

The Impact of FDI and R&D Input on China's Energy Intensity - Based on Empirical Study of Provinces Along the Belt and Road

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ABSTRACT

Since the Belt and Road Initiative was proposed and implemented in 2013, China's economic scale and growth rate rank among the top in the world, and foreign-invested enterprises have become an important engine to promote China's high-quality economic development. How to effectively utilize foreign investment to reduce China's energy intensity is crucial to sustainable and stable economic development. Based on the panel data of 17 provinces along the "Belt and Road" in China from 2011 to 2020, this paper established a fixed-effect model to investigate the influence of foreign investment utilization level on energy intensity. The results show that foreign direct investment, regional economic development level and research and development intensity have a significant effect on the decline of energy intensity. Factors such as industrial structure and energy structure will cause the increase of energy intensity. The results of subregional regression show that FDI inflow helps to reduce the energy intensity of the eastern and central regions, and the effect of the eastern region is better than that of the central region, but the energy intensity of the western region will increase. Based on the above, suggestions are put forward to rationally guide the inflow of foreign capital in different regions, increase the research and development of energy-saving technologies, accelerate the transformation and upgrading of industrial structure, and optimize the structure of energy consumption, in order to improve the utilization rate of energy in our country.

KEYWORDS

Foreign direct investment; Energy intensity; Provinces along the Belt and Road; Fixed effect model

1. INTRODUCTION

2023 marks the tenth year of the implementation of the Belt and Road Initiative. In the past decade, China has made remarkable achievements in the size and growth rate of its economy, becoming one of the major forces leading development on a global scale. In this context, China's level of attracting foreign investment has continued to improve, international investment cooperation has been strengthened, and China has become a major foreign investment destination in the world. By the end of 2021, China's actually utilized foreign direct investment amounted to 877.56 billion yuan, and foreign investment has exerted an important impact on China's economic and social development. However, China also faces the challenge of being one of the world's biggest polluters. In recent years, China's economic development has entered a new normal, and the quality of economic development has become more important. As a strategic resource to drive China's economic development, energy demand has been increasing in the past decade, leading to the depletion of fossil fuels and the aggravation of energy dependence. Therefore, how to effectively solve the energy problem has become the focus of the Chinese government and society. Internationally, China pledged at the 2015 Paris Conference that it will make non-fossil energy account for about 20% of primary energy

consumption by 2030. In the country, the National Development and Reform Commission and the National Energy Administration issued a notice on March 22, 2022, on the "14th Five-Year Plan" Modern Energy System Planning, clarifying the deployment of high-quality energy development during the "14th Five-Year Plan" period. These deployments include enhancing the security and stability of the energy supply chain, strengthening capacity building for independent energy supply, and aiming to increase the share of non-fossil energy generation to about 39% by 2025. This provides a clear direction and action guide for the high-quality development of energy in the coming period [9].

Therefore, under the premise of ensuring sustained and good economic growth, how to continuously reduce the dependence on traditional fossil energy and promote the improvement of energy efficiency has become the key to solving the current energy problem in China. At the same time, under the basic national policy of adhering to the opening up, the relationship between the introduction of foreign capital and energy utilization efficiency is coordinated, and the correct use of research and development investment to improve relevant technologies to improve energy efficiency is also an important entry point for China to solve energy problems. In this paper, the provinces along the "Belt and Road" in China are taken as the research object, and the influence of FDI on energy efficiency in China is tested by establishing a fixed-effect model, and the three regions in the east, middle and west are investigated specifically. Finally, summarize the test results and put forward the countermeasures and suggestions for improving energy efficiency.

2. LITERATURE REVIEW

As an important form to undertake international technology transfer and diffusion, foreign direct investment (FDI) has a significant impact on energy use efficiency. Views on the relationship between FDI and energy use efficiency mainly include:

- (1) The "pollution halo" hypothesis, which holds that enterprises can use foreign advanced technologies to improve local energy use efficiency, that is, FDI has technology spillover effect;
- (2) The "pollution paradise" hypothesis holds that the relatively loose environmental policies of the host country will attract a large number of industries with high energy consumption and high pollution to migrate to the host country through FDI, increasing the environmental pressure of the host country.

The influence mechanism of foreign direct investment (FDI) on energy efficiency has been widely studied, mainly including the following two viewpoints. The first is the "positivity" of FDI, that is, FDI technology spillover has a positive effect on improving energy utilization efficiency. Mielnika and Goldemberg (2002) found in their research that with the increase of foreign direct investment (FDI) in the sample of developing countries, energy use efficiency was significantly improved, which was mainly due to the effect of technology diffusion brought about by FDI [1]. Perkins et al. (2008) argued that foreign direct investment (FDI) not only brought cutting-edge technology and efficient management concepts, but also introduced environmentally friendly and energy-saving production technologies. This technology diffusion effect helps to improve production efficiency, reduce resource waste, and improve energy efficiency [2]. The research of Zhu Tong et al. (2010) further explains that FDI plays a positive role in disseminating advanced technologies, especially in the industrial field, and thus has a positive impact on energy efficiency [10]. Zhang Yu et al. (2013), based on the motivation of technological innovation of transnational corporations, believe that FDI carries more advanced technologies, and enterprises can make use of foreign advanced technologies to improve local energy utilization efficiency [11]. Huang's (2017) study highlights that technological innovation brought about by foreign direct investment (FDI), if not properly managed, may lead to deterioration, thereby hindering improvements in energy efficiency [3]. Li Xin 'an et al. (2022) confirmed the view that FDI improves energy efficiency of enterprises and reduces environmental

pollution through technology spillover by using panel data of 27 sub-sectors of manufacturing industry in China from 2009 to 2018 [12].

In addition, some domestic and foreign scholars hold the "negative" view of FDI. Keller (2004) pointed out that the increase of FDI does not directly lead to the decrease of energy intensity or the improvement of energy efficiency [4]. Zhao Xiaoli et al. (2007) used the data of China's foreign direct investment (FDI) from 1997 to 2005 to verify the investment tendency of FDI through analysis, indicating that it is more inclined to invest in industries with high energy consumption. This trend may lead to a deterioration in China's energy efficiency, thereby increasing the country's energy consumption rate [13]. Hubler and Keller (2010) studied the data of 60 developing countries, including China, and concluded that FDI has no consistent effect on the improvement of energy intensity [5]. Robert et al. (2013) used the data of prefecture-level cities for regression analysis, and the results showed that there was a significant negative correlation between foreign direct investment (FDI) and energy efficiency [6]. Mimouni (2018) studied samples from 100 countries from 1980 to 2015, and took into account changes in national income levels. The results show that FDI has an inverted U-shaped influence pattern on energy efficiency, that is, after a certain peak point, FDI has an inhibitory effect on energy efficiency [7]. When studying the data of prefecture-level cities in China from 2005 to 2012, Wei Long and Pan An (2018) argued that FDI exacerbated the environmental pollution of resource-based cities [14]. Amoako and Insaadoo (2021) argue that Ghana's FDI has not yet achieved energy efficiency, mainly because the country still has room for improvement in technology absorption and tax policies [8].

To sum up, domestic and foreign scholars have made important contributions to the research on the relationship between FDI and energy efficiency. At present, the research on energy utilization efficiency in resource-based areas, especially the provinces along the "Belt and Road" is relatively insufficient. At the same time, the studies directly related to FDI, R&D and energy intensity are relatively scarce, and most of them focus on time series analysis and seldom consider spatial pattern.

3. MODEL DESIGN AND VARIABLE DESCRIPTION

(1) Model setting

The purpose of this paper is to carry out the overall regression and regional regression of the provinces along the "Belt and Road" in China, and analyze the direction and degree of FDI's influence on energy intensity. The measurement model is constructed as follows:

$$\ln EI_{i,t} = \alpha_i + \beta \ln fdi_{i,t} + \mu \ln gdp_{i,t} + \eta \ln second_{i,t} + \lambda \ln RD_{i,t} + \theta \ln coal_{i,t} + \varepsilon_{i,t}$$

Where: i and t represent the i province and the t year respectively; $\ln EI$ stands for logarithm of energy intensity; $\ln fdi$ represents the logarithm of the level of foreign capital utilization; $\ln gdp$ represents the logarithm of economic development level. $\ln second$ represents the logarithm of industrial structure; $\ln RD$ represents the logarithm of R&D intensity; $\ln coal$ represents the logarithm of the energy structure; $\varepsilon_{i,t}$ are random disturbance terms

(2) Variable declaration

Energy intensity index (EI). In this paper, energy intensity is used as the explained variable to evaluate the energy consumption per unit of GDP in different regions, calculated as the ratio of total energy consumption to the GDP of each region.

Foreign capital utilization level (fdi). This paper uses the ratio of the total amount of foreign direct investment actually attracted by each region over the years to the gross domestic product of each region to measure.

Economic development level (gdp). As per capita GDP is an important index to measure regional economy, this study uses per capita GDP to represent the level of economic development.

Industrial structure (second). There are significant differences in the impact of different industries on energy consumption and energy use efficiency. In order to measure the impact on energy use efficiency, this study chooses the proportion of the added value of the secondary industry in the GDP as the measurement standard.

R&d intensity (RD). The role of R&D in promoting technological progress can improve the level of energy efficiency in China. In this paper, the proportion of internal R&D expenditure to GDP is used to measure the intensity of scientific and technological innovation.

Energy mix (coal). Replacing fossil fuels with high-quality energy sources is expected to reduce energy losses, leading to a reduction in energy intensity. In this paper, the proportion of coal consumption to total energy consumption is used as an evaluation index of regional energy consumption structure.

In this paper, foreign capital utilization level is taken as the main explanatory variable, and other variables that may have an impact on energy intensity are taken as control variables. The specific economic variables are shown in Table 1.

Table 1. List of model variables

Variable classification	Name and symbol	Method or unit of calculation	Expected sign direction
Explained variable	Energy Intensity	Energy consumption/ Gross regional product	
Explanatory variable	Foreign capital utilization level	Actual FDI utilization/Gross regional product	-
	R&d intensity	Internal expenditure for testing and development funds/gross regional product	-
	Level of economic development	Per capita GDP	-
Control variable	Industrial structure	Value added of secondary industry/Gross regional product	+
	Energy structure	Coal consumption/total energy consumption	+

(3) Data sources and descriptive statistics

This study uses panel data of relevant variables from 2011 to 2020 in provinces along China's Belt and Road Initiative for empirical analysis. Due to the large gap and lack of data between Tibet Autonomous Region and other provinces, the data of Tibet Autonomous Region are not included in this study. The numerical average of the adjacent two years replaces the individual missing data for other provinces. The data comes from the national statistical yearbook, the statistical yearbook of the 17 provinces along the route and the National Bureau of Statistics. Descriptive statistics of variables are shown in Table 2.

Figure1 and Figure 2 respectively show the corresponding relationship between FDI, R&D and energy intensity. Through the drawing of the scatter plot and the fitting line, it can be found that the fitting line is inclined to the lower right. This indicates that there is a significant negative correlation between FDI, R&D investment and energy intensity, that is, increasing foreign capital inflows and internal spending on regional testing and development funds will contribute to improving energy efficiency.

Table 2. Descriptive statistics of model variables

variable	Obs	Mean	SD	Min	Median	Max
EI	170	0.912	0.56	0.28	0.70	2.300
fdi	170	1.673	1.64	0.01	1.40	9.360
gdp	170	5.149	2.52	0.27	4.57	15.68
second	170	40.158	7.67	19.3	40.2	55.37
RD	170	1.389	0.88	0.28	1.15	4.15
coal	170	58.055	16.13	27.1	58.1	89.2

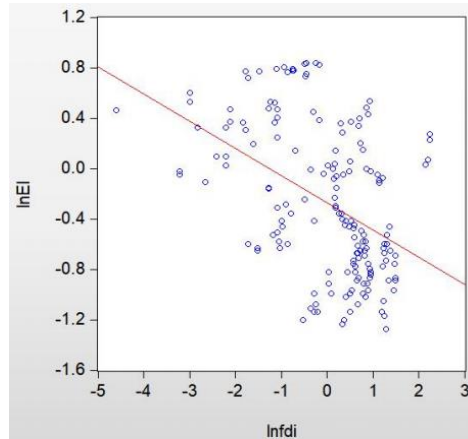


Figure 1. Relationship between energy intensity and FDI

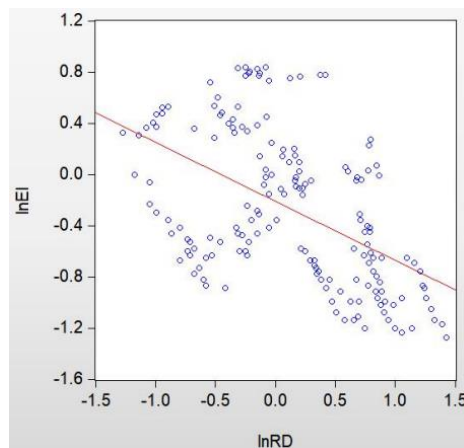


Figure 2. Relationship between energy intensity and R&D investment

4. EMPIRICAL RESULT ANALYSIS

(1) Population regression analysis.

Based on sample data and econometric model, this paper studies the influence of foreign direct investment and R&D on energy efficiency in China. Since there are certain differences between different provinces in China, Chowtest was first used to analyze the data, and the test result rejected the null hypothesis. Therefore, the individual fixed effect model (FE) was selected for regression analysis, and the software StataMP17.0 was used. The specific results are shown in Table 3.

Table 3. Regression results of influencing factors of energy intensity in provinces along the "Belt and Road"

item	FE			
	Model 1	Model 2	Model 3	Model 4
lnfdi	0.134*** (-3.96)	-0.121*** (-3.63)	-0.112*** (-3.49)	-0.139*** (-4.72)
lnRD	-0.355*** (-5.67)	-0.262*** (-3.82)	-0.361*** (-5.09)	-0.333*** (-5.15)
lngdp		-0.273*** (-2.98)	-0.190** (-2.09)	-0.138* (-1.66)
Insecond			0.682*** (3.79)	0.258 (1.44)
Incoal				0.714*** (5.96)
Constant	-0.228*** (-5.98)	-0.898 (-1.32)	-2.440*** (-3.46)	-3.834*** (-5.62)
R-squared	0.330	0.364	0.415	0.519
F	41.156	31.698	29.281	35.412

Note: ***, ** and * indicate that the above variables are statistically significant at the 1%, 5% and 10% levels, respectively.

From the perspective of explanatory variables, the influence coefficients of FDI and R&D on energy intensity are -0.134 and -0.355, respectively, and both are significant at the 1% level. It can be seen that the inflow of foreign capital and the increase of R&D investment can both reduce the energy intensity of provinces along the "Belt and Road" and improve energy utilization efficiency, which confirms the "pollution halo" hypothesis. This is mainly because on the one hand, FDI forms the spread of advanced technology through the technology spillover effect, which promotes the improvement of China's energy efficiency; On the other hand, through the competition effect, China's local enterprises to update equipment and adopt new technologies, indirectly improve China's energy efficiency. The effect of R&D intensity on energy intensity is negative, indicating that the current technology research and development has been able to translate into the progress of energy-saving technology, and the cost of national investment in technology plays a certain role in reducing energy intensity. Then, control variables such as economic development level, industrial structure and energy structure are added to the model one by one, and the regression results show that:

The coefficient of economic development level is negative and significant, and the higher the economic development level, the lower the energy intensity, indicating that the higher economic level changes people's consumption concept, tends to pursue a higher quality of life, and improves the energy utilization efficiency. The influence coefficient of economic development level is -0.432, indicating that energy intensity will decrease by 0.43% for every 1% increase in economic development level of countries along the belt and Road.

The effect of industrial structure on energy intensity is positive and significant, indicating that the increase in the proportion of the added value of the secondary industry in the total economic output value will lead to the increase of environmental pressure, thereby improving the level of energy intensity. Therefore, increasing the proportion of the tertiary industry in the industrial structure can effectively improve the energy utilization rate. The influence coefficient of industrial structure is 0.346, indicating that every 1% increase in the proportion of secondary industry in countries along the route will increase energy intensity by 0.35%.

The influence of energy consumption structure on energy intensity is positive, and is significant at 1% level, indicating that the proportion of coal in the energy consumption structure is not conducive to the decline of energy intensity. At present, coal consumption accounts for about 56% of the total energy consumption, and the introduction of clean energy and secondary energy technology is crucial to improve energy efficiency. The influence coefficient of energy consumption structure is 0.714, indicating that the energy intensity of the countries along the route will increase by 0.71% for every 1% increase in coal consumption.

(2) Regional difference analysis

In order to make the data more accurate and the conclusions more targeted, this paper divides the provinces along the "Belt and Road" into three regions: west, middle and east. The western region includes Chongqing, Guangxi, Xinjiang, Shaanxi, Gansu, Inner Mongolia, Ningxia, Yunnan, Qinghai nine regions; The central region is Jilin and Heilongjiang; In the east there are Hainan, Liaoning, Fujian, Zhejiang, Guangdong and Shanghai. The regression results are shown in Table 4.

Table 4. The impression factors of energy intensity in provinces along the "Belt and Road" are divided into regression analysis of west, middle and east regions

Variable name	The west	Middle part	The east
lnfdi	0.101** (2.50)	-0.0300* (-2.07)	-0.0884* (-1.94)
lngdp	0.0556** (2.49)	-0.865*** (-6.87)	-1.212*** (-10.64)
lnsecond	0.0508*** (4.98)	0.137 (1.22)	-0.875*** (-6.05)
lnRD	-0.0630* (-1.84)	-0.137* (-1.92)	0.539*** (6.47)
lncoal	0.0839*** (4.00)	1.311*** (5.87)	0.958*** (6.34)
Constant	3.442*** (20.53)	0.724** (2.43)	3.274*** (7.76)
R-squared	0.514	0.978	0.799
F	17.52	135.5	46.17

Note: ***, ** and * indicate that the above variables are statistically significant at the 1%, 5% and 10% levels, respectively.

The sub-regional regression results in Table 4 show that the impact of FDI and R&D on energy intensity has significant regional differences: in the eastern and central regions, the improvement of foreign investment utilization is conducive to the reduction of energy intensity. According to the data, every 1% increase in FDI will promote the reduction of energy intensity in the eastern and central regions by about 0.088% and 0.03% respectively. For the western provinces along the "Belt and Road", the impact of foreign investment utilization level on energy intensity is positive, that is, it is not conducive to promoting the reduction of energy intensity, which may be related to the western region's absorption of foreign investment is not enough, and the production equipment, technology, management methods are relatively backward. Research and development intensity has a negative effect on the western and central provinces along the line, and a positive effect on the eastern provinces along the line, indicating that technology research and development in the eastern region can not be well translated into the progress of energy-saving technology, that is, it is not conducive to the decline of energy intensity. For every 1% increase in R&D intensity, energy intensity in western and central regions will decrease by 0.06% and 0.14%, respectively, and energy intensity in eastern regions will increase by 0.54%.

The estimated results of the control variables are as follows: In the full sample regression and the sub-regional regression, the regression results of energy consumption structure show significant homogeneity, while other control variables show varying degrees of change.

The influence of economic development level on energy intensity in eastern and central regions is significantly negative, indicating that the improvement of economic development level in eastern and central regions will reduce energy waste in the province, while that in western regions is significantly positive, and the coefficients of the three regions are -1.212, -0.865 and 0.0556, respectively. Energy intensity in eastern and central regions will decrease by 1.2 percent and 0.87 percent, respectively, while energy intensity in western regions will increase by 0.06 percent.

The influence of industrial structure on energy intensity in the eastern and western provinces is different but significant. The larger the proportion of the secondary industry in the eastern region and the smaller the proportion in the western region, the higher the energy utilization efficiency, while the influence of industrial structure on energy intensity in the central provinces is positive but not significant. With a 1% increase in the proportion of secondary industry, energy intensity in western and central regions will increase by 0.05% and 0.14% respectively, while energy intensity in western regions will decrease by 0.88%.

The influence of energy consumption structure on energy intensity in the three regions is positive and significant, indicating that the larger the proportion of coal energy in the energy consumption structure, the more unfavorable the decline of energy intensity. The coefficients of the western, central and eastern regions are 0.084, 1.311 and 0.958, respectively. Every 1% increase in coal consumption ratio, the energy intensity of the three regions will increase by 0.08%, 1.31% and 0.96%, respectively.

(3) Robustness test

In order to verify the robustness of the conclusion, quantile test was conducted on the relationship between foreign direct investment, R&D input and energy intensity. The differences and rules of 10%, 30%, 50%, 70% and 90% quartile points were mainly tested (the larger the quantile, the greater the energy intensity) [14], and the test results were shown in Table 5. First of all, on the whole, the coefficient of FDI at the quartile point remains negative, which is consistent with the model regression result, indicating that the introduction of foreign capital improves the energy utilization efficiency in each region. Secondly, the estimated results in columns (1) to (3) show that the promoting effect of FDI on energy use efficiency is gradually enhanced, indicating that the energy use efficiency of provinces along the "Belt and Road" will increase with the increase of FDI. This is because regions with higher energy consumption have established more mature environmental management systems and better technical equipment, so the positive effect of foreign direct investment on energy use efficiency in columns (1) to (3) has gradually increased. Similarly, quantiles of 70% and 90% usually correspond to regions with lower energy intensity. In view of the relatively limited proportion of clean energy and clean technology in these regions, and the government's environmental regulatory system and governance measures are still to be improved, resulting in enterprises difficult to absorb advanced technologies introduced by external capital. Therefore, the promotion effect of FDI in columns (4) and (5) is relatively weak, and the improvement effect is not obvious. In general, the quantile test results still support the validity of the above conclusions. Finally, the results of quartile test show that regional R&D investment still has a significant negative effect on energy use efficiency, and its absolute value gradually decreases in columns (1) to (3), indicating that the promotion effect of the increase of R&D investment on energy use efficiency is gradually weakened. At the 70% quartile, the absolute value of R&D investment gradually decreases after reaching the maximum value, and the promoting effect of R&D on energy utilization efficiency gradually weakens, indicating that the government's R&D investment should follow the principle of moderation in improving energy environment.

Table 5. Robustness test

VARIABLES	fractile				
	10%	30%	50%	70%	90%
lnfdi	-0.077*	-0.174***	-0.183***	-0.077*	-0.138
	(0.043)	(0.02)	(0.046)	(0.046)	(0.111)
lnRD	-0.308***	-0.305***	-0.299***	0.523***	-0.265
	(0.052)	(0.043)	(0.106)	(0.105)	(0.267)
Constant	-0.823***	-0.529***	-0.325***	0.0284	0.531***
	(0.039)	(0.028)	(0.066)	(0.060)	(0.108)
Observations	170	170	170	170	170

Note: ***, ** and * indicate that the above variables are statistically significant at the 1%, 5% and 10% levels, respectively.

5. RESEARCH CONCLUSIONS AND COUNTERMEASURES

(1) Research conclusion.

FDI and R&D can reduce energy intensity along the Belt and Road in China. In general, from 2011 to 2020, the provinces along the "Belt and Road" have a significant effect on reducing energy intensity by attracting foreign investment, and control variables such as economic development level, industrial structure and energy structure of each region also have a significant impact on regional energy intensity. Specifically, the regional economic growth level and research and development intensity play a significant role in promoting the decline of energy intensity, while the increasing proportion of coal in the energy mix has a inhibiting effect on the decline of energy intensity.

The influence of FDI and R&D on energy intensity has regional differences. The higher the proportion of foreign direct investment in regional GDP, the lower the energy intensity. The main commonalities of the provinces with high energy intensity are that the economic development degree is not high, but the energy resources are relatively rich, and the utilization level of foreign capital is low. The provinces with low energy intensity are mainly concentrated in the economically developed areas such as the eastern coastal areas, and the level of foreign investment utilization in these areas is obviously better than that in other regions. The increase in FDI in the western provinces along the Belt and Road has not reduced local energy intensity. However, in the eastern and central provinces along the route, especially in the regions along the route, the level of FDI utilization has a positive impact on the reduction of energy intensity.

In general, the above phenomenon verifies two hypotheses about the impact of foreign capital on energy and environment, namely the "pollution paradise" and the "pollution halo" hypothesis. This suggests that regional development levels, resource endowments, and efficient use of foreign capital play an important role in the way foreign capital influences energy intensity.

(2) Countermeasures and suggestions.

We will strengthen the guidance of industrial transfer, actively guide the transfer of labor-intensive and resource-intensive industries from developed coastal areas to the central and western regions, provide relevant policy support, and promote the upgrading and balanced development of the industrial structure. Strengthen personnel training and introduction, carry out relevant training programs, and improve the quality of local labor force to meet the needs of foreign investment. At the same time, through the talent introduction program, attract high-level talents to work in the western region, improve the regional scientific and technological innovation and management level, and increase the attractiveness of foreign investment.

Actively carry out international technical exchanges and cooperation, learn from and introduce international advanced energy-saving technology and experience. Establish cooperative relations with other countries and institutions to jointly develop and promote energy-efficient technologies, and accelerate the process of technological innovation and application. We will increase support for research, development and innovation of new energy technologies, and encourage enterprises, universities and research institutions to strengthen cooperation and carry out research and development of new energy technologies. In addition, it is necessary to strengthen the protection of intellectual property rights and encourage and support the transformation and application of technological achievements. Enterprises and institutions are encouraged to lead market demand, invest in and use energy-saving technologies and equipment.

Promote economic restructuring, encourage traditional energy consumption enterprises to accelerate transformation and upgrading, and promote the development of clean energy production and utilization. By providing financial support, tax and fee reduction, green credit and other means, encourage enterprises to conserve energy and replace clean energy. Strengthen the construction of new energy demonstration projects: promote the demonstration and application of new energy in key areas and demonstration areas. For example, the promotion of solar water heaters and photovoltaic power generation systems in the field of construction, the promotion of electric vehicles and charging piles in the field of transportation, and the rapid development of new energy through demonstration effects.

REFERENCES

- [1] MIELNIKA O, GOLDEMBERG J. Foreign direct investment and decoupling between energy and gross domestic product in developing countries [J]. *Energy Policy*, 2002(30):87-89.
- [2] Perkins R, Neumayer E. Fostering environment-efficiency through transnational linkages? trajectories of CO₂ and SO₂, 1980-2000 [J]. *Social Science Electronic Publishing*, 2008, 40:2970-2989.
- [3] Huang J B, Du D, Tao Q. An analysis of technological factors and energy intensity in China [J]. *Energy Policy*, 2017, 109:1-9.
- [4] Keller W. International technology diffusion [J]. *Journal of Economic Literature*, 2004, 42(3):752-782.
- [5] Hübler M, Keller A. Energy savings via FDI? Empirical evidence from developing countries [J/OL]. *Environment and Development Economics*, 2010, 15(1):59-80.
- [6] Robert J R, Elliott. Energy intensity and foreign direct investment: A Chinese city level study [J]. *Energy Economics*, 2013, 40(1):484-494.
- [7] Mimouni K, Temimi A. What drives energy efficiency? New evidence from financial crises [J]. *Energy Policy*, 2018, 122(1):303-317.
- [8] Amoako S, Insaiddoo M. Symmetric impact of FDI on energy consumption: Evidence from Ghana [J/OL]. *Energy*, 2021, 223:120005.
- [9] Wang Ling, Yang Chen, Chen Ruixian. The influence of FDI on total factor energy efficiency in China: Reflections under the 14th Five-Year Plan [J]. *Foreign Economic and Trade Practice*, 2023(01):88-96.
- [10] Zhu Tong, Qi Xin, Zhang Liang. Do financial distortions lead to a large influx of FDI into our country? Evidence from provincial panel data in China [J]. *Nankai Economic Research*, 2010(04):33-47.
- [11] Zhang Yu, Jiang Dianchun. FDI, environmental regulation and energy consumption: empirical test based on energy intensity decomposition [J]. *World Economy*, 2013, 36(03):103-123.
- [12] Li Xin-An, Li Hui. Do the introduction of foreign capital and the bias of technological progress affect the carbon emission of manufacturing industry? Empirical test of panel data models from 27 manufacturing industries in China [J]. *China Soft Science*, 2022(01):159-170.
- [13] Zhao Xiaoli, Hu Junfeng, Shi Xuefei. Empirical analysis of the impact of industry distribution of foreign direct investment on China's energy consumption [J]. *Finance and Trade Economics*, 2007(3):117-120.
- [14] Wei Long, Pan An. Do export trade and FDI exacerbate environmental pollution in resource-based cities? Empirical research based on panel data of 285 prefecture-level cities in China [J]. *Journal of Natural Resources*, 2016, 31(01):17-27.
- [15] Qian M, Jin X L. Study on the impact of FDI and environmental regulation on energy use efficiency in provinces along the Belt and Road Initiative [J]. *Resources and Industries*, 2019, 23(06):79-85.

- [16] Guo Wenkai. Study on the influence of foreign investment utilization level on energy intensity in provinces along the Belt and Road [D]. Taiyuan: Shanxi University, 2021.
- [17] Xie J. Study on the impact of foreign direct investment on energy intensity in China based on spatial measurement [D]. Changsha: Hunan University, 2022.
- [18] Su H J. The impact of FDI on energy consumption intensity in China [J]. Inner Mongolia Coal Economy, 2020(11):69-71.
- [19] Li Kai, Qi Shaozhou. Is the hypothesis that FDI reduces energy intensity in host countries valid in China? Empirical analysis based on provincial industrial panel data [J]. Journal of World Economic Research, 2016(03):108-122+136.