280 kWh energy saving and emission reduction

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The research on carbon emission reduction is relatively rich. This study establishes a framework for further study. Considering the variations in research contents and perspectives, there is still some research space. This study empirically investigated the effects of establishing NHTDZs on CO2 emissions in China, using a multitemporal asymptotic difference approach. This demonstrates that the establishment of NHTDZs clearly reduces CO2 emissions about 2.53% after controlling influence factors. This indicates that NHTDZs achieve the goal of decreasing CO2 emissions.

The rest of the paper is organized as follows: part two provides the policy background and theoretical analysis; part three presents the research data and econometric modeling setup; part four reports the empirical results and robustness tests; part five conducts the mechanism test; part six conducts the heterogeneity analysis; and part seven presents the conclusions and policy recommendations.

After that, in 1991 and 1992, the State Council approved the construction of 51 NHTDZs in two stages, which formed the preliminary scale of construction of NHTDZs. After 2007, the State Council approved the construction of new NHTDZs at different stages. Especially after 2012, the speed of construction of NHTDZs further accelerated. By the end of 2022, the number of NHTDZs will reach 173. The time of establishment are shown in Fig. 1.

Number of NHTDZs number.

For example, Xiamen Torch NHTDZ focuses on the development of strategic emerging industries; Jining NHTDZ focuses on the allocation of human resources and innovation platform resources; and Suzhou NHTDZ focuses on incubating environmentally friendly innovative enterprises.

During this period, NHTDZs achieved significant results in terms of innovation, talent introduction, and the transformation of scientific and technological fruits. Figures2, 3, 4 present the NHTDZs in terms of innovation, talent accumulation and R& D expenditures.

In view of this, the authors used the establishment of NHTDZs as a natural experiment and selected samples collected between 2003 and 2019 to explore carbon emission reduction effects. After 2019, due to the new coronavirus epidemic, restrictions on economic activity and production resulted in reduced CO2

emissions50,51,52, which need to be excluded from this shock.

NHTDZs, as entrepreneurial highlands, talent highlands and science technology bases, are important for China"s strategic development. Its core competitiveness is innovation capacity. NHTDZs can improve the environment by combining human capital with innovation53, reducing carbon emissions54. Human capital has a positive moderating effect on the environmental impact of green innovation53.

Human capital stimulates society"s willingness to use energy saving and environmental technologies. It increases individual productivity to achieve emission reductions55. The improvement in China"s human capital is largely attributable to increased educational attainment56. The education level of practitioners in China"s NHTDZs is international first-class and team structure is constantly optimized (see Fig. 4). NHTDZs drive regional transformation and upgrading through the improvement of the human capital structure and industrial structure from labor-intensive and low-value-added industries to capital-intensive and high-value-added industries, realizing green development.

NHTDZs have attracted ample HNTEs and innovative talent through preferential policies. Through financial incentives, loan interest subsidies, project grants, the transfer of rights and interests and risk compensation, NHTDZs are growing quickly. For example, the Changsha NHTDZ arranges 500 million yuan annually as a science technology innovation and industrial development fund. In addition, government subsidies are considered labels that increase companies" recognition of capital markets, and enterprises will go further into green development planning57. The following hypothesis is proposed.

H1: The establishment of NHTDZs can reduce CO2 emissions.