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RESEARCH ON THE EFFECT OF CHINA'S CARBON EMISSION RIGHTS TRADING PILOT POLICY ON RESIDENTS' INCOME INEQUALITY

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Abstract

In recent years, environmental problems and income inequality have become two major problems hindering China's economic development, and the carbon emission trading pilot is expected to become a good solution to promote the development in the coordinated way of the environment and economy, as well as an critical driving force to promote common prosperity. This paper's data is from the China Family Panel Studies (CFPS) between 2010 and 2018, utilizing the deference-in-differences (DID) model to examine the effects of China's experimental program for trading carbon emission rights on residents 'income inequality, while also carrying out heterogeneity analysis, mechanism analysis and robustness test. The empirical results reveal that the policy in China can obviously reduce the degree of income inequality of the residents by 2.18%. At the same time, the impact of the policy on household income inequality is heterogeneous between urban and rural areas, different income groups, regions with different CO2 emission intensity and between different regions. The pilot policy can affect the income inequality of the population through five paths: carbon emission, industrial structure, technological innovation, employment structure and environmental pollution level. On the basis of the findings above, the paper offers policy proposal for the gradual development of a future national united carbon market.

INTRODUCTION

Common prosperity is the necessary requirement of socialism and an vital mission of the Party. A report from the 20th CPC National Congress indicated that "Chinese modernization is the modernization of common prosperity for all people. In the

modernization process, we should strive to facilitate the common prosperity of all people and resolutely prevent polarization." While advancing towards the second centenary goal, we must realize that income inequality has gradually turned into an essential factor limiting the coordinated economic and social development in China. From the perspective of the income distribution gap, according to the Gini coefficient of per capita disposable income, issued by the National Bureau of Statistics, China's coefficient has been kept above 0.462 since the 21st century, decreasing after reaching its peak in 2008 (0.4U1), but still far beyond the international warning line. In terms of the wealth distribution gap, according to data released by the World Inequality Database, the total share of wealth owned by the top 10% of China's net personal wealth rose from 47.75% in 2000 to 68.8% in 2021; On the contrary, the share of total wealth owned by the bottom 50% of Chinese residents in net personal wealth dropped from 14 percent in 2000 to 6.17 percent in 2021, indicating a growing inequality in wealth distribution. The continuous expansion of resident income inequality will lead to a series of social problems, which are not conducive to the harmonious and stable development of society, nor to the improvement of the overall social welfare.

The increasingly severe environmental problems, accompanied by income inequality, have also become the hindrance achieve common prosperity. In the light of the statistics of the World Bank, no other countries can be compared to China's CO2 emissions in 2021, about

10.523 million tons, an increase of 548.7 million tons compared to 2020, with a growth rate of about 5.5%. In recent years, environmental problems caused by carbon emissions, such as the greenhouse effect, extreme weather and haze, have brought great troubles to residents' health and industrial production. Various countries are finding ways to solve the problem. The carbon trading policy, as the largest carbon emitter in the world, is an an crucial measure and practice for China to give active response to global climate change. From the end of 2013 to the beginning of 2014, five cities (Beijing, Shanghai, Shenzhen, Tianjin and Chongqing) and two provinces (Guangzhou and Hubei) opened their carbon trading markets in succession. In Fujian province, nine cities also started a second carbon trading pilot programin 2017, as shown in figure 1. The online national carbon market trading was officially released on July 16, 2021. In the first implementation cycle, the power generation industry was the first to be included in carbon trading, with 2,162 key emitters and some 4.5 billion tonnes of CO2 emissions, making it the world's largest carbon market.

Building a market and narrowing the income gap are both essential goals for realizing common prosperity. So is there a connection between them? For reducing carbon emissions, ETS is a market-driven policy tool. The primary mechanism consists of cap control, emission quota allocation and trading emission quota. Specifically, it means that policy makers decide the total greenhouse gas emission quota of the whole carbon market in a period according to the realities of the trading subject, and then allocate it to the participants .The ones who exceed the given emission quota in actual production (buyer) pay a certain amount to participants with excess quota (seller) to get carbon emission permits to achieve the goals of carbon emission reduction (Liu et al., 2017). When implementing the carbon trading, the transaction expenditure is positive. The initial distribution of market trading and carbon emission rights will impact income distribution and the existing pattern of benefit distribution. The benefit imbalance will inevitably cause income inequality accordingly. Therefore, from the perspective of the policy of China, this paper will study the impact of the policy on residents' income inequality, which will help relevant government departments to improve environmental quality and provide new research ideas for narrowing residents' income inequality.

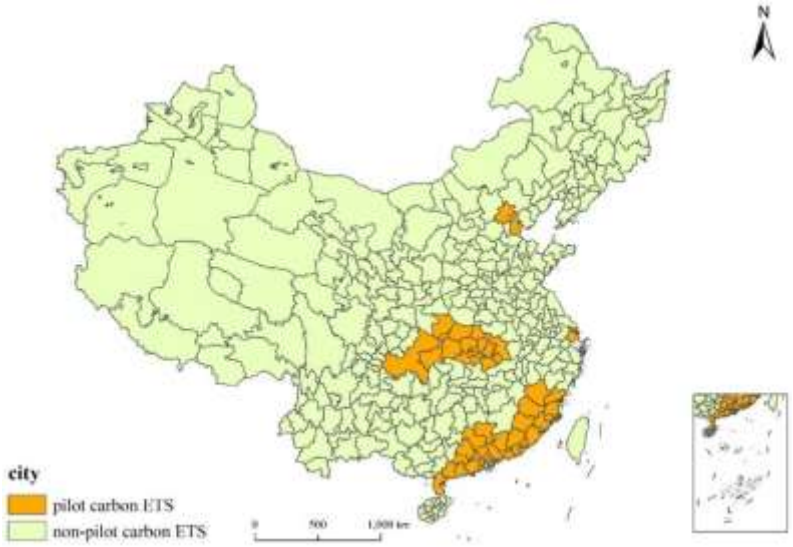

Figure 1: China's carbon emission trading pilot areas

Literature Review

Over the years, academic research on the policy has become at the forefront of low-carbon economics. At present, scholars have evaluated the policy effect of the China's carbon emission rights trading pilot policy in terms of environmental, economic, enterprise and energy-saving outcomes. In terms of environmental effects, most literature believes that the policy can effectively decrease the total carbon emission as well as its intensity in pilot areas (Huang et al.,2018; Zhou D and Liu YC, 2020; Li ZG and Wang J, 2021). At the same time, some scholars also believe that in the pilot areas, the policy can cut down pollutant emissions (Li SL and Lin PN, 2020). In terms of economic consequences, Zhou CB and Qin Y (2020) believe that the policy can facilitate the transition of China's low-carbon economy. The policy principally facilitate the high-quality development of regional economies through gathering scientific and technological talents, the standardization of investment attraction, and the industrial upgrading (Jing GW, 2022). These policies can also promote regional green innovation efficiency by changing energy consumption structure and industrial upgrading (Xiao ZH et al., 2022).

In terms of enterprise effect, it can realize transformation and upgrade through technological innovation channels (Liu HW et al., 2020). The policy can significantly improve enterprises' green technology innovation in both quantity and quality (Zhu J et al., 2023). In terms of energy-saving effect, the policy can make contributions to the development of energy and environmental efficiency in pilot cities , Besides, it can also promote the emission reduction (Liu HY and Guo WQ, 2022). The pilot policy can reduce total energy consumption and optimize its structure (Huang XL et al., 2018).

Many scholars have conducted extensive research on the factors affecting household income inequality. Studies have found that at the macro level, regional economic development and marketization level (Liu JM and Zhu MJ, 2020), government distribution policies, technological progress (Sun YL and Li X, 2015), international trade (Zhao XX and Sun XN), FDI (Zheng XY et al., 2018), dependence on natural resources (He SJ, 2019) and other factors influence household income inequality. In terms of micro individuals, residents' educational level (Chen XD, 2021), health status (Zhang F and Zou W, 2010), occupation (Li JQ and Zhang KS, 2023), age (Yao YX, 2021), household registration (Liang SK and Chen CB 2022),and gender (Chang HQ, 2009) have become an important cause of inequality.

Different conclusions have been drawn form the research about the connection between

income imbalance and carbon trading, which are split mainly into the following 3 categories: The first is that carbon emissions trading policies can narrow the income gap. According to Zhang and Zhang (2020), China's pilot policy has increased rural residents' income and employment opportunities, achieving ecological poverty alleviation. According to panel data from 273 cities in China, Yu et al(2021) evaluates what the policy can produce on urban-rural income gap, in which the results show that it could be reduced significantly. Feng CH (2021) analyzes provincial panel data and concludes that China's pilot policy could effectively increase rural residents' income and reduce poverty in pilot provinces. Zhang and Zhang(2022) discuss the impact on income inequality and its dynamics, and the results indicate that China's policies help on its reduction, which would also increase over time. Fang et al(2023) conducted an empirical analysis in the light of China's provincial panel data, showing that the pilot policy reduces the urban-rural income gap. The second view is that these policies can not reduce household inequality levels. Dirix and Peeter(2016) argue that CDM projects in the market of carbon trading failed to improve the welfare level of poor people in host countries, and therefore could not narrow the income gap. Pecastaing et al(2018) conclude that these projects boasted a great impact on household spending expenditure in Peru, but no influence on employment and poverty alleviation. A third argument is that an emissions trading policy will affect different income groups differently. Parry(2004) concludes that the grandfathering system used in the initial carbon quota in the carbon trading system of the United States would lead to the fact that the poor get poorer while the rich get richer. Huang et al(2019) believe that the system of carbon emission trading would boast adverse influence on city dwellers but a favorable effect on country dwellers.

Existing literature pay less attention to how pilot policies of carbon emission rights trading affect residents' income gap. This paper tries to sort out possible paths of impacts of these strategies in relevant studies: First, the pilot policy can affect the income gap by reducing the total carbon release or emission intensity in pilot areas. These policies are market-based environmental programs, which can reduce emissions in the local market and neighboring areas through cross-border transmission effects (Dong ZQ and Wang H, 2021). In the process of exploring carbon release and income gap, more scholars focus on what the income difference can produce on carbon emissions, believing that inequality will exacerbate them, or that carbon release and income gap show an inverted "U" shaped relationship (Lin BQ and Jiang ZJ, 2009). But few studies looked at the affect of carbon emissions on income inequality, which are mainly demonstrated through the connection between emissions and economic development. Second, industrial structure. Under the carbon trading system, by issuing carbon quotas to enterprises, there is a need to buy emission rights whenthose are exceeded. The quota has less impact on industries with lower emission reduction costs, while having a greater influence on heavy industry with high energy consumption, emissions and pollution, raising its survival cost. Therefore, to a certain extent, carbon trading policies can promote upgrading industrial structure, inhibit the "three high" industries, and motivate the growth of high-tech and modern service industries (Sun ZQ et al., 2020). And the income gap will be affected by industrial structure through skill and capital intensity (Lin SJ et al., 2022). Third, technological innovation. The pilot policy increases the research and enterprises' development willingness in carbon emission through limiting the carbon emission amount of enterprises, so as to upgrade the green technology innovation level in carbon pilot areas (Liu Y et al., 2017).Technological innovation can lead to a large income gap by differentiating the pay growth of high - and low-skilled workers. Fourth, employment and income. Existing literature studies have found that agricultural and forestry carbon sink trading takes agricultural and forestry as ecological products and sells carbon emission rights to some enterprises that need to emit

CO2, which increases the income of residents in rural areas and achieves the goal of poverty alleviation. At the same time, agricultural and forestry carbon sequestration projects can directly increase jobs in rural areas, while employment can increase the income level of rural residents (Zhang and Zhang, 2020). Fifth, environmental pollution. Enterprises' emissions in pilot areas will be impacted by the carbon quota assigned by the government. In order to curb carbon emissions, businesses will invest more in technology, which will boost production efficiency, lower emissions of pollution, and improve the quality of the environment (Jing GW and Chen G, 2022). Environmental pollution such as sulfur dioxide and industrial wastewater discharge will affect the urban-rural income gap by affecting residents' physical and mental health (Zhu JH and Wang Y, 2019).

In conclusion, the extant literature comprehensively study what impact the policy can produce on the income gap. Most of empirical methods adopt DID model andPropensity Score Matching (PSM)-DID model, and the majority of the data come from the provincial or city level. Most of them conclude that the policy has narrowed the gap. Nevertheless, the value of study about the influence of the pilot policy on income inequality is still worth further discussion. First, the literature now focuses on the assessment of the effectiveness of the policy, and only a few articles conduct mechanism analysis. Second, most of the existing literature use the urban-rural income gap as an indicator when measuring the income gap. But the gap exists not only between urban and rural areas, but also between districts, industries, occupations as well as micro-groups. Third, existing empirical studies are is limited to the provincial or urban level, and there is a lack of analysis on the income gap of micro households.

In view of this, this paper uses the micro household database to measure the resident income inequality index and uses a DID model to conduct quantitative analysis on the effect of the policy on resident income inequality. It can give a reference to further implementing the domestic carbon market. The government has adopted a market-based environmental policy - the carbon emission Trading pilot. It can realize dual goals of carbon emission reduction and narrow the income gap of residents, and finally achieve common prosperity. In comparison with the extant literature, the possible innovation of the paper is revealed in four aspects. For the first one, the author uses the micro database (CPFS) to calculate the micro household income inequality index, controls factors on the micro family level and individual level at the same time in the empirical study, and also adds factors at the macro level. It provides micro-empirical evidence for evaluating what differences the pilot policy can make on residents' income inequality. Second, this paper sorts out five possible paths of what influences the pilot policy can make on residents' income gap, which provides a possibility for exploring the mechanism of these policies to reducing residents' income inequality. Thirdly, this paper tests the pilot policy's effect on residents' income inequality, and further analyzes the effective mechanism of reducing residents' income inequality. It is found that the policy can improve the income inequality of residents by reducing carbon emissions, upgrading industrial structure, technological innovation, adjusting employment structure, and reducing environmental pollution levels. Fourthly, the conclusions can give advice for the targeted establishment as well as futher implementation of the carbon emission trading system and the national unified carbon emission trading market.

Research Hypothesis

(1) The effect of the pilot policy on residents' income inequality Scholars explored the relation between the pilot policy and income inequality from the perspectives of the price of the carbon and poverty alleviation. There will be a distribution effect form the carbon price which is formed by carbon trading.With the changing consumption mix of urban and rural households, urban households' carbon burden is higher than that of rural households, and the carbon emission cost

of wealthy households will be higher, which means that carbon price will not worsen the extent wealth disparity (Yan and Yang,2021). Through a series of "carbon sink +" projects, such as the forestry carbon sink project, photovoltaic poverty alleviation carbon emission reduction project, and rural biogas carbon emission reduction trading project, the pilot policy will bring new employment opportunities and skills training opportunities to rural areas, increase farmers' income, realize ecological poverty alleviation, and reduce income gap (Zhang and Zhang,2020; Du,2019). On the basis of the analysis above, the author puts forward the research hypothesis:

Hypothesis 1: the pilot policy is conducive to alleviating the income inequality of Chinese residents.

(2) The transmission mechanism of the policy to residents' income inequality

1. Carbon Emission

At the beginning of the design of the pilot policy, its purpose aims to control carbon emissions and achieve carbon reduction. At present, the policy has become one of the important measures to decrease CO2 emissions, and become one of the most important policies to achieve the dual carbon target. The pilot policy aims to cut down CO2 emissions by treating their rights as a commodity and authorizing them to be purchased and sold in the carbon market.Some scholars together with experts have tested that this policy can obviously restrain inhibit the growth of regional carbon emissions through empirical studies (Huang XL et al., 2018; Zhou D and Liu YC, 2020; Dong ZQ and Wang H, 2021).

However, few studies on what effect carbon emissions can make on income inequality are extant, which can be analyzed from three perspectives: economic growth, industry and region. In terms of economic growth, economic development in China mainly presents a one-way nonlinear causal relationship of "carbon emission → economic growth → income inequality". That is, the increase in carbon emissions will promote economic growth in a one-way manner, and economic growth is the non-linear Granger reason leading to urban-rural income inequality (Ouyang Q et al., 2016). From the view of industry, carbon emission intensity reduces the income gap by restraining high income and raising low income through the high carbon industry. From a regional perspective, carbon emission intensity reduces the income gap by restraining high income through employment in high-carbon provinces (Yan LP et al., 2022).

2. Industrial Structure

Promoting low- carbon and green transformation and accelerating the adjustment of energy industry framework is also one of the goals of the pilot policy. At the first construction stage of the policy, the included power, cement, petrochemicals, steel, aviation and construction industries all belong to industries of huge carbon energy consumption. Therefore, from the aspect of industrial structure, with the carbon market mechanism, these high-load energy industries need to bear highter costs of carbon emission because of gargantuan energy consumption, and their competitive disadvantage is more prominent compared with other industries, which will accelerate the industrial structure's optimization and upgrading towards the direction of low energy consumption and high added value. The initial establishment of the national carbon trading market was made in 2021, which will gradually cover the power generation industry to the chemical, petrochemical, building materials, nonferrous metals, aviation, paper making and other industries, and play a more significant role in facilitating the improvement and transformation of these industries.

The industrial structure adjustment will affect income distribution through skill and capital intensity. First, the decline in the ratio of industry will reduce the proportion of unskilled intensive industry and increase the ratio of skilled intensive service industry, expanding the need for high-skilled staff and thus increase the high- skill premium and widen the income gap. Second, this adjustment slow down expanding labor-intensive industries while it stimulates

expanding capital-intensive service ones, which will increase the need for capital to labor, thus adding the faster rise of capital rent to labor wages, thus adding the share of capital income, reducing the share of labor income and widening the income gap (Lin SJ, 2022).

3. Technological Innovation

As for policy design, what impact the pilot policy made on enterprise innovation is mainly seen in two aspects. Firstly, setting free carbon emission credits leads to a cost-back forcing effect (Yu DF et al., 2023). The carbon emission trading market will internalize the expenditure of carbon emissions into enterprises' production cost. Over the counterparts with low energy efficiency, enterprises with high energy efficiency will get more competitive advantages, encouraging enterprises to realize emission reduction and energy conservation by technological transformation and upgrading . Second, the economic incentives brought by carbon trading. For enterprises with a low marginal cost of innovation, advanced equipment is preferred for production. While meeting the carbon emission quota, supererogatory carbon emission rights can be resold to enterprises with a high marginal cost of innovation in the secondary market. Existing studies indicate that the implementing of the policy can remarkably improve the enterprises' green technology innovation in both quantity and quality (Zhu J et al., 2023).

The path of technological innovation affecting the income gap is mainly based on the following approaches. First, the "incremental effect" of returns to scale. As a production factor, technological innovation has the feature of increasing marginal returns, which makes the salary of high-skilled personnel higher than that of other workers and widens the income gap of different groups. The second is the "substitution effect" of skill bias. Technological innovation has skill bias, which will replace the unskilled labor force, cause the change of employment structure of high- skilled and low-skilled labor force, and increase income inequality. The third is the "spillover effect" of technology and knowledge. Low-skilled workers can improve production efficiency and reduce the income gap by learning high skills.

4. Employment Structure

As a market- based environment regulation policy, there is controversial influence of environmental regulation on employment. The conventional view is that it adds the expenditure of production for enterprises. To reduce costs, enterprises will lower down the need for labor (Huang et al2019). A carbon emission trading system's establishment will continually increase the amount of unemployed people in energy- intensive industries like coal and there are scholars who also believe that environmental construction. However, regulations can encourage the opening of new fields or markets through ecological innovation and green investment in the implementation process, thus providing more employment opportunities. Ren SG and Li B (2019) found that the China's policy has a positive influence on the labor need of the included enterprises. Since a majority of the enterprises included in the carbon trading mechanism are secondary industries with high emission, high pollution, high energy consumption, these enterprises are more sensitive to the implementation of the policy than that in the primary industres and the tertiary industres. Therefore, the carbon trading policy may directly impact the labor force's employment in the secondary industry. The skills-biased technological progress theory holds that technological progress will lead to upgrading employment structure, thus improving the return on skills and affecting the income gap.

5. Environmental Pollution

The pilot policy is able to influence regional pollution emissions by energy structure and technological innovation effect. The cost of emissions will be increased by fluctuations of the carbon price in the emission cap-and-trade market. To curb carbon emissions and reduce production costs, enterprises will increase scientific and technological investment and demand for scientific and technological talents on the one hand.

Technological innovation will be used to lower pollution emissions and increase production efficiency. On the other hand, enterprises will choose to improve the energy mix to make more green products and less pollutant emissions (Li SL and Lin PN, 2020).

The level of environmental pollution is an important factor impacting the income inequality. In fact, pollution reduction does not directly affect the income distribution gap, but is realized through human capital. Specifically, worsening pollution will significantly reduce residents' health levels, widening the urban-rural income gap (Liu C and Li X, 2021).

On the basis of the analysis above, the author puts forward the research hypothesis:

Hypothesis 2: The policy can indirectly affect residents' income inequality through carbon emission, industrial structure, technological innovation, employment structure and environmental pollution level.

Research Design

(1) Date Sources

The micro-level data in here paper are from the China Family Panel Studies database. CFPS started its preliminary work and official visits in 2008 and 2010 respectively. Since then, it has followed up on the research subjects every two years. The data samples come from 25 provinces in China, and the initial sample includes all the family members from 16,000 households. CFPS aims to develop a database that can comprehensively and accurately reflect variation in China's society, economy, education, population and health by collecting, tracking and processing economic and social data from communities, families and individuals in different regions of China, to provide data basis for government public policy formulation and academic research. Since the data for 2020 has yet to be fully published, the author selects the data form 5 periods from 2010 to 2018 in the CFPS database and deletes the unidentifiable and missing samples according to the general method. In addition, household's head identity was matched and identified by the two indicators of the family decision-maker or the financial respondent, who was taken as the representative individual of the household. A total of 50,143 household samples were retained and processed as panel data. Among them, 10,756 households were sampled in 2010, 10,168 in 2012, 10,064 in 2014, 9,534 in 2016 and 9,621 in 2018.

In addition, this paper collects city-level macro panel data matching the CFPS micro database based on the publicly released China City Statistical Yearbook, China Statistical Yearbook, China Statistical Yearbook on Construction, China Regional Statistical Yearbook and China Energy Statistical Yearbook.

(2) Model construct

At the end of 2013, Beijing, Guangzhou, Shanghai and Tianjin launched their carbon trading markets. In April and June of 2014, Chongqing and Hubei began carbon trading respectively. This paper regards the policy as a quasi-natural- experiment, and evaluates what effect the pilot policy can make on resident income inequality by DID method. In this paper, the assessment of income inequality in the pilot policy is mainly on the basis of the sample of households in cities in 2013 and 2014. The year 2014 is set as the policy implementation point, and samples of households in pilot cities in 2013 and 2014 are defined as the treatment group, while samples of households in non-pilot cities are regarded as the control group. Since the carbon trading market is also launched in Fujian Province in 2017, sample data of households in Fujian Province were excluded to make sure the stability of the results due to the late occurrence of the event and the small size of the data sample (Fang et al.,2023). This paper's constructed model is as follows:

(1)

Where i and t indicate the variables of household i in year t. refers to the economic inequality. refers to the time dummy variable and refers to the intergroup dummy variable. is an interaction term of time and the pilot policy impact, and its coefficient represents the income inequality level caused by the pilot policy, is the control variable, including the regional characteristics at a micro level, and

characteristics of micro family and micro self-employed master. is stochastic error terms.

(3) Variable Declaration

1. Dependent Variables

In this paper, the dependent variable is the inequality in the resident income: . The indicators of income in the CFPS household economic database include "per capita wage income of a household", "net income of a household", "wage income of a household", "business income", "property income", etc. Among these indicators, "wage income per household" is more accurate, comparable with previous years, and used more often in the literature. To avoid the interference caused by the change of questionnaire results between years and measure the degree of resident income inequality more accurately, the index "per capita wage income of households" was chosen in this paper to calculate the Gini coefficient of households at the city level (Zhou GS and Ding XY, 2022). The results show that the average Gini coefficient of the households in the national sample in 2010 was 0.4338, rising to 0.4549 in 2012, 0.4349 in 2014, 0.4494 in 2016 and 0.4508 in 2018, which is basically consistent with the data trend shown by the National Bureau of Statistics.

2. Independent Variable

The independent variable is the interaction of the time dummy variable and the inter-group dummy variable:. The author sets the year 2014 as the beginning point of the pilot policy. The author sets households in pilot cities as inter-group dummy variables. If households are located in pilot cities, then; Otherwise, it is denoted as.

3 (Control Variables

Literature review shows that the control variables selected in this paper can be divided into three levels. The first level is regional characteristics, which includes the regional economic growth level, foreign direct investment and regional financial expenditure level. This paper selects the urban GDP and per capita GDP the indicators to measure the regional economic growth level. The ratio of total foreign direct investment in GDP in this paper is in the usage to measure the level of foreign direct investment. Research shows that foreign direct investment will exacerbate regional income inequality (Zhang CL et al., 2021). An important method for the government to regulate economic and social development is to regulate the level of fiscal expenditure, which plays an critical role in the issue of income distribution. This paper uses the proportion of fiscal expenditure to GDP to measure the level of urban fiscal expenditure (Li QM, 2022).

Second, in terms of family characteristics, this paper selected household size (Wu BB et al., 2021),the ratio of children (under 14 years old),the ratio of elderly (over 65 years old), family healthcare expenditure, and the fact whether the family receives social and government subsidies as the control variables. Population age structure and population aging have an unequal expansion of the income gap (Wang et al., 2017). So this paper selects the ratio of children and the ratio of the elderly as the control variables. Government and social subsidies can play a role in narrowing the income gap, so this paper chooses whether families receive government and social subsidies as the control variable at the family level (Deng DS et al., 2020).

The third level is personal characteristics. This paper selects the financial person or the family's household as the head. Human capital is the critical factor to determine the resident income level, and the inequality of human capital will directly affect the inequality of income level. For micro individuals, the main factors affecting human capital include education, health, age, gender etc. Individuals receive vocational training and other educational methods to further improve their labor skills through the accumulation of knowledge. Health is the basic premise of human survival and activities, as well as the premise and carrier of all human capital (Liu RF and Shi JQ, 2021). Age is a factor affecting the human capital level and value orientation. Individual marital status is a variable that can reflect

family structure. Moreover, the complexity of family structure will have an impact on income. Chang HQ (2009) argued that a large number of social scientific investigation structures and medical tests have proved that men have more advantages in both the physical and psychological aspects, which results in a significant gender gap between men and women in terms of income.

The dependent variables, independent variables and control variables in this paper are described in Table 1, and Table 2 can reveal the descriptive statistical results of various samples.

Table 1: Description of variables

Variable Type	Variable Name	Variable Symbol	Variable Definition
Dependent Variables	Residents' income Inequality	lnequality	The Gini coefficient is calculated at the city level for the index of "wage income per household"
Independent Variable		Treat*Time	TP interaction term of time and the policy: TP=1 after the year of policy implementation of the treatment group, otherwise TP=0
Control Variables			
Time		Time	Time dummy variable. After the ETS pilot, Time dummy variable is Time=1; otherwise, Time =0
The pilot policy impact		Treated	Households in pilot provinces of carbon trading were Treated=1, otherwise Treated=0.
Level of economic development			
	ln_gdp		GDP at the city level, take the logarithm
	ln_pgdp		Per capita GDP at the city level, take the logarithm
FDI		fdi_to_gdp	The level of FDI at the city level as a share of GDP
Financial expenditure		fis_to_gdp	The proportion of fiscal expenditure at the city level to GDP
Family Size		familysize	Total household size
Family healthcare expenditure		ln_medicical	Whether the family family healthcare expenditure, take the logarithm
Whether the family receives social subsidy			and receives social and government subsidies government subsidies :were subsidy=1 (otheerwise subsidy=0
The ratio of children		srb	The ratio of children aged 14 and under in the overall household population
The ratio of the elderly		lrb	The ratio of elderly aged 65 and abover in entire household population
Age squared		age2	The square of the age of the householder
Gendermale			Gender of householder: male =1, female =0

Marital status marriage Marital status of householder: married =1, unmarried =0
Educational level edu_year Number of years of schooling for the head of household
Health status of householders: very unhealthy
Health condition health

Table 2: Descriptive statistics of variables

=1, unhealthy = 2,3 = relatively unhealthy =3, average =4, healthy =5

Variable Name Full sample Mean Standard Control group observations value deviation observations
Mean value
Standard deviation
Treatment group observations
Mean value
Standard deviation

Gini_faminc_per	50143	0.445	0.0750	38522	0.454	0.0723	11618	0.414	0.0756
Ln_gdp	50143	16.90	1.167	38522	16.57	0.881	11618	18.00	1.317
Ln_pgdp	50143	10.64	0.610	38522	10.53	0.564	11618	11.04	0.592
Fis_to_gdp	50143	0.196	0.110	38522	0.201	0.119	11618	0.179	0.0708
Fdi_to_gdp	50143	0.0209	0.0199	38522	0.0183	0.0186	11618	0.0298	0.0213
familysize	50143	3.676	1.713	38522	3.689	1.687	11618	3.635	1.797
subsidy	50143	0.592	0.492	38522	0.601	0.490	11618	0.562	0.496
In_medicial	50143	6.748	2.672	38522	6.734	2.630	11618	6.793	2.806
male	50143	0.560	0.496	38522	0.562	0.496	11618	0.556	0.497
Age2	50143	2,837	1,455	38522	2,791	1,414	11618	2,992	1,572
Edu_year	50143	7.405	4.538	38522	7.228	4.468	11618	7.993	4.716
Health	50143	3.061	1.297	38522	3.068	1.306	11618	3.038	1.264
Marriage	50143	0.861	0.346	38522	0.868	0.339	11618	0.840	0.366
srb	50143	50,143	0.306	38522	0.306	0.446	11618	0.305	0.454
lrb	50143	50,143	0.184	38522	0.175	0.323	11618	0.214	0.353

(1) Parallel trend test

It is an essential prerequisite assumption for DID estimation that the treatment and control groups must meet the requirement of "parallel trend test". Before the implementation of the policy, the two groups must boast the same variation trend, namely comparability, to ensure that the control group becomes the counterfactual of the treatment group after implementing it. The results of the parallel trend test will directly affect the accuracy of the results. The test of this model is shown in Figure 2. The resident income inequality of the two groups has no obvious difference in the first two periods before the policy timing, but shows a significant difference after the policy timing, thus it passes the parallel trend test.

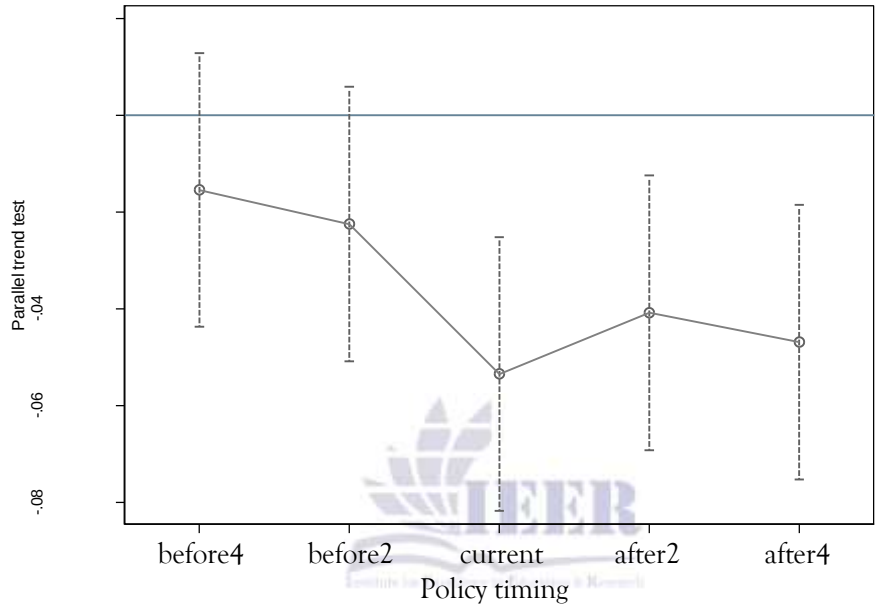

Figure 2: Parallel Trend Graph

(2) Baseline Regression Analysis

Table 3 indicates the results estimated by this model. Only independent variables are added to model (1). According to the regression results, the pilot policy has a remarkable effect on narrowing the resident income gap. And the pilot policy has reduced resident income inequality by 2.41%. To eliminate the interference of other related variables, control variables in terms of macro-level characteristics, family- level characteristics and individual-level characteristics, are added successively in models (2), (3) and (4). With the model being improved, the fitting effect of it is also getting better.

In terms of the interaction term Treat*Time, the regression result shown in model (4) is that the estimated coefficient of the term is -0.0218 and is obvious at the 1% level. That shows that the pilot policy can lower the income inequality of the residents by 2.18%. The viewpoint is the same with Fang et al (2023), Zhang and Zhang (2020) and, Yu et al (2021) etc. The income redistribution, price factors, and employment effects of government auction permits license may cause that. The increase of government revenues can be reached by emission permit allowances auctions held by the carben trading market. If the government uses these increased revenues to subsidize residents, redistributing carbon trading revenues will help reduce the income gap among residents (Landis & Heindl, 2019; Lin & Jia, 2020). This policy would raise the price of carbon-intensive goods usually consumed by the rich. Rich households have a higher carbon

burden than low-income households, so the carbon price will not worsen the gap of wealth (Yan&Yang,2021). The policy reduce employment opportunities in energy-intensive industries, while people in such industries earn more than those who work in other industries. From this side, the number of people who earns more decreases due to ETS, thus narrowing the income gap (Zhang and Zhang,2023). Table 3: Empirical results on these pilot policies on residents' income disparities.

(1)	(2)	(3)	(4)
Variable Name	Inequality	Inequality	Inequality
Inequality			
Treat*Time	-0.0241***	-0.0228***	-0.0224***
-0.0218***			
	(-12.482)	(-11.840)	(-11.646)
(-11.393)			
ln_gdp	-0.0373***	-0.0360***	-0.0362***
(-6.579)	(-6.349)	(-6.438)	
ln_pgdp	0.0366***	0.0343***	0.0346***
(5.611)	(5.265)	(5.317)	
fis_to_gdp	0.0144***	0.0131***	0.0134***
(2.898)	(2.623)	(2.694)	
fdi_to_gdp	-0.1459***	-0.1345***	-0.1385***
(-5.001)	(-4.615)	(-4.760)	
familysize		-0.0030***	-0.0032***
(-6.672)	(-7.123)		
srb		-0.0017*	-0.0030***
(-1.801)	(-3.046)		
lrb		-0.0050**	-0.0023
(-2.340)	(-1.041)		
subsidy			0.0063***
0.0065***			
			(6.382)
(6.579)			
ln_medicial			-0.0007***
-0.0007***			
			(-4.577)
(-4.352)			
age2			-0.0000***
			(-4.424)
edu_year			0.0011**
			(2.510)
health			0.0008*
			(1.905)
marriage			0.0026
			(1.074)
male			-0.0093
			(-0.618)
Observations	50,143	50,143	50,143
50,143			
R-squared	0.032	0.035	0.039
0.041			
Number of pid	23,296	23,296	23,296
23,296			

Note: The empirical results were calculated by Stata16 software. ***, ** and * represents the levels significance of 1%, 5% and 10% respectively. The value of T in parentheses, same as below.

For the control variables, the macro-level control variables affects residential income inequality in a relatively remarkable manner. Among these, the GDP of regional economic development level and foreign direct investment boast apparent effects to promote the alleviation of residential income inequality. At the household level, health care expenditures, household size, and dependency ratio are of significant promotion effect on income inequality among residents. At the individual level, the coefficient on age is significantly negative, and the coefficients on years of education and health level are obviously positive at the 5% and 10% levels, respectively.

(3) Robustness Test

To accurately calculate what impact the pilot policy can make on residents'

income inequality and reduce the estimation deviation caused by other confounding elements, this paper adopts three methods to conduct a robustness test, in terms of replacing the dependent variables, Change the interval of regression time to identify how sensitive the policy is to the time change and eliminating the influence of concurrent events.

1. Change the Dependent Variable

This paper shows that explained variable is resident income inequality. It is measured using the Gini coefficient of households at the urban level in "per capita household wage income" from the CFPS household economic database. Scholars usually use the Kakwani index of relative income deprivation to measure income inequality at the micro level. To confirm the robustness of the research findings, we also use the Kakwani index of relative income deprivation to replace the Gini coefficient as the explained variable for the regression. The formula is here. Let Y represent a cluster with a sample size of n. The household incomes in the reference cluster are arranged in ascending order. The overall income distribution of the reference cluster is). The individual income inequality status measured by income deprivation status can be represented with the following formula: . In this formula, is the mean of the incomes of all surveyed samples in the cluster Y. is the mean of the incomes of surveyed samples with income exceeding in cluster Y. is the number of samples in cluster Y whose income exceeds as a percentage of the total sample size. (percentage of the samples in cluster Y whose income exceeds .) As shown in model (1) of Table 4, the coefficient of the this pilot policy on residential income inequality is significantly negative. This still supports the previous conclusion, thus proving the robustness of the paper's findings.

2. **Change the Regression Time**

To identify whether the influence of this pilot policy on resident income inequality will change with the sample time, this paper identifies the how sensitive the policy is to time change by changing the regression time. The policy began in 2014, and the year 2014 is the intermediate time point. The regressions are conducted for samples from each 2 years before and after the policy. If the coefficients and significance of the regression results do not change, the the previous estimation results are stable. The results of Model (2) in Table 4 say that by changing the time interval and shortening the time interval, the coefficient of this policy on residential income inequality is remarkably negative.And it still produces the same conclusion as the previous, thus proving paper's findings stable.

3. Remove Interference form Relevant Policies

Assuming that another relevant policy is implemented during the pilot period, the treatment effect will be affected. Therefore, the influence of other relevant policies should be excluded form the empirical test. In September 2016, the Chinese government released the *Pilot Program for Paid Use and Trading of Energy Use Right*. It is very similar to the program of carbon emissions trading. Moreover, it means to allow Henan Province, Fujian Province, Sichuan Province and Zhejiang Province to have access to energy use right after paying and trading system. Energy use right is the right of enterprises to use the total amount of all kinds of energy each year directly or indirectly. This policy is similar to carbon trading right. Therefore implementing this policy may also affect the residents' income inequality, thus causing bias in our empirical results. To exam whether such interference exists, all samples from Zhejiang, Fujian, Henan and Sichuan were excluded from the research samples, and empirical tests were conducted again to eliminate the possible interference caused by this policy. As shown from the results of model (3) in Table 4, the coefficient is largely negative. It verifies the conclusion above that this pilot policy is conducive to reducing residents' income inequality.

Table 4: Robustness test

Variable Name	Change the Dependent Variable (1) RD	Change the Regression Time (2) lnequality	Remove Interference of Relevant Policies (3) lnequality
Treat*Time	-0.0431***	-0.0061**	-0.0228***
	(-8.477)	(-2.527)	(-11.458)
Constant	0.9012***	0.9480***	0.5525***
	(5.885)	(10.189)	(9.611)
Control variable	YES	YES	YES
Observations	50,143	29,766	40,887
R-squared	0.023	0.056	0.040
Number of pid	23,296	17,621	19,146

Heterogeneity Analysis

(1) Classification by Urban and Rural Areas

To further research what the pilot policy can produce in different cities and rural areas, the paper carries out the regression of urban and rural classification samples according to the classification of urban and rural areas in the CFPS village residence database. Table 5 gives the results, showing that the policy has a obvious impact on resident income inequality in both urban and rural places. What's more the relative coefficients of rural samples and urban samples are -0.0106 and -0.0166 respectively. Rural samples can be analyzed by the offset mechanism of carbon trading. At present, China is gradually promoting the entry of agroforestry carbon sink into the carbon trading market. Household methane and animal waste management can be traded as voluntary greenhouse gas emission reduction projects in the carbon market agroforestry carbon sink. Guiding agricultural and forestry carbon sinks into the carbon market, can improve the utilization rate of resources in rural areas, facilitate the increasing of farmers' income as well as the ecological environmental protection to a certain extent, which realizes ecological poverty alleviation. What can be found is that the pilot policy has a much more substantial influence on the income inequality of urban residents. This is mainly caused by the industrial structure difference between urban and rural areas. Chinese towns mainly consist of manufacturing and service industries, while rural areas are mainly agriculture. The pilot policy impact upon the income difference of residents through the industrial structure. What the industries initially included in the pilot policy are mainly regarded as the secondary industries, while the industries dominated by manufacturing in cities are more susceptible to the impact of this trading policy.

Table 5: Empirical results of the effect of these policies on residents' income gap groupedby

Variable Name	lnequality	lnequality
Treat*Time	-0.0106***	-0.0166***
	(-4.155)	(-5.508)
Constant	1.0211***	0.5866***
	(14.325)	(6.505)
Control variable	YES	YES
Observations	33,228	16,915
R-squared	0.062	0.098
Number of pid	15,826	8,800

urban and rural areas Rural Sample Urban Sample

(2Classification by Per Capita Income Level

This paper is meant to explore whether the differences pilot policy made on resident income inequality are different among different income groups. In this paper, per capita net household income in the CFPS household economy database is sorted in descending order. And according to the per capita net income, the samples are divided split into three groups. The group with low income, the group with middle income and the group with high income were respectively used for regression. The regression results in Table 6 indicates that, the effect of this pilot policy on the middle-income group is negative, but not obvious; the impact on the low-income group was positively significant; the impact on the high-income group is negatively obvious. The coefficients of the interaction term are -0.0147, -0.0012 and -0.0282 respectively, showing what influence the pilot policy makes on the group with high income is greater than that on the group with low income. It is because the pilot policy will raise the prices of carbon-intensive goods, such as air transportation, automobiles, and other high-carbon consumer products. In China, it is the high- income group that is the consumer of carbon-intensive goods. Therefore, the carbon market boast a stronger impact the high-income group's income distribution.

Variable Name	lnequality	lnequality	lnequality
Treat*Time	0.0147***	-0.0012	-0.0282***
	(3.300)	(-0.273)	(-8.256)
Constant	0.9551***	0.6389***	0.9596***
	(7.941)	(5.049)	(10.347)
Control variable	YES	YES	YES
Observations	16,712	16,716	16,715
R-squared	0.093	0.047	0.135
Number of pid	10,674	11,816	10,541

Table 6: Empirical results of the impact of these policies grouped by income on residents' income gap

Low-income Group Middle-income Group Hight-income Group

(3) Classification by Carbon Emissions

How effectively the carbon trading system works would be affected by the level of carbon emissions. For instance, in cities of higher carbon emissions, the regulatory effect of carbon trading rights pilots may be greater. Thus, this paper divides these samples into two sub-

samples on the basis of CO2 emissions: a high emission group and a low emission group. In this paper, from 2010 to 2018, the annual average emissions of each city are calculated. The median of the average emissions of each city is selected for grouping. Table 7 of the regression results show that in cities with higher CO2 emissions, what effect this pilot policy makes on residents income inequality is more significant. Maybe it is because that cities with higher carbon emissions correspond to areas with higher economic levels or more developed energy industries, which also correspond to areas with high consumption and production of carbon-intensive goods. Therefore, there will be a greater effect on the income distribution in these areas.

Table 7: Empirical results of the impact of these policies grouped by income on residents' income gap

	Low Emission Group	High Emission Group
Variable Name	lnequality	lnequality
Treat*Time	0.0072***	-0.0178***
	(2.631)	(-7.345)
Constant	0.4222***	1.4331***
	(4.614)	(14.827)
Control variable	YES	YES
Observations	25,073	25,070
R-squared	0.086	0.171
Number of pid	12,894	13,667

Classification by Region

Considering the imbalance of regional development in China, the effects of the policy may be heterogeneous at the regional level . As only Chongqing in western China belongs to the experimental group, there are few samples. We use the National Bureau of Statistics classification criteria to split the country into different parts, in terms of the eastern region, and central and western regions. The following Table 8 reveals that the interaction coefficient of the eastern region is negatively significant, with the coefficient of -0.0228. This conclusion indicates that the policy is more beneficial to alleviating the residents income inequality in the eastern region.

Table 8: Empirical results of these policies on residents' income gap grouped by region

	Eastern Region	Western Region
Variable Name	lnequality	lnequality
Treat*Time	-0.0178***	0.0144***
	(-8.192)	(2.818)
Constant	0.6894***	1.2292***
	(9.028)	(13.223)
Control variable	YES	YES
Observations	23,440	26,701
R-squared	0.085	0.041
Number of pid	10,858	12,459

Mechanism analysis

According to the previous analysis, the residents income inequality is obviously decreased by the policy. Then, how does the policy achieve this driving effect? A study of this mechanism of action can help further understand the intrinsic link between the pilot policy and residents income inequality.

The analysis of the study's research hypothesis suggests that the pilot policy can indirectly affect residents income inequality through technological innovation, carbon emissions, industrial structure, employment structure , and environmental pollution levels. To this end, these five indicators are selected as Mediator variables in this paper to explain the intrinsic influence mechanism of this driving effect by constructing a mediating effect mode.

(1) Model Setting and Variable Selection

Based on the research design of Wen ZL and Ye BJ (2014), the author designs the following mediating effect model. For details, see (2) - (3). In the selection of carbon emission indicators, CO2 emission at the city level is used as the control variable (Yu et al.,2021). In the selection of industrial structure indicators, the proportion of the gross value of the tertiary industry to that of the secondary industry is used to measure industrial structure (Liu, CM et al., 2019). when selecting the technological innovation indicators, this paper adopts the sum of government fiscal expenditures on education and science and technology as a share of Gross Domestic Product to measure technological innovation (Yu et al. 2021). In selecting employment structure indicators, author takes the proportion of secondary industry employment in urban and rural areas to total employment to measure employment structure (Ren LY, 2021). When selecting indicators of environmental pollution level, this paper adopts the sum of industrial sulfur dioxide emissions of wastewater per capita and sulfur emissions per capita as indicators. Because in the data from prefecture-level cities, there is no statistical data on solid waste emissions (Shi DQ et al., 2018).(2)(3)

In model (2) and model (3) , are the Mediator variables to be tested, representing carbon emissions (ln_c022), industrial structure (advance), technological innovation (jscx), employment structure (jyjgd2), energy consumption structure (tm), and environmental pollution level (rjfepfl) respectively. Since in model (1) is negatively significant, it is only necessary to observe the significance of B in model (2) and C in model (3). If both B and C are significant, the mediating effect exists. If at least one of B and C is not obvious, the coefficient product method (Bootstrap) is continually used to test. The sampling number is set to 1000, gaining 1000 estimates of mediating effects and 95% confidence interval respectively. If the confidence interval does not contain 0, mediating effect significantly exists.

(2) Mechanisms of Action of Carbon Emission Rights Trading Pilot Policy Affecting Residents Income Inequality

1. Carbon Emission

Table 9 reports the influence of carbon emission as a Mediator variables on the pilot policy and residents income inequality. The first column in Table 9 reports how the pilot policy impact on the Mediator variables. The coefficient, which is -0.0874, is obvious at the 1% level. It indicates that the emissions will be lowered by the pilot policy. In the second column of Table 9, the report results reveal that the coefficient of the pilot policy is -0.0209 and that of carbon emission is 0.0103. Both are significant at the 1% level. According to Table 9's regression results , the pilot policy will reduce the level of residents income inequality through carbon emissions reduction. Meanwhile , The results reveal that the bias corrected Bootstrap confidence interval under 95% confidence is (0.0005, 0.0008), excluding zero. That indicates a significant mediating effect of carbon emissions on the relationship between this policy and the residents income gap.

Table 9: Mechanism analysis of carbon emission mediating effect

(1)	(2)
Variable Name	ln_co22 lnequality
Treat*Time	-0.0874*** -0.0209*** (-8.836) (-11.112)
ln_co22	0.0103***

(11.649)		
Constant	2.3249*** 0.7225*** (2.935) (12.808)	
Control variable	YES	YES
Observations	50,143	50,143
R-squared	0.475	0.045
Number of pid	23,296	23,296
BootstrapBC95% confidence interval	(0.0005 (	0.0008)

2. Industrial Structure

Table 10 reports what the role of the mediating variable of industrial structure plays between this pilot policy and the residents income inequality. The first column in Table 10 reports the pilot policy's impact on the mediating variable of industrial structure with a coefficient of 0.1087 which is obvious at the 1% level. It reveals that this policy promotes the structure upgrading. In the second column of Table 10, the reported results indicate a coefficient of -0.0203 for the pilot policy and a coefficient of -0.0139 for the industrial structure, both significant at the 1% level. The reported regression results in Table 10 indicates that the level of residents income inequality will be reduced through the pilot policy through the industrial structure. Furthermore the paper also conducts a Bootstrap test, whose results show that the bias corrected Bootstrap confidence interval under 95% confidence is (-0.0032, -0.0026), which does not contain a zero value. This reveals that how the mediating effect of industrial structure works on the relationship between the pilot policy and residents income gap is significant.

Table 10: Mechanism analysis of mediating effect of industrial structure

(1)	(2)	
Variable Name	advanced	lnequality
Treat*Time	0.1087***	-0.0203*** (18.507) (-10.704)
advanced		-0.0139***
(-6.198)		
Constant	6.4645***	0.8363*** (13.983) (15.077)
Control variable	YES	YES
Observations	50,143	50,143
R-squared	0.672	0.042
BootstrapBC95% confidence interval	) -0.0032 (	-0.0025 .

3. Technological Innovation

The results in Table 11 reports the effect of technological innovation as an intermediary variable on both this pilot policy and resident income inequality. The first column of Table 11 reports what impact the pilot policy can make on technological innovation as an intermediary variable. The coefficient is 0.9192, which is obvious at the 1% level. It shows that the policy will facilitate the industrial restructuring. In the second column of Table 11, the reported results reveal one coefficient of -0.0201 for this pilot policy and another coefficient of -0.0019 for technological innovation, both significant at the 1% level. Based on the regression results reported in Table 11, the policy will lower the level of resident income inequality through technological innovation. The author also further conducts a Bootstrap test, whose results show that the bias corrected Bootstrap confidence interval under 95% confidence

is (0.0004, 0.0007), which does not contain a zero value, revealing that the mediating influence of technological innovation on the relationship between this policy and the resident income gap is significant.

Table 11: Mechanism analysis of the mediating effect of technological innovation

Variable Name	(1) jscx	(2) lnequality
Treat*time	0.9192***	-0.0201***
	(9.791)	(-10.287)
jscx		-0.0019***
		(-10.557)
Constant	88.4602***	0.9149***
	(8.655)	(15.410)
Control variable	YES	YES
Observations	50,143	50,143
R-squared	0.397	0.044
Number of pid	23,296	23,296
BootstrapBC95% confidence interval	) 0.0004 (	0.0007 .

Employment Structure

Table 12 indicates the results of the impact of employment structure as a mediating variable between the policy and the income inequality of the population. The first column in Table 12 reports the pilot policy's effect on employment structure as a mediating variable with a coefficient of -0.0392 that is obvious at the 1% level. It indicates that the policy can reduce employment in the secondary sector and adjust the employment structure. In the second column of Table 12, we can see that the coefficient of the pilot policy is -0.0139 and the coefficient of employment structure is 0.1920. Both are significant at the 1% level. According to the regression results reported in Table 12, it can be concluded that the level of residents' income inequality can be lowered by the pilot policy through employment structure adjustment. At the same time, the Bootstrap test is further implemented, from which the results indicate that the bias corrected Bootstrap confidence interval under 95% confidence is (-0.0005, -0.0001), excluding zero value, indicating that the employment structure boasts obvious mediating influence on the pilot policy and resident income gap.

Table 12: Mechanism analysis of the mediation effect of employment structure

Variable Name	(1) jyjgd2	(2) lnequality
Treat*time	-0.0392***	-0.0139***
	(-11.815)	(-5.806)
jyjgd2		0.1920***
		(20.936)
Constant	-0.6590***	0.7513***
	(-8.683)	(12.005)
Control variable	YES	YES
Observations	39,809	39,809
R-squared	0.151	0.069
Number of pid	21,627	21,627
BootstrapBC95% confidence interval	(-0.0005)	-0.0001 .

Environmental Pollution Level

Table 13 reports the results of the influence of environmental pollution level as an intermediary variable on the policy and resident income inequality. The first column of Table 13 reports that the regression coefficient between the policy and environmental pollution level is not obvious. In the second column of Table 13, the report indicates that the pilot policy coefficient is -0.0217 and the environmental pollution level coefficient is -0.0003. Both are obvious at the 1% level. However, with the further conduction of the Bootstrap test, the results show that the bias corrected Bootstrap confidence interval under 95% confidence is (-0.0009, -0.0005), excluding zero, indicating that environmental pollution level has a significant mediating influence on the pilot policy and residents' income gap.

Table 13: Mechanism analysis of the mediating effect of environmental pollution level

	(1)	(2)
Variable Name	rjfepfl	lnequality
Treat*time	0.1311	-0.0217***
	(0.581)	(-11.304)
rjfepfl		-0.0003***
		(-5.296)
Constant	-12.0467	0.7504***
	(-1.389)	(13.733)
Control variable	YES	YES
Observations	49,860	49,860
R-squared	0.240	0.042
Number of pid	23,072	23,072

BootstrapBC95% confidence interval (-0.0009) -0.0005 .

Research Conclusions and Policy Suggestions

(1 . Research Conclusions

In the last decade, the carbon emission trading system has turned into one of the most important climate policies in China. We use DID to analyze the influence of the pilot policy on residents' income inequality on the basis of the panel data of the CFPS database from 2010-2018. We theoretically explain what mechanical effect of the pilot policy can produce on resident income inequality, Then we subsequently use the stepwise regression method and Bootstrap method to test the mechanism effect. The following conclusion is reached: the policy can significantly reduce resident income inequality by 2.18%. The result still holds after a series of robustness tests. Secondly, what impact the pilot policy can make on resident income inequality is heterogeneous between different income groups, between urban and rural places, between regions with different CO2 emission intensities, and between different regions. Among them, the adjustment effect on income inequality of urban residents is greater than that of rural ones; it can effectively adjust the income gap of high-income people; regions with high carbon emissions are significantly affected by this policy; it can effectively alleviate the resident income inequality in the eastern region. Third, the pilot policy can affect the resident income inequality through five paths: carbon emission, industrial structure, technological innovation, employment structure and environmental pollution level. Therefore, the pilot policy can help China realize the win-win goal of low-carbon transition and common prosperity.

(2) Policy Suggestions

First, the government can facilitate the building of a domestic carbon trading market, covering more fields and industries. The empirical results show that the pilot policy offers a new scheme to the resident income inequality alleviation, and it can realize the "win-win" of income inequality reduction and carbon emissions. Currently, China is in the primary stage of building its own carbon market, just covering the electric power industry, among which the high-emission enterprises have been included as the key emission units. According to construction program approved by The State Council, only the power industry will be included in the trading at the beginning due to the different ways of calculating carbon emission quotas in various industries. During the period of "14th Five-Year Plan", national carbon exchange will absorb more industries and enterprises. In particular, non-power "two high" industries and enterprises will be introduced into the trading system first. During the "14th Five- Year Plan", the national carbon market will take the power industry as a breakthrough and incorporate other industries on the basis of the principle of "mature one and incorporate one". Considering the stable operation of the carbon market in the power generation sector, seven industries with high energy emissions and high consumption, including building materials, chemicals, domestic civil aviation, non-ferrous metals, petrochemicals, paper and steel, will be gradually added into the current national carbon trading system.

Second, we should improve the carbon pricing mechanism, upgrade the industrial structure, innovate technology, adjust the employment structure, strengthen environmental supervision and other measures to promote the pilot policy to reduce resident income inequality. The study of this paper finds that the pilot policy can alleviate resident income inequality by promoting carbon emission reduction, upgrading industrial structure, technological innovation, adjusting employment structure and improving environmental pollution levels. Therefore, it is necessary to further improve supporting measures in the future. China's initial carbon quota is mainly distributed for free. The proportion of compensated carbon allocation should be gradually expanded to explore the mechanism of auction distribution. We should actively develop the service industry, promote technological reform in high-carbon industries, and optimize the regional industrial structure. We should continue to invest more in science and technology and give play an vital role of technological innovation in the carbon trading market. Given the changes in labor demand, the government should actively promote labor employment training and guidance, improve the flexibility of employment services, strengthen the cultivation of highly skilled labor, develop higher education and higher vocational education, fill the gap of highly skilled personnel, and optimize the vocational training of low-skilled workers.We will strengthen environmental law enforcement, ban the protection of polluting enterprises, and eliminate enterprises with backward production capacity and high pollution levels promptly.

Third, differentiated carbon emission trading policies should be implemented to give appropriate policy preferences to low-income groups, central and western regions and places with low carbon emission levels, to minimize the income gap. Through the heterogeneity analysis, it is found that in the regions above, the pilot policy does not contribute to narrow the resident income gap. Therefore, differentiated policies should be implemented in the future carbon emission trading policies to give preferential policies to these groups or regions such as in terms of special financial transfer payments to boost the balanced development of carbon emission trading rights among regions.

Authors' contribution

YH: Conceptualization, Designing, Methodology, Validation. ZZL & ZJX: Writing- original **draft, Software.**

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