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Impact Assessment and Mechanism Analysis of Low-carbon Pilot Cities on Carbon Intensity

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Abstract: *Since the reform and opening up, China's economy has achieved rapid development for more than 40 years with the input of high-intensity production factors, and in 2010, it became the largest manufacturing country with a huge industrial system. As a responsible developing country, China government has made a public commitment to the world: China's carbon dioxide emission intensity will be reduced by 40-45% in 2020 and 60-65% in 2030 compared with 2005. From the reality, driven by the policy environment, lowcarbon technology patents in China have shown explosive growth in recent years, and the progress of lowcarbon technology is mainly concentrated in the field of clean energy technology. At the same time, the proportion of domestic coal consumption continues to decline, and the intensity of carbon footprint is slowly decreasing. Therefore, we have reason to explore that the impact of lowcarbon technological progress on carbon emission intensity is mediated to some extent by energy consumption structure. The results show that the progress of lowcarbon technology at the present stage is mainly to achieve the inhibition of carbon emission intensity by optimizing the energy structure. In the control variables, industrial structure and population size can significantly improve the intensity of carbon footprint, and the level of urbanization, per capita GDP and foreign direct investment have a significant inhibitory effect on the intensity of carbon footprint.*

Keywords: *Low carbon pilot; Carbon strength; Impact assessment*

1. Introduction

With the rapid development of China's economy, the issue of carbon footprint has become increasingly important, and environmental issues have become the focus of increasing attention. The development of economy is closely connected with the non-release of carbon. There is a close connection between the two. J's carbon environmental problems have certain constraints on the rapid development of economy [1]. Affected by global warming, in recent years, heatwaves have occurred frequently in Asia, Europe, Oceania and other places, and droughts in western Africa and southern Europe have been stronger and longer, heavy precipitation events in land areas have increased frequently, and extreme severe weather such as floods and typhoons have emerged in endlessly around the world; Since 1971, the world's glaciers have generally accelerated melting and shrinking, and the ice reserves in Antarctica and Greenland have rapidly decreased [2]. The Arctic sea ice area has shrunk at a rate of 3.5% - 4.1% every decade. It is estimated that the Arctic will become ice free by 2050 [3]. Since 2006, the Chinese government has paid attention to the development of energy conservation and emission reduction, promoted the development strategy of lowcarbon economy and strengthened the progress of lowcarbon technology. This shows China's responsible attitude towards carbon footprint and its determination to take a lowcarbon development path, and highlights China's image as a big country actively responding to global climate change [4].

From the perspective of energy, 90% of China's carbon footprint come from coal. In 2017, the total domestic carbon footprint were nearly 10 billion tons, and the carbon footprint from coal were about 8.948 billion tons. The total carbon footprint from gasoline, diesel and natural gas and other energy sources were 961 million tons, accounting for only about 10% of the total emissions [5]. In order to mitigate climate warming and assume the responsibility of a large country, the Central Committee of the Communist Party of China has made a series of requirements for domestic emission reduction work [6]. And put forward the double control goal of energy intensity and total energy consumption, that is, the energy consumption per unit of GDP in 2020 will be 15% lower than that in 2015, and the industrial structure should be optimized, energy conservation in key areas should be enhanced, and the total energy consumption in the country should be controlled within 5 billion tons of standard coal [7].

Therefore, based on the advantage of large sample data at the prefecture level, this paper first uses

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the PropensityScoreMatching (PSM) method to match samples, and then carries out DID test on the matched samples, so as to meet the randomness and homogeneity assumptions required by DID model as much as possible, and tests the robustness of the conclusions to ensure the accuracy of the empirical results. There is a lack of in-depth discussion on the mechanism behind the policy. Therefore, this paper further discusses its mechanism from various aspects on the basis of the policy effect.

2. Theoretical analysis and research hypothesis

2.1. Investigation on energy efficiency of lowcarbon pilot cities

The excessive level of greenhouse gases in the atmosphere caused by human activities not only damages the health of the body, but also damages the ecosystem of the earth beyond the limit of automatic ecosystem repair. The transformation of lowcarbon economy has become the world consensus. Although China has successfully fulfilled its commitment to energy conservation and emission reduction in the international community, due to the weak environmental foundation, there are still major challenges in energy conservation and emission reduction and environmental governance [8]. China's industrialization process is rapid and has entered the middle and late stages of industrialization. The total energy demand is huge. As the main carrier of social economy, the production and consumption activities of cities are the main source of carbon footprint. In 2009, the fossil energy consumption in urban areas of China accounted for 60% of the total energy consumption of the country. First, "rent-seeking" in the segmented market leads to serious resource mismatch, and "adverse selection" in energy competition leads to inefficient use of urban energy and high carbon emission intensity [9]. In the regional integration market, on the one hand, the improvement of market mechanism and the weakening of energy trade barriers and the reduction of transportation costs brought by market opening have forced energy-rich cities to improve energy efficiency and reduce the intensity of carbon footprint [10].

The detection methods are mainly divided into four categories: IPCC clean-up algorithm (also known as carbon emission coefficient method), model factor decomposition method, measured method and carbon footprint. Even if "dirty technology" is used at the beginning. With the in-depth development of reform and opening up, China's economic growth depends on investment and export, which promotes the rapid growth of China's economy, and this economic reform model is of great significance to China's lowcarbon footprint. In addition, internal consumption institutions have also produced a change that the reduction rate of people's consumption of carbon footprint is higher than the growth rate of government consumption of carbon footprint, so the overall carbon emission intensity in the distribution model has slightly decreased. Efforts should be made to develop the application channels of renewable energy so that it can play a role in all sectors of society, such as solar photovoltaic power generation and thermal utilization. Biomass energy can not only be used for power generation, but also be used to produce biofuel ethanol gasoline, etc. Technology can create unlimited possibilities. The use of existing renewable energy is limited, and there are more unknown areas to explore. New energy can be fully utilized at all levels of the economy and society, covering all corners. As shown in Figure 1.

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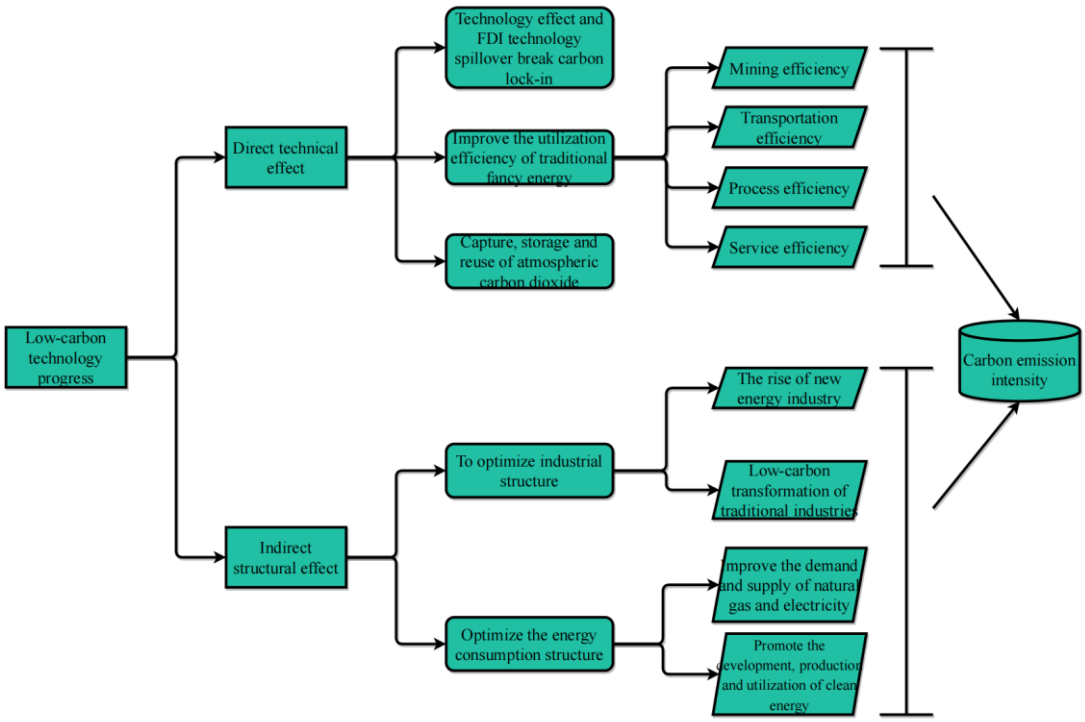

Figure 1: The path map of low carbon technology progress affecting carbon emission intensity

2.2. Mechanism analysis of the influence of lowcarbon pilot policy on energy efficiency

China's lowcarbon city pilot has the characteristics of exploratory pioneering, comprehensive and professional, and authorized autonomy. The core of China's lowcarbon pilot policy is to explore a win-win development path for the environment and economy in the pilot area in an innovative way on the premise of ensuring the sustainable and stable development of the overall social economy. Lowcarbon pilot policy is an incentive policy put forward in response to the irrational urban industrial structure and the easy formation of urban "hot island" in the process of urban development. Under the lowcarbon goal, the pilot cities have higher autonomy and innovation to overcome the difficulties of carbon footprint. Adjusting the industrial structure is the first challenge facing the pilot cities. The secondary industry includes the industry with the largest energy demand, and reducing the dependence of local economy on the secondary industry can reduce carbon footprint to some extent. Which will have a serious impact on the living environment of human beings. Therefore, energy, economy and environment are more and more inseparable, and the discussion and research on the internal relationship among them has become a global research hotspot.

China is the largest trade exporter, and improving the quality of exports can bring huge environmental benefits. The use of foreign capital can not only enjoy the technology brought by foreign capital, but also make the proportion of capital, energy, labor and other inputs close to the optimal allocation. Improving the quality of foreign investment is also an important part of social energy conservation. However, due to geographical location and economic volume, the total amount of foreign capital actually used by society will show huge differences, selecting the index as the ratio of the actual utilization can eliminate the heterogeneity of cities to some extent. Similarly, selecting the ratio of the total amount of foreign trade to local GDP as the index of the dependence on foreign trade.

3. Metrological test of China's carbon intensity and its influencing factors

3.1. Long-term equilibrium analysis of carbon intensity and its influencing factors

Before constructing the cointegration model of time series variables ln CI, ln EI, ln CP and ln TP, the stationarity of these time series variables should be tested to avoid the phenomenon of "pseudo-regression", that is, the time series variables that are independent from each other and have no logical relationship are regressed, and the regression results show that the estimation coefficients of these time

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series variables are significant. The test methods used to test the stationarity of time series variables are DF test, ADF test, KPSS test, PP test and ERS test. On this basis, Mackinnon expanded the original critical value table of DF test and formed a critical value table which was widely used later. According to the expanded critical value table, the appropriate significance level can be selected according to the needs, and t statistics can be used to decide whether to reject or accept the original hypothesis. This test method is an extension of the original DF test, so it is called extended DF test, namely ADF test. Therefore, the decline in the consume in the cointegration equation will promote the decline in carbon intensity, and the main driving force comes from the decline in the consume in the tertiary industry. However, the decline in the consume has no obvious effect on carbon intensity, mainly because the increase in the consume in the secondary industry leads to an increase in carbon dioxide emissions, which offsets the decrease in carbon dioxide emissions in the tertiary industry.

According to Pearson correlation coefficient, which is in line with the characteristics of output growth with input growth in DEA model, and is suitable for DEA analysis. As can be seen from Figure 2, China's lowcarbon technology progress index GEBML rose from 0.921 in 2016 to 0.974 in 2016, showing a fluctuating growth on the whole. At the same time, the growth of the GEBMLTC index of technological level is significantly higher than the efficiency level, and its contribution to the progress of lowcarbon technology exceeds the technical efficiency. The improvement of technological level plays an increasingly important role in the development of China's lowcarbon economy, and is the main source of power to improve China's lowcarbon technological progress.

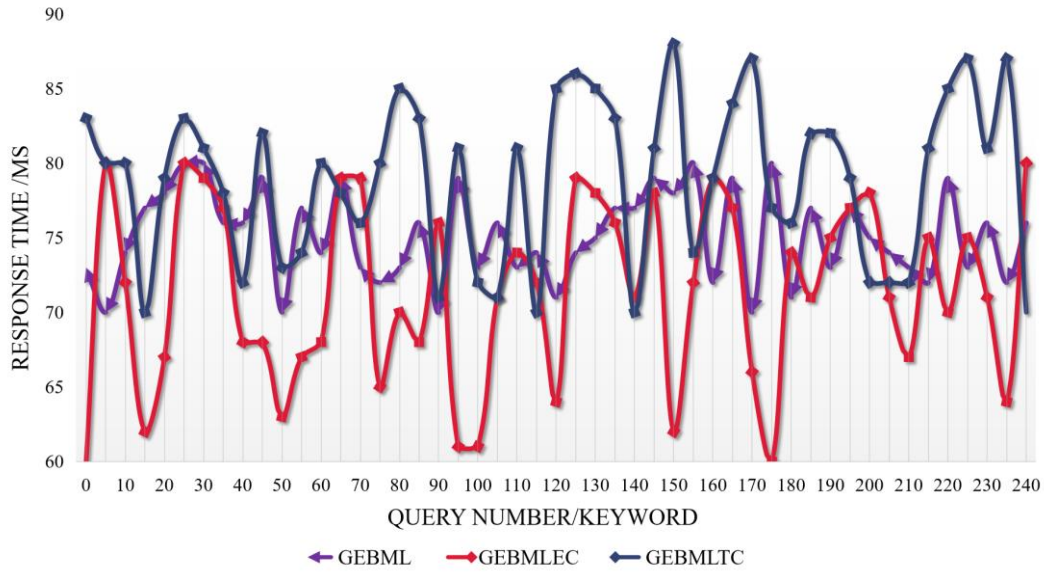

Figure 2: GEBML index and its decomposition value growth trend from 2016 to 2022

The trend of technological change is more similar to the trend of lowcarbon technological progress, which shows that technological change is the main influence of regional lowcarbon technological progress and change, while technical efficiency change only plays a role of strengthening or weakening, but this role of strengthening and weakening can not be ignored.

3.2. Improvement of reducing carbon emission intensity in China

Because carbon footprint are not spatial and regional, all regions should strengthen cooperation and promote lowcarbon footprint. Encourage and correctly guide all regions to follow the path of energy conservation and green and lowcarbon sustainable development. Under the international trend, the country should formulate relevant laws and policies to limit the carbon footprint of various regions. In addition, we need to focus on the overall development from both the overall and independent aspects. We need to promote the common emission reduction of all regions. The independent development is to establish key regions, which is a typical example of the Luohe region to take emission reduction measures independently according to its own advantages. The level of economic development is expressed by per capita GDP. Many previous studies have shown that there is a nonlinear relationship between per capita carbon dioxide emissions and per capita GDP based on the EKC hypothesis. Therefore, as a measure of economic development, per capita GDP has a significant impact on the intensity of carbon footprint. The influence of population size on carbon emission intensity mainly has

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two aspects. On the one hand, the expansion of population size will increase energy consumption in production activities and daily life, which will bring great pressure to the ecological environment; On the other hand, the expansion of population size can enrich human capital, improve the technical level and economic level, and have both positive and negative effects on carbon emission intensity. This means that the effect of reducing China's carbon intensity by reducing energy intensity will be more significant and lasting; However, the changes in the consume and the proportion of the secondary industry have less significant influence on the change of carbon intensity than the energy intensity. This is because China's energy endowment of "rich in coal but poor in oil and gas" determines that the consume in China will not change much for quite a period of time, so the influence of coal consumption on carbon intensity is greatly suppressed.

The reason may be that the higher the level of urban industrial upgrading, the faster the urban economic development from high such as agriculture and manufacturing to low such as services, showing a decline in carbon emission intensity driven by industrial structure transformation; At the same time, the industrial upgrading is accompanied by the optimization of the industrial development environment and the improvement of the innovation atmosphere, which leads to the agglomeration of urban innovation factors, high value-added industries and other high-end factors, showing the reduction of carbon emission intensity driven by the optimization of the development environment, and thus strengthening the promotion role of integrated regional expansion in the reduction of urban carbon emission intensity. The development of industry is highly dependent on the consumption of natural resources, especially energy, resulting in a large amount of carbon footprint.

4. Conclusions

Accurate evaluation of the effect of lowcarbon pilot policies is of great significance for pilot cities to better carry out lowcarbon pilot work and further promote lowcarbon pilot policies. In view of the insignificant role of carbon sinks in improving the carbon emission performance of lowcarbon pilot cities, the concept of green development should be vigorously advocated. On the one hand, the existing forest vegetation should be actively protected, on the other hand, the urban development should be reasonably planned, the ecological environment in the process of urbanization and industrialization should be highly concerned, and a livable urban environment should be created. In the face of a standard deviation impact of the proportion of the secondary industry, the carbon intensity presents an alternating change of three stages of positive response - negative response - positive response. In the initial stage, the response of carbon intensity to the impact of the change of the proportion of the secondary industry is relatively slow. In the medium term, carbon intensity begins to show a negative response and this negative response is constantly amplified. Based on the research focus, this paper chooses the intermediary effect model to further measure the specific impact path of lowcarbon technological progress on carbon intensity, which will inevitably ignore some factors. I hope that we can discuss the subdivision of lowcarbon technologies in the future, and deeply study the differences in the carbon emission intensity of different technologies within lowcarbon technologies.

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