pereira, J. J. (2021): Assessment of carbon stock in forest biomass and emission reduction potential in Malaysia. – Forests 12(10): 1294.
[44] Ribaj, A., Mexhuani, F. (2021): The impact of savings on economic growth in a developing country (the case of Kosovo). – Journal of Innovation and Entrepreneurship 10: 1-13.
[45] Song, Y., Peng, H. (2019): Strategies of forestry carbon sink under forest insurance and subsidies. – Sustainability 11(17): 4607.
[46] Stringer, L. C., Dougill, A. J., Thomas, A. D., Spracklen, D. V., Chesterman, S., Speranza, C. I., H, Rueff., M, Riddell., M, Williams., T, Beedy., D, J. Abson., P, Klintenberg., S, Syampungani., P, Powell., A, R. Palmer., M, K. Seely., D, D. Mkwambisi., M, Falcao., A, Sitoe., S, Ross., Kopolo, G. (2012): Challenges and opportunities in linking carbon sequestration, livelihoods and ecosystem service provision in drylands. – Environmental Science & Policy 19: 121-135.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_68516881

[47] Valade, A., Bellassen, V., Magand, C., Luyssaert, S. (2017): Sustaining the sequestration efficiency of the European forest sector. – Forest Ecology and Management 405: 44-55.
[48] Wang, L., Shang, Y., Li, C. (2023a): How to improve the initiative and effectiveness of enterprises to implement environmental management system certification. – Journal of Cleaner Production 404: 137013.
[49] Wang, L., Shang, Y., Li, S., Li, C. (2023b): Environmental information disclosure-environmental costs nexus: evidence from heavy pollution industry in China. – Sustainability 15: 2701.
[50] Wang, L., Chen, L., Gao, P., Li, C. (2024a): Construction and application of carbon performance evaluation index system for Chinese industrial enterprises from the perspective of low- carbon transition. – Journal of International Development. DOI: 10.1002/jid.3984.
[51] Wang, L., Chen, L., L, Y., Li, C. (2024b): Spatio temporal evolution characteristics and spatial spillover effects of forest carbon sink efficiency in China. – Environment, Development and Sustainability 1-33.
[52] Wang, L., Chen, L., Li, C. (2024c): Research on strategies for improving green product consumption sentiment from the perspective of big data. – Journal of Retailing and Consumer Services 79: 103802.
[53] Wang, L., Gao, P., Li, C. (2024d): Public response to heterogeneous environmental policies: scenario-based experiments from interest appeal, implementation costs, and commitment mechanism. – Energy Sources, Part B: Economics, Planning, and Policy 19(1): 2304905.
[54] Wu, J., Hou, F., Yu, W. (2021): The effect of carbon sink plantation projects on local economic growth: an empirical analysis of county-level panel data from Guangdong Province. – Sustainability 13(24): 13864.
[55] Wu, S., Li, J., Zhou, W., Lewis, B. J., Yu, D., Zhou, L., Jiang, L., Dai, L. (2018): A statistical analysis of spatiotemporal variations and determinant factors of forest carbon storage under China's Natural Forest Protection Program. – Journal of Forestry Research 29: 415-424.
[56] Yang, B., Zhang, L. (2019): Is China's urban population density too high: a perspective of economic growth. – South China Journal of Economics 5: 78-96.
[57] Yang, C. (2021): Evaluation on poverty reduction effect of China's targeted poverty alleviation policies and fiscal expenditures. – Statistics & Decision 37(16): 19-23.
[58] Zhang, F., Peng, Z. (2021): Biomass Carbon stocks and carbon stock economic value of forests in Beijing. – Forest and Grassland Resources Research 6: 52-58.
[59] Zhang, H., Peng, Q., Wang, R., Qiang, W., Zhang, J. (2020): Spatiotemporal patterns and factors influencing county carbon sinks in China. – Acta Ecol. Sin 40: 8988-8998.
[60] Zhang, Y., Huang, Y. (2019): Are forest carbon sequestration projects helpful in reducing poverty? – Issues of Forestry Economics 39(1): 71-76.
[61] Zhang, Y., Chen, J., Hu, M., Offer, A. (2016): Valuation of forest carbon sinks in China within the framework of the system of national accounts. – Journal of Forestry Research 27(6): 1321-1328.
[62] Zou, K., Zheng, Y., Liu, X. (2022): Research on the pilot policy promote the integration of sci-tech and finance: empirical analysis based on PSM-DID. – China Soft Science 7: 172-182.
[63] Zou, Y. Y., Li, J. Q., Qi, Y. N., Guan, J., Tian, G. S. (2020): Demand willingness and influencing factors of emission control enterprises for forest carbon sink in the context of carbon trade: based on the theory of planned behavior. – Linye Kexue 2020(8): 162