Research on the Impact of Low-carbon City Pilot Policies on the Quality of Urban Export Products: Based on Porter Hypothesis

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Abstract. Green sustainable development and opening up to the outside world at a high level are the important strategy of China's economic development in the new period. On the basis of theoretical analysis, this paper takes the low-carbon city pilot（LCCP）policy as "quasi-natural experiment" and uses 286 prefecture-level cities in the country from 2005 to 2016 as study samples to investigate the difference of LCCP policies to the quality of urban export products using difference-in-differences（DID）method. Empirical analysis shows that LCCP policies affect quality of urban export products in a positive significant way, and the conclusions hold up after a number of robustness tests. Further research finds that this policy will promote export products quality in inland cities more significantly; Green innovation has a positive moderating effect on this facilitating effect. This article is the first domestic document to discuss the effects of LCCP policies from the urban perspective, which is conducive to the scientific implementation of regulation policy in environmental, and provides important policy implication for realizing the "win-win" between economic trade and environmental protection.

Keywords: Low-carbon city pilot, Quality of export products, Green innovation, Quasi-natural experiment.

1. Introduction

Many countries jointly face the grand challenge of climate change of the world. For this reason, China has proposed action targets to limit emissions of greenhouse gases and has successively formulated a sequence of policies and guidelines to environmental protection. In this context, the the low-carbon city pilot (LCCP) policy came into being. In 2010, the National Development and Reform Commission (NDRC) launched the first batch of low-carbon pilot work for "five provinces and eight cities". The second and third batches, which were established in 2012 and 2017, respectively, steadily increased the scope of the pilot projects to encompass the entire nation.

The LCCP policy intended to investigate a unique green and low-carbon development path by combining the local industrial characteristics and development strategies in each pilot area. The low-carbon zone policy implemented by Germany can effectively reduce the average emission level of fine particles and improve the air quality in cities[1].The LCCP policy implemented by China can speed up the development of low-carbon technology research and development innovation, thus reducing Corporate sewage, and significantly reduce urban air pollution[2]. At the same time, the trial city's green total factor productivity（GTFP） can be indirectly increased by the LCCP policy through channels of improving the city's innovation level and promoting industrial upgrading[3]. On the whole, low-carbon cities construction itself helps to the realization of "win-win" between ecological conservation and economic development.

The rapid growth of import and export trade is a double-edged sword. It is more than drives the rapid growth in China, it also intensifies the environmental degradation. Cutcu et al. (2023)[4] used the 10 fastest-growing countries as a sample to verify the strong negative correlation between foreign trade and ecological foundation. Yu and Li(2021)[5] utilized the data from China’s 30 provinces to examine that tightening environmental supervision measures can raise the quality of foreign direct investment and thus contributed to the swift development of foreign trade. At present, there are two interrelated hypotheses in the academic study on the linkage between environmental protection policy and foreign trade—"Porter hypothesis" and "race-to-the-bottom hypothesis".

Based on the "Porter hypothesis", the government should adopt an active environmental protection policy, because an appropriate and reasonable environmental protection policy can induce enterprises to carry out technological innovation, and its innovation revenue generated in the process can offset or even exceed environmental protection costs. The technological innovation generated will directly or indirectly improve the product quality. According to the "Porter Hypothesis", for one thing, the LCCP policy can encourage businesses to improve their production processes, improve their production efficiency, and significantly reduce production costs, so that exporting enterprises can obtain cost advantages, which will encourage them to choose to expand the scale of exports, thus generating revenue effects to improve the quality of export product [6]. For another, reasonable design of environmental regulations can enable enterprises to engage in environment-friendly technological innovation, significantly improve the enterprise's green innovation ability and green resource allocation ability [7], advance the export quality of companies.

Based on the "race-to-the-bottom" hypothesis of environmental regulation, in the context of trade liberalization, local governments strive to loosen environmental regulation and competitively decrease environmental standard in order to maintain rapid economic growth in their regions. For one thing, environmental regulation will make it more expensive for businesses to prevent and control pollution, while also increasing their investment in green resources.This will impede their ability to develop, which will make it more difficult to produce high-quality export products. Deng(2021)[8] discovered a negative correlation between the quality of exported products and the achievement of environmental protection target. For another, environmental regulation's incentive impact on innovation lags somewhat, which hinders technological innovation in the current terms and promotes innovation in the lag phase[9]. The majority of companies will passively respond to government regulations in a short period of time and reduce innovation dynamics.

The marginal contribution of this research is as follows: 1)Using prefecture-level cities as the study object, the study establishes the connection channel of the influence of LCCP policies on the export products' quality from the city level, which can better reflect the differences between different regions when this policy is implemented. 2) This paper constructs counterfactual analysis under the quasi-natural experimental environment, effectively corrects the sample selection bias, comprehensively analyzes the effect of LCCP policies on the quality of urban export products, and empirically tests the existence of green innovation mechanism. 3) In the practical sense, it is helpful to offer new policy ideas for China's import and export trade and supply a scientific foundation on which to improve its environmental policies.

The structure of the remaining part is as follows: the second part is literature review and analysis of the theoretical mechanism of the impact of LCCP on the quality of urban export products. the third part is the specific research design. The fourth part is the empirical results, including benchmark regression, parallel trend test, robustness test, etc. The fifth part analyzes the heterogeneity and influencing mechanism of the LCCP polices on the urban export quality. The last part, according to the research conclusions put forward the policy proposal.

2. Literature review and research hypothesis

2.1 Environmental regulation and the quality of urban export products

Environmental regulation can stimulate the technological innovation of enterprises, improve the productivity level of businesses, save the input of resource elements and offset the production cost, which is helpful to promote the realization of the positive association between environmental control and exports trade. Environmental regulations will add the environmental costs of firm, and urge firms to "absorb" the impact of this cost impact by adjusting the product quality and price, for example, by making differentiated product quality, which indirectly promotes the product transformation within businesses and the entering and exiting of businesses within the industry, and improves resource allocation efficiency, thus promoting the upgrading of the city's overall product quality[10]. The energy-conservation and low-carbon measures have significantly improved the export performance

of firms, including expansion of export scale and upgrading of export product quality[11]. The policy of "two control zones" has improved the quality of China's export products, indicating that environmental regulation is beneficial to improving the international competitiveness of China's export products [12].

Numerous studies have shown that the impact of environmental regulations on the quality upgrading of China's export products is "U" shaped. Under the restriction of environmental regulation, technology introduction can greatly contributes to the upgrading of export quality, while independent research and development acts as a disincentive[13]. There are significant industry differences in the impact of environmental regulations on the quality upgrading of Chinese enterprises' export products, with am inverted "U" shape in the pollution-intensive industry and a "U" shape in the cleaning industry [14].

As the specific implementation and development of LCCP policies differ greatly in cities, and because the regional characteristics, factor endowments, and R&D investment of different regions all affect the quality of local export goods, further discussion is necessary.There are obvious differences between the economic growth of eastern coastal cities and inland cities and the decoupling effect of environmental pollution. On one side, researches have shown that the export trade of inland cities and node cities is more significantly impacted by the opening of Banlieh in Central Europe[15]. On the whole, under the influence of many trade policies and environmental policies in the 21st century, export products quality in the eastern coastal regions did not show a comparative advantage, but was lower than that in the middle and western inland areas. On the other side, environmental regulations play a critical part in boosting the high-quality development of the entire eastern coastal cities, and also promotes the innovation of the less developed coastal areas in the west, which confirms the applicability of the Porter Hypothesis in coastal areas of developing countries. As coastal areas gradually turn to regional coordinated development, they can enjoy more digital economic dividends than inland provinces and can better boost the high-quality development of export trade[16].

Based on this, this study puts forward the following hypothesis :

H1: The LCCP policy helps to raise the caliber of urban export goods.

H2: The export quality of coastal areas may benefit more from the LCCP policy's implementation than inland locations, but it might be otherwise.

2.2 Moderating effect of LCCP policy: green innovation level and quality of urban export products

Green innovation is an important engine to drive the innovation and development of foreign trade and to construct a new development pattern with both domestic and international cycles [17].

China's export products are facing more and more green barriers. Due to strict environmental standards in importing countries, many categories of products have been weakened. And improving green production technology, improving the technical level of environmental protection industries and promoting the smooth transformation of green technological achievements can effectively eliminate green barriers [18], thus improving the quality of China's import and export commodities. Zhang(2022)[19] empirically explores the positive relationship between green innovation and export quality by using relevant data of export enterprises in China.

Environmental regulation realizes the win-win development of regional green economy and environmental protection through GTFP. Moderate environmental policies can provide continuous incentives for technological innovation and efficiency improvement of heavily polluting industries, and thus encourage an increase in total factor productivity for the green industry[20]. Environmental regulation can affect the transformation of China's industrial development mode by acting on GTFP, thus realizing a win-win situation of industrial intensive development and green development[21]. The LCCP policy is to promote regional green economic growth through green technology changes, and the green growth effect of eastern and western cities is more significant [22].

A U-shaped relationship exists between regional industrial structural upgrading and environmental supervision.Only by crossing the threshold of environmental regulation can we promote the benign

adjustment of industrial structure [23]. According to the LCCP policy, the local government should enhance its investment in policy research and development funds and give innovation subsidies to those businesses that have the capacity to innovate. And, when technology upgrading to reduce pollutant emissions, enterprises have also significantly increased the number of green patents[24].

From this, this study puts forth the hypothesis H3: a higher level of green innovation can enhance the promoting effect of LCCP policies on the quality of urban export products.

3. Research and design

3.1 Construction of measurement model

The LCCP policy, which began in 2011, is an external policy effect on the quality of export products, so it can be regarded as a quasi-natural experiment in environmental policies. In July 2010, the NDRC issued a notice that the first batch of 72 cities officially launched LCCP work. Subsequently, in November 2012, the second batch of low-carbon pilot notice was released, identifying a total of 29 low-carbon pilot areas and starting to put them into practice in 2013. In January 2017, the third batch of low-carbon pilot list was announced, 45 cities were selected according to relevant documents.

Because green policy implementation takes some time to take impact, it might not have a noticeable impact on the quality of urban export goods in a short time. The first two batches of cities chosen for the pilot scope serve as the experimental group in this study, while other cities serve as the control group. Furthermore, considering that there are four cities in the roster of low-carbon regions in the second batch whose provinces have been approved as pilot areas before, this paper regards the time when these four cities were first identified as pilot cities as their pilot time.

This paper adopts multi-period DID model and controls the fixed effects of year and provinces. The specific measurement model is as follows:

$$quality_{it} = \beta_0 + \beta_1 treatpost_{it} + \beta_2 X_{it} + \mu_t + \mu_j + \epsilon_{it} \quad (1)$$

where i represents the city, j represents the province, t represents the year, and $\mathrm{quality_{it}}$ represents the quality of city i's export product during the year t.Treat is the dummy variable of the processing group, if the city is among the first and second batch of low-carbon pilot cities, the value is 1; otherwise, it is 0. Post is the virtual variable of time, if city i has implemented LCCP policy in year t, the value is 1; otherwise, it is 0. The start time of LCCP in different batches of pilot is different.X_{it} is a set of control variables, μ_t is year fixed effects, μ_j is province of fixed effects, ϵ_{it} is then interference item.

3.2 Control variable

To enhance the effectiveness of the empirical analysis findings, this study chooses the following data that may influence urban export products' quality as the control factors: 1）Per capita GDP(pgdp) represents the index of regional economic development level. 2）The amount of foreign capital actually utilized by a city (fdi) reflects the degree of opening up of a city. 3）Urban per capita road area (road) represents the level of basic implementation. 4）The level of regional investment in scientific research and education(edu) is indicated by the ratio of regional science and education expenditure to government expenditure. 5）Urbanization level(urban) is expressed as the proportion of permanent urban population to the permanent population of the whole city by year-end. 6）The proportion of ordinary college and above population in the city's resident population (human). 7）The percentage of fixed assets investments in the city's GDP (assets). In this study, all nominal variables are treated as year 2000-based period, while the pgdp and the fdi of regions with larger dimensions are treated as logarithm.

3.3 Data description

This paper aligns the product-level data released by the General Administration of Customs of China with the international version of HS96' s six-digit code for reference Wang(2014)[25] method identifies each pair of data for five variables such as the customs clearance of enterprises to obtain product data at the city level. Finally, Shi (2014)'s[26] methodologies are used to further process the customs data to calculate the quality of urban export products.

The sample does not include Hong Kong, Macao and Taiwan and the cities with changed administrative levels during this period. The pertinent statistics are mostly from official statistical data such as China City Construction Statistical Yearbook. The average of the published cities in a province is used to replace some cities' unpublished incomplete data, and the article uses the interpolation method to fill in some missing data. The descriptive statistics of each variable are shown in Table 1.

Table 1 Descriptive statistical results

Variable	Observations	Mean	Std.Dev.	Min	Max
$treatpost$	2,420	0.146	0.353	0	1
$lnpgdp$	2,420	10.29	0.645	8.590	11.86
$lnfdi$	2,420	10.02	1.562	4.174	13.71
$assets$	2,420	0.681	0.239	0.219	1.644
$human$	2,420	1.532	1.740	0.054	9.472
$urban$	2,420	0.505	0.139	0.200	0.936
$road$	2,420	14.79	5.905	3.970	33.62
edu	2,420	0.195	0.0465	0.0881	0.297
$quality$	2,420	0.743	0.0676	0.393	0.965

4.Empirical results and analysis

4.1 Benchmark model regression results

Columns (1) and (2) in the table 2 show the results of bidirectional fixed effects without or with control variables, respectively. It can be seen that regardless matter whether control variables are added, the estimation coefficients of the explanatory variable in this article are significantly positive, and the marginal contribution of LCCP policy to the promotion of urban export product quality is 1.1%.In light of the remarkable differences in economic strength and population size between the four municipalities and other prefecture-level cities. This article regressed using sub samples after excluding four municipalities, summarizing the regression results findings in column (4) of Table 2. We can conclude that there has been no appreciable change in the size of the explanatory variable's coefficient and it is still statistically significant at 10% level.

Therefore, hypothesis 1 of this article has been certified.

Table 2 Benchmark regression results

	Full sample		Excluding municipalities	
	（1）	（2）	（3）	（4）
treatpost	0.012*	0.011*	0.012*	0.011*
	(1.90)	(1.83)	(1.89)	(1.79)
lnpgdp		0.011		0.011
		(1.46)		(1.42)
lnfdi		0.007***		0.007***
		(2.95)		(2.83)
edu		0.062		0.063
		(0.96)		(0.95)
road		-0.000		-0.000
		(-0.43)		(-0.44)
human		0.000		0.000
		(0.01)		(0.01)
urban		-0.024		-0.024
		(-0.98)		(-0.98)
assets		-0.025**		-0.025**
		(-2.03)		(-2.04)
_cons	0.741***	0.582***	0.741***	0.582***
	(255.48)	(8.10)	(253.72)	(8.09)
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	2419	2419	2401	2401
R^2	0.182	0.212	0.180	0.210

Notes: *, * *, * * * are significant at 10%, 5% and 1% respectively; The values in brackets are standard errors. The same below.

4.2 Parallel trend test

The parallel trend test is a prerequisite for using DID approach. The net effect of policy can be calculated only through a parallel trend test. Thereout, this study is informed by Song et al.'s (2019)[2] methodology, applies the event study to the parallel trend of the export product' quality of each city in the year of the policy shock and before that year, and analyzes the dynamic effect of this policy. The method can be expressed as follows:

$$quality_{it} = \alpha_0 + \sum_{k\geq -5}^{5} D_{it}\alpha_k + \mu_t + \mu_i + \epsilon_{it} \qquad (2)$$

Among them,D_{it} is a time dummy variables, taking a value of 1 if city i is a low-carbon pilot city in year t, and 0 otherwise. The following variables have the same symbolic meaning as the symbol in equation (1). The coefficient α_k illustrates how the LCCP policies affect the caliber of export products.

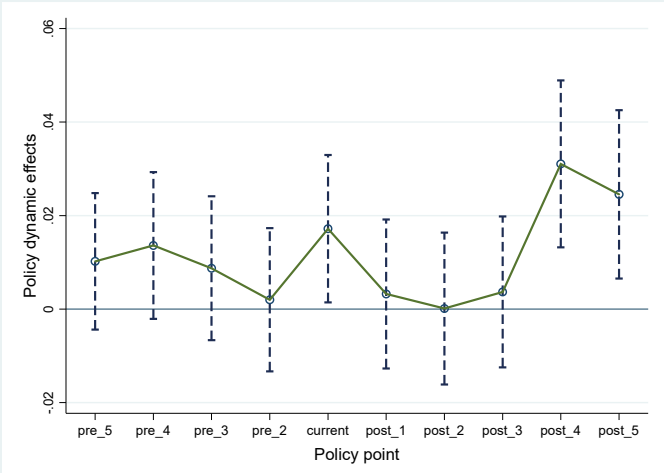

Figure 1 Parallel trend test

The results of the parallel trend test in Figure 1 show that the coefficient estimates of the time virtual variables in each period before the implementation of the LCCP policy are small and insignificant. This manifests that before the policy's adoption, there was no discernible difference in the quality of export goods between low-carbon pilot and non-pilot cities, proving that the experimental group and the control group were in line with the parallel trend hypothesis. From the perspective of dynamic effect, the regression parameter is not significant in the first three years after the policy was implemented, but significant in the fourth and fifth years, manifesting that the LCCP policy's influence on the quality of urban export products is lagging in the short term, reflecting that the LCCP policy has a long-term impact on the enhancement of the quality of export product.

4.3 Placebo test

To avoid the impact of unobservable factors on the estimation of the effectiveness of the PCCL policies, a treatment group will be established at random in order to conduct a placebo test in this paper. After randomly generating a set of LCCP lists, substituting them into the original benchmark model, extracting the coefficients of the error variable treatpost, and repeating the above process 500 times for model estimation, the results are shown in Figure 2. It can be observed that the unobservable factors have not impact on the estimation result because the regression coefficients are clustered around 0 and obey the normal distribution. Therefore, it is not by chance that the LCCP policy promotes the upgrading of export product quality.

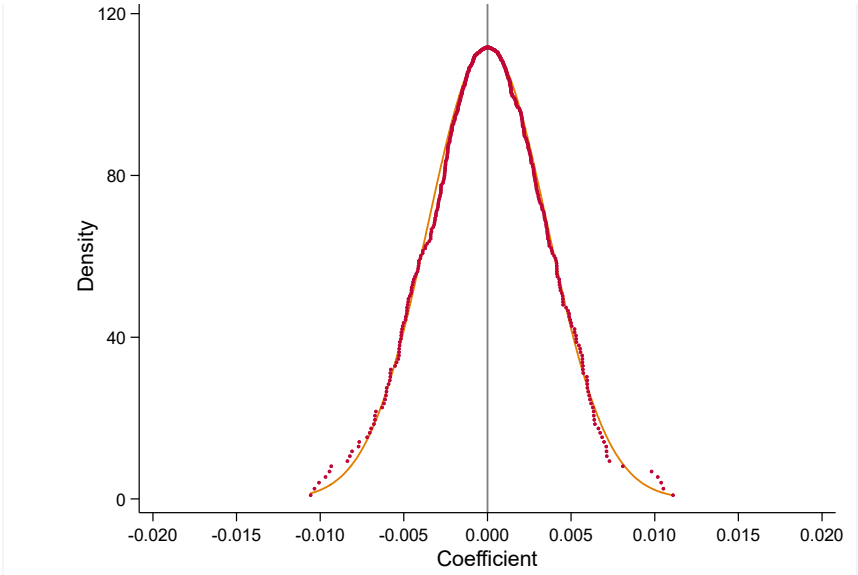

Figure 2 Placebo test

4.4 Robustness test

4.4.1 PSM-DID test

In order to avoid endogeneity issues caused by sample selection bias when evaluating the effectiveness of LCCP policies. In this research, the propensity score matching approach is employed to verify the robustness of the conclusion. The matching variable is the control variable in formula (1). The Logit model is used to calculate the probability of cities being selected as pilot cities. One-to-one neighbor matching approach is used to match the selected cities year by year, and the unmatched sample data are deleted. The benchmark model is re-estimated from the matched data.The coefficient estimates of the core explanatory variable treatpost is significantly positive, and the result is shown in column (2) of the table below, which is basically consistent with the benchmark regression result. It follows then that this research results are still robust after taking the sample selection bias into consideration.

Table 3 Results of robustness test

	(1) Benchmark regression	(2) PSM-DID regression	(3) Exclude others policy interference	(4) 2010-2016
treatpost	0.011*	0.017**	0.018**	0.029***
	(1.83)	(2.27)	(0.008)	（0.009）
_cons	0.581***	0.596***	0.581***	0.686***
	(8.38)	(6.22)	(0.090)	（0.108）
innocity			0.002	
			(0.015)	
Control	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	2419	2325	2323	1464
R^2	0.082	0.320	0.320	0.419

4.4.2 Exclude other policy interference

The process of assessing the impact of LCCP construction on the quality of urban export products will be interfered with by other city-level policy influences within this time period.Therefore, this paper pays special attention to the innovative city pilot policy implemented since 2008, and adds innocity, the cross term of the virtual variable of the relevant policy with the virtual variable of time and province, into the regression equation, so as to control the influence of the policy on the estimated results.The results are reported in column (3) of Table 3. The coefficient of treatpost, the core variable, are relatively similar to the results of the benchmark regression, while the coefficients of innocity is small and statistically insignificant can be analyzed, demonstrating that the innovative city policy has not caused any error in the estimation results.

4.4.3 Shorten the sample period

Taking into account the significant effects of the 2008 worldwide financial crisis on the global economy, this paper draws on the practice of Yuan [27] to shorten the research span to 2010-2016.After re-estimating the benchmark model, the results suggest that the estimated coefficient is still significantly positive, which further demonstrates the reliability of the conclusions in this study.

5. further analysis

5.1 Heterogeneity test based on geographical location

Influenced by a series of factors such as transportation cost and economic development level, geographical location is also an important factor affecting import and export trade [28]. This paper classifies cities into coastal cities and inland cities on the basis of their geographical location, and observing the Table 4, we find that the LCCP policies has a positive influence upon the advancement of the inland cities' export products quality, and it is significant at the level of 5%. The possible reason for the above conclusion is that in the past several years, the government has put in place a variety of supportive policies in inland areas, such as revitalizing the development of the northeast and the west, which has greatly activated the local economic potential. The green innovation incentive effect and digital technology innovation brought by the LCCP policies can also play a better role.

Table 4 Analysis results of geographical location heterogeneity

	(1) Coastal areas	(2) Inland regions
$treatpost$	0.005	0.019**
	(0.29)	(2.15)
$\_cons$	1.244***	0.505***
	（3.09）	（4.62）
Control	Yes	Yes
Province FE	Yes	Yes
Year FE	Yes	Yes
N	396	1929
R^2	0.524	0.315

5.2 Regulating effect of green innovation

The most direct indicator to measure the output of technological innovation activities is the quantity of patents. This research refers to the method of Qi et al. (2018)[29] and selects the proportion of urban green utility model patent application authorization volume in the total patent application authorization volume of the city as the green innovation level with green to represent. On the basis of equation (1), the interaction between green innovation level and LCCP policy is introduced, and the interaction panel model is built to investigate the moderating impact of green innovation level on the policy effect of the pilot policy. The regression results reported in Table 5 show that the regression coefficient of cross-product term treatpost×green is significantly positive at the level of 5%, and R^2 increased from 0.212 to 0.314, thus the goodness of fit has been improved obviously. This demonstrate that the green innovation has a significant positive moderating effect on the original policy impact. Suppose H3 holds.

Table 5 Impact mechanism test: green innovation

variable	Green innovation
treatpost × green	0.160**
	(2.20)
_cons	0.596***
	(5.93)
Control	Yes
Province FE	Yes
Year FE	Yes
N	2325
R^2	0.314

The reason for the above conclusion may be that green innovation shows "technology dividend" effect, and the development of green technology improves firms' green competitiveness and enhances motivation of quality innovation. The willingness of enterprises to carry out sustainable development and the LCCP policy form overlapping advantages, which can also effectively promote the industrialization of environmental protection technology and promote the modernization of industrial structure achieve an increase in product quality.

6. Conclusions and recommendations

This research employs a multi-period DID model to investigate the impact of the LCCP policies on the quality of urban export products, using panel data from 2005 to 2016. The results show that: The LCCP policies can significantly improve the quality of export products of cities, which strongly supports the "Porter hypothesis". After conducting a variety of robustness tests, including parallel trend test, placebo test, shortening sample period and excluding other policies, the conclusion remains

valid. Heterogeneity analysis shows that the promotion effect was more significant in inland cities. Our finding confirms that the LCCP policies mainly improves the quality of urban export products by improving the city's green innovation level.

The policy recommendations proposed in this article are as follows: Above all, the LCCP policies have a significant positive impact on the quality of urban export product. This shows that the LCCP policy, an environmental governance policy, effectively promotes the coordinated development of economic construction and ecological civilization construction. Each pilot area ought to fully consider its own market and industrial characteristics, formulate practical plans according to local conditions, such as establishing differentiated carbon emission reduction evaluation mechanism and high-quality suggestions for subsequent other environmental regulations.

Secondly, in the process of policy follow-up, cities should be designed with different policy combinations according to different geographical locations. For coastal cities, local governments and enterprises should set high standards for product quality, pay attention to the advantages of regional endowments, and constantly enhance the international competitiveness of export products, thus better lead the China's manufacturing export trade flourished.

Finally, in terms of policy design, we should focus on improving the green innovation, such as increasing subsidies after scientific and technological research and development, implementing preferential tax policies for enterprises that develop and use patented technologies for environmental protection, and accelerating enhancing and upgrading of the green industrial structure accelerated.

In a word, the only way for China's sustainable economic development in the future is to explore reasonable and appropriate means of environmental regulation and promote green technological innovation.

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