Volume 5, Issue 11, pp. 56-58, 2021.
International Journal of Scientific Engineering and Science
ISSN (Online): 2456-7361

Research on the Impact of Low-Carbon Technology Innovation on Electricity Intensity

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***Abstract*— *This paper selects the relevant data of 13 prefecture-level cities in Jiangsu Province from 2002 to 2018, and the impact of low-carbon technology innovation on industrial electricity consumption under different spatial linkage intensity is measured by the entropy method with the calculation of traffic linkage intensity, economic linkage intensity and information linkage intensity between each city and the surrounding cities incorporated into the system two-stage GMM model. The results of the study found that low-carbon technology innovation has a significant negative effect on industrial electricity intensity, and its impact on power intensity is different under different urban spatial linkages.*

***Keywords*— *Low-carbon technological innovation; electricity intensity; spatial relationship; SGMM.*

I. INTRODUCTION

China puts forward the concept of green and coordinated development, and the urbanization process in Jiangsu Province has entered a period of rapid development, and is facing increasingly prominent problems such as energy consumption and environmental degradation. Relying on low-carbon technology innovation to develop low-pollution, scientific and rational urban planning is imminent. Electricity intensity, that is, electricity consumption of the whole society divided by GDP, is an important indicator reflecting economic development and energy consumption. In Jiangsu province, industrial electricity consumption accounts for about 80% of the total social electricity consumption, and the proportion of industrial electricity consumption will directly affect the overall goal of low-carbon development. Based on this, the study of the role of low-carbon innovative technologies in the industrial sector electricity consumption is useful for analyzing the current characteristics of the role of low-carbon technological innovation and providing corresponding policies for the government.

II. LITERATURE REVIEW

Making full use of innovation capabilities and enterprise transformation capabilities to strive for the first breakthrough in low-carbon technologies is considered a must for achieving a Chinese-style low-carbon path (Hua 2011). Electricity has become an important foundation for urban development (Yao et al. 2017), and its strategic importance in promoting the transformation and upgrading of China's energy structure and leapfrogging development to achieve the goal of being an energy powerhouse. Relying on low-carbon technology innovation to develop low-pollution, scientific and reasonable urban planning is imminent. Shang Juan,Wang Zhuo et al. (2018) explored technological innovation and new urbanization in Shaanxi Province as a research subject. It was found that the urbanization process is transforming from an economy-centered to a people-centered direction, and science and technology is a powerful driving force of this process (Shang et al. 2018). From the current domestic research results, the research related to low-carbon technology industry in the power industry itself is still relatively lacking. Scholars have mainly elaborated on three aspects of low-carbon development theory, low-carbon innovative industrial structure and how to use technological innovation to achieve low-carbon development (Alexander et al. 2016). Lu Fengxian and Wang Xi et al. (2012) started from the theoretical basis of low-carbon development research and argued that the focus of low-carbon economic theory lies in strengthening low-carbon technological innovation and institutional innovation, emphasizing energy conservation and emission reduction (Lu et al. 2012). Zhao, Bo and Bi, Kexin (2016) analyzed the dynamic evolution of low-carbon breakthrough innovation in China's manufacturing industry from the perspective of patent measurement and concluded that low-carbon breakthrough innovation in China's manufacturing industry is concentrated in a few industries with high carbon emissions and high fossil energy consumption, and the constraint mechanism of low-carbon breakthrough innovation in such industries should be enhanced, and certain inclination should be provided in both policy and funding (Zhao and Bi 2016). Li Wei and Xi Yongqin (2017) studied under the dual perspective of foundation heterogeneity and environmental regulation and found that the foundation heterogeneity of low-carbon development in various regions significantly affects the innovation capabilities and the innovation industry structure to promote low-carbon development. Development advantage, that is, the worse the development foundation, the more significant the role of innovation in promoting low-carbon development (Li and Xi 2017).

III. METHOD

In this paper, the following model is constructed to test the extent of the impact of low-carbon technologies on electricity intensity, as expressed in Equation 1.

$$\begin{cases} IEI_{it} = b_0 + b_1 BTI_{it} + b_2 US_{it} + b_3 SI_{it} + b_4 TI_{it} + b_5 OD_{it} + m_i + a_t + e_{it} \\ NEI_{it} = b_0 + b_1 BTI_{it} + b_2 US_{it} + b_3 SI_{it} + b_4 TI_{it} + b_5 OD_{it} + m_i + a_t + e_{it} \end{cases} \quad (1)$$

In Equation 1, the subscript i represents the city, and t represents the year. IEI_{it} represents the logarithm of the city's industrial electricity intensity. BTI_{it} represents low-carbon technological innovation. US_{it} is the year-end city population, used to express the size of the city. SI_{it} indicates the proportion

IJSES

International Journal of Scientific Engineering and Science

Volume 5, Issue 11, pp. 56-58, 2021. ISSN (Online): 2456-7361

of the city's secondary industry in GDP, TI_{it} indicates the proportion of tertiary industry in GDP, SI_{it} and TI_{it} are used together to reflect the industrial structure of the city. OD_{it} is the degree of openness to the outside world, measured by the proportion of import and export trade in GDP. m_i represents all other fixed effects that are not included in the model but may still have related effects on the explained variable. a_t represents the time effect, e_{it} is the error term of white noise. In this paper, in order to control and reduce the endogeneity problem of the model, it is expanded to a dynamic model by introducing a lagged term of the dependent variable, which makes the model a typical dynamic panel model. In order to understand the effect of increasing the independent variable by one unit on the percentage of the dependent variable, the dependent variable is logarithmically treated in this paper. The specific model is shown in Equation 2.

$$\begin{cases} \log IEI_{it} = b_0 + r\log IEI_{i,t-1} + b_1 BTI_{it} + b_2 US_{it} + b_3 SI_{it} + b_4 TI_{it} + b_5 OD_{it} \\ \qquad + c_1 eco_{it} + c_2 traf + c_3 inf + m_i + a_t + e_{it} \\ \log NEI_{it} = b_0 + r\log NEI_{i,t-1} + b_1 BTI_{it} + b_2 US_{it} + b_3 SI_{it} + b_4 TI_{it} + b_5 OD_{it} \\ \qquad + c_1 eco_{it} + c_2 traf + c_3 inf + m_i + a_t + e_{it} \end{cases} \quad (2)$$

In Equation 2, the meaning of ecoit represents the total intensity of economic linkage in province *i* in year *t*; the meaning of trafit represents the total intensity of traffic linkage in province *i* in year *t*; and infit represents the intensity of information linkage in province *i* in year *t*. The remaining variables are the same as above.

IV. RESULTS

The empirical results of the model are shown in Table 1. Column (1) of Table 1 shows the panel regression results of the mixed OLS with control variables, and the core explanatory variable BTI coefficient is significantly negative, indicating that low carbon technology innovation has a significant effect on reducing electricity intensity. Column (2) shows the results of the fixed effects regression, where the coefficients of the core explanatory variables remain negative after controlling for the fixed effects of cities. Column (3) shows the regression results of the system GMM with a positive coefficient on the lagged term logIEI and a negative coefficient on the core explanatory variable BTI.

TABLE 1. Empirical results of low-carbon technology innovation and industrial electricity intensity

Explanatory variable	**(1) Pool OLS**	**(2) FE**	**(3) SGMM**
L.logIEI			0.735*** [0.1321]
BTI	-0.000421** [0.0002]	-0.000424* [0.0002]	-0.00109* [0.0008]
Control variable	yes	yes	yes
eco	-0.00000013 [0.0000]	-0.00000013 [0.0000]	9.37e-08 [0.0000]
traf	3.50e-09* [0.0000]	3.53e-09* [0.0000]	1.25e-09 [0.0000]
Inf	-0.000169 [0.0011]	-0.000164 [0.0011]	0.00150 [0.0015]
cons	-2.612*** [0.2209]	-2.615*** [0.1150]	-1.810*** [0.6531]

The reliability of the results must be enhanced by testing the soundness of the model setup and the validity of the instrumental variables in systematic GMM estimation. In particular, the p value of the AR(2) test result is 0.710, indicating that the original hypothesis cannot be rejected at the 10% level of significance, that is, there is no second-order serial correlation in the residual terms after the difference. The results of the Hansen Test for over-identification indicate the use of appropriate instrumental variables, that is, the model is reasonable.

V. CONCLUSIONS AND SUGGESTIONS

Main Research Conclusions

This paper concludes that the study finds that there is indeed a negative relationship between the city's low-carbon technology innovation and industrial electricity intensity, and its effect on electricity intensity is different under different inter-city spatial linkages. The overall effect of the model is better after adding three spatial linkage factors, namely, economic factor, transportation factor and information factor, and the negative effect of electricity intensity in the lagged period on electricity intensity in the current period is significantly higher.

Policy Suggestion

Firstly, government enterprises can develop differentiated low-carbon technology innovation policies in line with the different characteristics of each industry. Secondly, make full use of the economies of scale brought about by urban linkages and factor clustering to reduce urban electricity intensity. Thirdly, from the current development of low-carbon technology, nuclear energy, wind energy and other industries, it seems that the research of hydropower and solar energy can become the focus of future research on low-carbon electricity technology.

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project of Jiangsu University (No.: J20CC0062).