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Impact of low-carbon pilot cities on surrounding cities

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Abstract: *Innovation is the source of strength for urban development, and LC is the only way for urban development. Affected by factors such as fragile ecology, single industrial structure, weak innovation foundation and geographical disadvantages, low-carbon (LC) pilot policies will hinder technological innovation in resource-based cities, large cities and western cities. The results show that the pilot policy of LC cities has significantly promoted the growth of urban green total factor productivity, but this effect shows typical heterogeneity in different regions; In the eastern pilot cities, it is significantly positive, while in the central and Western pilot cities, it is significantly negative. After decomposing urban green total factor productivity into urban green technological progress and technological efficiency, it is found that the pilot policy of LC city has a significant effect on urban technological efficiency and urban green technological progress. Accordingly, some suggestions are put forward to further promote the LC pilot policy and guide the construction of LC cities.*

Keywords: *Low-carbon city; low-carbon pilot; environmental pollution*

1. Introduction

The Chinese government has also been paying close attention to the sustainable development model of the low-carbon (LC) economy, striving to achieve an organic combination between economic growth and energy conservation and emission reduction, and to avoid "high carbon lock-in" while achieving urbanization and industrialization. It has formulated relevant policies and tried to refine the rejuvenation of the Chinese nation [2]. The global greenhouse gas emissions accompanied by economic growth and the resulting global climate change are a common challenge for all mankind and a worldwide problem that needs to be solved urgently [3]. At present, China is in a critical period of strategic transformation from high-speed economic growth to high-quality economic growth, and more emphasis is placed on the role of green total factor productivity growth in promoting high-quality economic growth [4].

From the perspective of policy, the pilot of LC cities, as a model of environmental pollution control, needs to further study its internal mechanism and specific effects on environmental pollution [5]. Have these pilot areas taken effective measures to reduce carbon intensity? Existing studies have not drawn consistent conclusions, and often focus on policy effect testing rather than policy mechanism analysis. carbon emission reduction targets in stages [1]. Developing a LC economy is an important embodiment of China's commitment to global environmental responsibility and a strategic move to achieve the great If LC pilot areas achieve a reduction in carbon emission intensity, only by further digging out the specific measures behind it can we use the first and first trial. The opportunity to better play a leading role in demonstration and provide experience for other regions [6]. This paper makes a theoretical and Empirical Analysis on the impact of LC pilot city policies on green innovation efficiency, which enriches the research in related fields. On this basis, put forward reasonable policy suggestions to promote the improvement of LC pilot policies and the improvement of green innovation efficiency, so as to speed up the transformation of China's economic growth model and promote green and sustainable economic growth. Under the above background, it is of great significance to study the impact of LC pilot policies on green innovation [7].

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2. Pilot policy and influence mechanism

2.1. Policy background for LC pilot city construction

As a development mode of LC pilot city construction, pilot cities may reduce pollutant emission level through innovation and application of clean technologies, transformation and upgrading of industries to low pollution and low energy consumption, and policy constraints. First of all, the influencing factors of technological innovation have direct and indirect levels [8].At the direct level, there must be investment in R&D talents and R&D funds. Since the pilot areas are provincial-level or larger central cities, the area under their jurisdiction is relatively large, making it difficult to control policy implementation. The "Notice" clearly proposes to "establish an industrial system characterized by LC and develop modern service industry". With the gradual deepening of the pilot policy, industries with high energy consumption and high pollution bear higher environmental costs, and these industries are forced to withdraw or relocate. Industries dominated by emerging manufacturing and service industries will gain huge room for growth. Generally speaking, under the explicit constraints of the strict LC pilot policy, the production costs of enterprises with high pollution, high energy consumption and low production efficiency will increase accordingly and the profits will be reduced. With this in mind, rational enterprises will choose the third way [9]. Secondly, the LC pilot policy reduces the risk of technological innovation, increases the certainty of valuable investment in energy conservation and emission reduction, and enhances the willingness of individuals to make innovative investments. The LC pilot policy with reasonable design is guided by the government, which makes individuals recognize the importance of innovation, so that rational individuals can spontaneously choose innovation to achieve the goal of energy saving and emission reduction [10].

2.2. Mechanism analysis

For the industry, under the strict environmental constraints of policy pilots, the cost of industries with high energy consumption and high pollution has risen, forcing the entire industry to reduce the level of pollutant emissions through technological innovation. If LC pilot cities can reasonably arrange LC industries, especially the tertiary industry with low energy consumption and low emission, they will reduce energy consumption, realize green development, and finally achieve harmony and win-win of ecological environment and economic growth. Specifically, from the perspective of China's energy consumption structure, the proportion of electric energy consumption in energy terminal consumption shows a rising trend. At this stage, thermal power generation is still the main power generation, so the production and consumption of electricity has become an important source of carbon emissions in China.

Table 1: Univariate analysis

Result variable	Before LC pilot cities			After the pilot city of LC			Double difference value
	control group	Processing group	Differences	control group	Processing group	Differences	Diff-in-diff
C1	0.393	0.167	-0.227	0.249	0.141	-0.108	0.119
standard deviation	0.035	0.027	0.026	0.032	0.028	0.030	0.040
P value	0.000	0.000	0.000	0.000	0.000	0.001	0.004

Policy-oriented R&D investment and the number of scientific and technological talents are the decisive factors affecting innovation, especially the government's R&D investment is of great supporting significance to start-up enterprises. At the same time, from the perspective of effective allocation of resources, the essence of industrial structure change is the process of transfer of production factors among different departments, and industrial structure is an effective carrier to determine the flow of scientific and technological innovation resources. The process of pollution control by enterprises through technological upgrading or new product research and development will objectively increase the demand for scientific and technological talents, and promote the substitution of high-skilled labor for low-skilled labor. Table 1 lists the carbon intensity and its changes of the samples of the treatment group and the control group before and after the implementation of LC pilot cities. Before the implementation of LC pilot cities, the carbon intensity values of the treatment group and the control group were 0.167 and 0.393 respectively, and the difference between them was significant at

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the level of 1%.

3. Model construction and variable description

3.1. Model settings

This paper takes two batches of LC city pilot construction policies as quasi natural experiments, and uses the classic policy evaluation model - double difference method to evaluate the comprehensive impact of China's LC pilot construction on environmental pollution. In order to avoid the selective bias of the samples, which will affect the empirical analysis conclusion, this paper uses the method of propensity score matching (PSM) to eliminate the selective bias of the samples, and takes the LC city pilot as a "quasi-natural experiment", and uses the double difference method (DID) to evaluate the impact of the LC city pilot on the growth of urban green total factor productivity, that is, to investigate the differences of green total factor productivity between pilot cities and non-pilot cities before and after the implementation of the policy.In the research of research methods, a multi-period double-difference model is constructed to identify the LC economic effect of innovative cities. The benchmark regression model is set as follows:

$$Y_{it} =_a o + lDID_{it} + \sum a2controlit + \sum city + \sum year + \varepsilon_{it} \quad (1)$$

Where, i and t represent city and time respectively; y_{it} represents the explained variable, i.e. carbon intensity; did_{it} is the core explanatory variable of this paper, which represents whether the city is selected as the pilot of innovative city; $control_{it}$ is a series of control variables at the city level; $city$ and $year$ are dummy variables of city and year; ε is an unobservable random error term. Output variables include expected output and unexpected output. Unexpected output includes wastewater discharge, sulfur dioxide discharge and dust emission.

In addition, in order to examine the interaction effect of industrial agglomeration and LC pilots on the growth of urban green total factor productivity, we further added the interaction term of LC pilots and related industrial agglomeration to the benchmark model (1), and obtained model (2):

$$GTFP_{it} = a + \beta 1did_{it} + \beta 2agg_{it} + \beta 3did_{it} \times agg_{it} + \beta 4X_{it} + \mu i + \lambda_t + \varepsilon_{it} \quad (2)$$

In order to simplify the model and avoid being unable to identify due to too many parameters, the model contains only one cross term at a time and is tested in turn. For the estimation of model (1) and model (2), we use the two-step System GMM method. The LC economic effect of industrial upgrading is more obvious than the LC economic effect of rationalized industrial structure. Therefore, industrial upgrading is adopted to reflect the structural transformation effect, and industrial upgrading is usually characterized by the output value of tertiary industry/output value of secondary industry.

3.2. The impact of LC pilot city construction on environmental pollution

The construction of LC pilot cities provides a good quasi natural experiment for improving and controlling environmental pollution. This paper uses did model to investigate and evaluate the impact of LC pilot policies on urban environmental pollution. Table 2 examines the impact of the construction of LC pilot cities on exhaust emissions. The estimation results show that whether the corresponding control variables are added or not, the construction of LC pilot cities can significantly reduce the urban exhaust emissions. After the control variables are added, the exhaust emissions are significantly reduced by 15. 4%. The estimated results are consistent with the research findings of Liang Pinghan and Gao Nan, who believe that the water pollution emissions mainly come from industrial production, and the water pollution indicators are easily affected by collusion between government and enterprises, while the automobile exhaust, residential coal and industrial pollutants emissions in modern life are less affected by collusion between government and enterprises. As shown in Table 2:

Low-carbon pilot policy makes the government pay more attention to the investment of scientific and technological innovation from expenditure and other aspects; At the same time, the government's investment in sci & tech alleviates the financing pressure faced by the innovation subject and effectively reduces the innovation risk. This means that the LC pilot policy has improved technological innovation in cities by increasing policy-based R&D funding. Taking into account green and

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development, this requires government financial funds to be tilted towards energy conservation and emission reduction construction projects, industrial policy support for technological transformation and transformation and upgrading of high-polluting industries, emphasis on high-tech emerging industries, and the establishment of special funds for LC paths and industries. technology to guide and increase capital investment in the construction of ecological civilization.Therefore, the LC pilot policy has prompted the government to increase R & D investment in green innovation. More green and LC industries will be developed in pilot cities in the East. Therefore, more marginal benefits can be obtained in the LC experiment, and the effect of eastern cities on green growth is stronger.

Table 2: Impact of LC city construction on environmental pollution

	(1)	(2)	(3)	(4)
	Exhaust emission	Exhaust emission	Wastewater discharge	Wastewater discharge
DID	-0.198	-0.154	-0.020	-0.005
Economic development		0.374		0.117
Population size		0.368		0.133
Urbanization		0.182		-0.215
Opening to the outside world		20.569		14.245
Industrial structure		0.861		1.422
Infrastructure		0.047		0.052
Human resources		0.059		-0.012
R & D investment		-0.091		-0.018
Constant term	20962	-3.830	3.435	0.786
Sample size	2996	2996	2996	2996

4. Conclusion

The regression results of the benchmark model show that LC pilot policies can help improve the efficiency of urban green innovation. The results of the parallel trend test show that the benchmark model regression satisfies parallel trends, and it is desirable for the benchmark model to use double DID. It means that LC pilot cities have indeed reduced carbon emissions, optimized the allocation of urban resources, and improved the efficiency of urban green innovation through policy guidance. We should increase the special fund support for the pilot projects of innovative cities, and guide enterprises to increase investment in research and development and accelerate breakthroughs in LC technologies through policies such as financial subsidies, financing incentives, and green finance. The weight of innovation indicators is used to evaluate urban innovation achievements based on the orientation of green and LC. Accurate and objective assessment of the implementation effect of LC city pilot policies has important policy implications for pilot cities to better adjust or improve policies and measures to achieve LC development, and to further promote LC city pilot experience nationwide.In particular, when exploring the LC development model, some cities in underdeveloped areas should combine the local resource endowment, give full play to the advantages of natural resources, try to avoid blindly developing industries with high energy consumption and high emission in pursuit of GDP, establish the development concept of "green water and green mountains are golden mountains and silver mountains", develop the economy and promote the construction of new urbanization on the premise of protecting the local ecological environment.

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