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Spatial Effects of Financial Inclusive Development and Energy Efficiency in Yangtze River Delta Region

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Abstract

In the reality that the development of new energy is facing the technical bottleneck and the development is slow, sustainable development can be achieved by improving energy efficiency. And finance as an important means of resource allocation, can promote the allocation of funds, technological progress, and ultimately achieve the purpose of improving energy efficiency. Based on the relevant data of the Yangtze River Delta Economic Belt from 2007 to 2019, this paper explores the spatial effects of the development level of financial inclusion and energy efficiency. The index system for the measurement of green energy efficiency and financial inclusion development level is constructed, the spatial Durbin model is established through relevant tests, the spillover effect of regional financial inclusion degree in spatial dimension is analyzed, the spatial influence mechanism of financial inclusion level on energy use efficiency is investigated and relevant suggestions are given.

Keywords

Energy Efficiency; Financial Inclusive Development; Spatial Econometric Models.

1. Background Introduction

As an important material basis for a country's economic growth, natural resources are closely related to economic development and economic security. As the world's largest energy producer and consumer, the transformation and efficient use of China's energy structure is of great significance to national security and green development, and the level of energy efficiency has a direct bearing on global energy utilization and environmental protection. In this context, the country's efforts to optimize the energy structure and reduce carbon emissions through energy efficiency have become a new challenge for China to achieve the goals of "carbon peak" by 2030 and "carbon neutrality" by 2060. The level of financial inclusion development is an important factor affecting energy efficiency. In recent years, with the rapid development of China's economy, innovation and change in the financial sector have also been advancing, which has had an important impact on energy efficiency.

2. Literature Research and Thought Analysis

2.1 Theoretical Analysis

Under the premise that countries around the world have put forward the goal of carbon neutrality and carbon peak to achieve the sustainable development of human living environment, how to effectively reduce unnecessary energy consumption caused by human activities has become a problem worthy of discussion. On the measurement of energy efficiency and financial inclusive development, as well as the research on the correlation, domestic and foreign scholars have conducted a long time research from different angles and levels.

In the early stage, single-factor energy efficiency was mainly used as a metric index, such as the commonly used energy consumption elasticity coefficient, energy productivity, energy intensity, etc.

The energy efficiency index of a single index has the advantages of high data availability, convenient calculation and wide application range, but it can not reflect the complexity and universality of its connotation. Hu&Wang (2006) first proposed to measure "total factor energy relative efficiency" as the dependent variable in the study. In 1978, American operational research scientists Charnes, Cooper and Rhodes proposed the concept of DEA for the first time: "DEA is a non-parametric method that uses linear programming model to evaluate the relative efficiency of various decision making units". Shi Dan (2006) and Wang Qunwei (2008) cited DEA method in the evaluation and demonstration of China's total factor energy efficiency. Data envelopment analysis does not require preset parameters and effectively reduces the influence of subjective factors. Therefore, it is widely used and constantly improved in energy efficiency measurement.

Promoting financial inclusion is part of a social poverty reduction policy. If low-income groups are excluded from the financial system, their vulnerability and poverty can be perpetuated. Aghion and Bolton's (1997) research also proves that lack of financial services leads to poverty traps and inequality. The World Bank took the lead in paying attention to the issue of financial inclusion and initially put forward its ideas in the report "Building an Inclusive Financial System" published in 2004. In 2005, the United Nations proposed for the first time to build an "inclusive financial system" worldwide and defined the definition of financial inclusive development: It emphasizes the need to improve financial infrastructure, expand financial services to less developed areas and low-income groups at affordable costs, provide them with affordable, convenient and efficient financial services, and continuously improve the availability of financial services. In its 2009 financial reform agenda, the G20 placed financial inclusion at the top of its agenda. To judge the financial inclusion status of a country or region, policy makers are now more likely to estimate it through indicators from multiple dimensions and levels. Scholars such as Sarma (2008), Chakravarty and Pal (2010) use axiomatic methods to construct their own comprehensive index schemes. Some index schemes have been widely used in empirical research.

Regarding the correlation and mechanism between financial inclusive development and energy efficiency, different scholars have conducted studies from different dimensions. For example, Azhgaliyeva et al. (2018) believe that financial inclusive development has a positive effect on increasing capital inflow and broadening investment channels for enterprises to improve energy efficiency. Based on the above research results, this paper analyzes the spatial relationship between energy efficiency and financial inclusive development of cities in China's Yangtze River Delta Economic Zone.

2.2 Research Ideas

As one of the largest energy consumers and producers in the world, China's energy efficiency level is directly related to global energy utilization and environmental protection. In recent years, with the rapid development of China's economy, innovation and change in the financial sector have also been continuously promoted, which has had an important impact on energy efficiency. Financial inclusion has both positive and negative impacts on the development of energy efficiency. From different levels, the final comprehensive effect depends on the degree of superimposed positive and negative impacts. From a positive perspective, the reform in the financial field has promoted the structural adjustment of the energy supply side, promoted the technological innovation and equipment renewal of energy enterprises. In addition, the digital transformation in the financial field has reduced the information barrier, greatly reduced the asymmetry of information, and brought a more environmentally friendly and fast new energy consumption mode to people's lives. From the negative point of view, the expansion of production scale and the optimization of energy structure and energy technology innovation are often not synchronized, which to a certain extent objectively causes the loss of resources and the reduction of energy utilization efficiency, which is the "coupling - decoupling" theory used in the international description of the nature of the asynchronous change of economic growth and material consumption. This paper verifies the comprehensive influence results of this theory in the Yangtze River Delta region, and gives a theoretical analysis.

3. Index System and Data Source

This paper takes 41 cities in the Yangtze River Delta Economic Belt as the research target, and takes the financial inclusive development data and energy efficiency data of Zhejiang, Jiangsu, Anhui and Shanghai from 2007 to 2019 as samples to study the impact of financial inclusive development on energy efficiency. Some basic routine data in this paper are mainly from provincial and municipal statistical yearbooks and Urban Statistical Yearbooks, such as nominal GDP, administrative area, year-end permanent population and other indicators; Some financial data come from wind database, EPS database, the website of China Banking and Insurance Regulatory Commission, etc., such as the geographical distribution of financial institutions' business outlets and other indicators.

3.1 Explained Variable: Energy Efficiency

Since this paper aims to explore how energy efficiency is affected by exogenous factors, it is first necessary to calculate the energy efficiency values of each city during 2007-2019. Input factors include energy consumption, capital stock, regional area and employment number, expected output factors include gross domestic product, and nonexpected output includes industrial wastewater discharge, sulfur dioxide discharge and smoke dust. With reference to the research results of Zhang Jun et al. (2004), the sustainable inventory method is used to estimate the actual capital stock of each city in Anhui Province in 16 years by combining the capital stock of the previous period, the investment volume of the current period and the depreciation rate. The economic aggregate data of output factors is obtained by using the 2006 base period combined with the GDP deflator. Due to the availability of data, this paper selects industrial wastewater discharge, sulfur dioxide discharge and smoke dust in each region as pollutant variables when considering environmental pollutants of output factors.

Table 1. Energy efficiency input-output table

	Contains items	Indicators	Units
Inputs	Energy	Energy consumption	Tons of standard coal
	Capital	Capital stock	10000 Yuan
	Area	Urban area	Square kilometers
	Labor	Number of employees	10,000 people
Expected output	Gross product	GDP	10000 Yuan
Undesirable output	Total wastewater	Industrial wastewater discharge	10000 Ton
	Air pollution	Sulfur dioxide emissions	Ton
		Smoke dust	

The Malmquist-Luenberger productivity index constructed by Chung et al. (1997) is introduced into the total factor energy measurement that includes the undesirable output. Based on the SBM model built by Tone (2001) and the global-Malmquist productivity index calculated based on Global DEA proposed by Pastor and Lovell (2005), this paper calculates the energy efficiency value of the Yangtze River Delta economic zone.

3.2 Explanatory Variable: Financial Inclusive Development

The higher the degree of development of the financial market, the more it can mobilize more idle funds to invest and transfer to the demand side, increase the activity of the economic market, and ultimately promote the improvement of energy utilization efficiency. With reference to the financial development indicator system established by Sarma and Pravat & Arindam in 2008, this paper constructs the measurement indicator system from three aspects: financial development scale, easy access to financial services, and financial development activity.

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Table 2. Index system of financial inclusive development level

Included Items	Indicators	Units
Size of financial development	Per capita deposits and loans	Yuan/person
	Insurance depth	%
	Ratio of deposits and loans to GDP	%
	Geographical distribution of financial institutions' outlets	Pieces/km^2
Degree of easy access to financial services	Geographical distribution of the number of people employed in the financial industry	Person/km^2
	Population distribution of business outlets of financial institutions	Pieces/person
Financial development activity	Insurance density	Yuan/person
	Demographic distribution of the number of people employed in the financial industry	%

Sarma et al. earlier proposed their financial inclusion indicator formula based mainly on the Human Development Index adopted by the United Nations. The basic formula of financial inclusion index proposed by Sarma is as follows:

$$IFI = 1 - \sqrt{\sum_{i=1}^{k} [(M_i - d_i)/(M_i - m_i)]^2/k}$$

Where, k is the number of dimensions used, Mi is the maximum value of data in dimension i, mi is the minimum value in dimension i, and di is the corresponding value in dimension i. Based on the above explanatory variables and the calculation method of explanatory variables, the final calculation results are prepared for model research.

3.3 Other Control Variables

This paper selects the following four control variables to discuss their spatial impact on the financial development of each region:

Table 3. Other control variables

Control variables	Control variables	Units
opening	Actual foreign investment	Us $10,000
manufacturing	Manufacturing employment/number of employees per unit	%
innovation	Number of patents granted at the end of the year	item
advancedis	Proportion of tertiary industry in GDP/proportion of secondary industry in GDP	%

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4. Model Testing and Construction

In this paper, the construction process of the spatial effect model of financial inclusion and energy efficiency in China is as follows:

(1) Construct a spatial weight matrix to lay the foundation for the spatial effect test.

(2) Conduct a preliminary spatial autocorrelation analysis of the data and calculate the Moran index.

(3) Screening and selecting the most accurate and appropriate spatial estimation model.

Due to the economic development level, energy saving and emission reduction technology of adjacent cities, the population numbers are closer, this paper adopts the economic-geographical distance matrix by introducing the spatial weight matrix, that is, the absolute value of the difference between the average GDP of the two places is divided by the square of the distance.

4.1 Spatial Correlation Analysis

Moran's I is a measurement method for measuring spatial autocorrelation proposed by Australian statistician Moran in 1950. Spatial autocorrelation is when a signal shows a correlation between neighboring locations in space, and because it is multidimensional and multi-directional, it is more complex than one-dimensional autocorrelation. Among them, the Moran global index can reflect the degree of data dispersion or aggregation, the specific calculation formula is as follows:

$$I = \frac{N}{W} \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{N} (x_i - \bar{x})^2}$$

Where, N is the number of spatial individuals, in this paper N=41, wij is the element in the spatial weight matrix, Y is the variable to be tested. In this paper, STATA17 software is used to calculate the relevant results of the Moreland index from 2007 to 2019 as follows:

Table 4. Global Moreland index table

year	I	Z-value	P-value
2007	0.511	6.688	0.000
2008	0.523	6.844	0.000
2009	0.495	6.538	0.000
2010	0.561	7.187	0.000
2011	0.580	7.400	0.000
2012	0.587	7.430	0.000
2013	0.610	7.537	0.000
2014	0.592	7.470	0.000
2015	0.596	7.509	0.000
2016	0.627	7.857	0.000
2017	0.663	7.931	0.000
2018	0.632	7.780	0.000
2019	0.664	8.079	0.000

According to Table 4, the test P-values of each year from 2007 to 2019 were all less than 0.01, and the Moreland index was significant at the 1% level, and the Moreland index value was positive. Therefore, the null hypothesis is rejected, that is, there is a spatial correlation, and it needs to be further verified by a spatial econometric model.

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4.2 Choice of Spatial Model

Table 5. LM test results

Test	Statistic	df	p-value
Spatial error:			
Moran's I	70.159	1	0.000
Lagrange multiplier	647.302	1	0.000
Robust Lagrange multiplier	196.660	1	0.000
Spatial lag:			
Lagrange multiplier	627.285	1	0.000
Robust Lagrange multiplier	176.643	1	0.000

LM test includes two parts: the first part is the spatial error model test, which includes Moran index test, LM test, Lagrange multiplier test; The second part is the spatial lag model test, including LM test, Grange multiplier test. The P-value results of the above tests are significant, that is, they all reject the hypothesis of "no spatial autocorrelation". In this paper, both SEM test and SAR test are significant, so the spatial Durbin model is selected for the subsequent test.

In order to ensure the effectiveness of the spatial Durbin model, based on the LM test results, this paper further conducts LR test and Wald test to investigate whether the spatial Durbin model will degenerate into a spatial error model or a spatial lag model.

Table 6. LR test results

lrtest sdm sar	
Likelihood-ratio test	LR chi2(5) = 18.94
Assumption: sar nested within sdm	Prob > chi2 = 0.0000
lrtest sdm sem	
Likelihood-ratio test	LR chi2(5) = 40.25
Assumption: sem nested within sdm	Prob > chi2 = 0.0000

As can be seen from Table 6, the test results are all significant at the 1% level, so the null hypothesis is rejected, and the spatial Durbin model will not degenerate into a spatial lag model or a spatial error model.

Table 7. Wald test results

SDM/SAR test results	chi2(3) = 10.76
	Prob > chi2 = 0.0131
SDM/SEM test results	chi2(5) = 38.74
	Prob > chi2 = 0.0000

As can be seen from Table 7, Wald test statistics are significant in both test results, indicating that compared with SAR model and SEM model, spatial Durbin model is more effective. Therefore, the spatial Durbin model of spatial financial inclusive development and energy efficiency constructed in this paper is as follows:

$$EE_{it} = \alpha l_N + \rho W EE_{it} + IFI_{it}\beta + WIFI_{it}\theta + \gamma X + \varepsilon_{it}$$

Where, i and t represent each city and year respectively. The explained variable is energy efficiency EE, which is represented by the total factor energy efficiency value calculated above. IFI, representing financial development, is the core explanatory variable in this paper, as measured by the Financial inclusion index, and X is the other control variable.

5. Empirical Analysis

5.1 Analysis of Benchmark Regression Test Results

First, observe the benchmark regression results of the model, as shown in Table 8:

Table 8. Baseline regression results

EE	Coefficient	Std	t	p
IFI	0.147	0.053	2.77	0.006
opening	0.059	0.017	3.47	0.001
manufacturing	0.023	0.021	5.25	0.000
innovation	0.066	0.008	7.99	0.000
advancedis	0.095	0.016	8.61	0.000
cons	-0.104	0.052	-1.98	0.048

Using Stata17 to perform baseline panel regression on the model, the results are shown in the table above. It can be seen from the results that all variables are significant at the 1% level, and the R2value is 0.7536. The fitting regression result is better. As can be seen from the benchmark regression results, financial inclusive development has a significant positive impact on energy efficiency, reflecting the stable and benign development trend of the influence of financial development level on energy.

5.2 Spatial Durbin Model and its Effect Decomposition

Table 9. Results of spatial effects of financial inclusion development on energy efficiency

EE	Coefficient.	Std. err.	z	P>|z|	[95% conf. interval]	
Main IFI	0.0887	0.0358	2.48	0.013	0.0185	0.1589
Wx IFI	0.1448	0.0603	2.40	0.016	0.0265	0.2632
Spatial rho	0.3156	0.0627	5.03	0.000	0.1926	0.4386
Variance |sigma2_e|	0.0016	0.0001	14.9	0.000	0.0014	0.0018
LR_Direct IFI	0.1013	0.0348	2.91	0.004	0.0331	0.1696
LR_Indirect IFI	0.2409	0.0712	3.38	0.001	0.1013	0.3805
LR_Total IFI	0.3422	0.5854	5.85	0.000	0.2275	0.4569

According to Table 9, the p value of the spatial autoregressive coefficient is 0.000, which is significant at the 1% level, and its coefficient is 0.3156, which is positive, indicating that the energy efficiency of the explained variable has a positive spatial spillover effect on itself.

From the β value, the coefficient of the core explanatory variable reaches the significance level of 1%, and the coefficient value is 0.0887, indicating that the level of financial inclusive development has a positive impact on energy efficiency. The result of adding the spatial coefficient term can

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explain the spatial conduction effect better than the direct effect result coefficient. The p value of WIFI is 0.016, which is significant at 1% level, and the coefficient is 0.1448, indicating that the level of financial inclusion development has a positive spatial spillover effect, and the surrounding area has a positive conduction effect on the local explained variable energy efficiency.

Then, the degree of spatial influence is decomposed and analyzed. The core explanatory variables are significant in direct effect, indirect effect and total effect. In the total effect, one unit change in the level of financial inclusion in all regions can affect the energy efficiency value of the region by 0.3422 units, which can be divided into direct and indirect effects. In the direct effect, a 1 unit increase in the level of financial inclusion in the region will lead to a 0.1013 unit change in the regional energy efficiency value. Compared with the direct effect, the change of energy efficiency in the region is more affected by the development of financial inclusion in the neighboring region. The increase of financial inclusion in the neighboring region by 1 unit can lead to the change of energy efficiency by 0.2409 units. Therefore, in the process of the development of the Yangtze River Delta economic Zone, the development of energy efficiency is largely promoted and supported by the neighboring regions with better economic and financial development, and the spatial integration and systematic development have achieved remarkable results.

Then, the internal influencing mechanism was analyzed to explore how the development of financial inclusion affected energy efficiency at different levels. At the policy support level, China's financial inclusive development system has issued a number of support policies for improving energy efficiency. For example, the Green Credit Guidelines guide the public to deepen the concept of green credit, strengthen the scale of green credit, and standardize the details of green credit development, which reflects the government's guiding role in supporting green energy efficiency for financial inclusive development. At the corporate structure level, China's financial inclusive development provides financial support for green energy saving industries. For example, the promotion and use of new energy and the improvement of financial inclusiveness make more funds flow to key green fields including the new energy industry. By reducing fossil energy consumption and increasing the supply of new energy, environmental pollution and excessive carbon emissions caused by it can be reduced while ensuring the normal demand for energy supply in economic development. Thus contributing to the realization of green and low-carbon development goals. At the technical level, financial inclusive development enables the flow of funds within enterprises, more research and development funds can be invested in advanced science and technology on energy efficiency improvement, promote technological innovation and equipment upgrading of energy enterprises, and help promote the structural adjustment of energy supply side. In terms of people's lives, the digital transformation of the financial sector has reduced information barriers, greatly reduced the asymmetry of information, and brought a more environmentally friendly and fast new energy consumption mode to people's lives.

6. Conclusion

With the gradual attention paid to the quality of the ecological environment, the level of financial inclusive development may become an effective market-based means to improve energy efficiency, which will greatly affect the energy efficiency changes in a country or region, and on this basis improve the energy consumption structure, regional carbon emissions and environmental quality levels. In the era of economic globalization, domestic financial inclusive development can have a positive impact on economic and technological cooperation and trade between countries. At the same time, as one of the world's largest energy consumers and producers, China's energy efficiency level is directly related to global energy utilization and environmental protection. Improving the level of financial inclusive development to optimize energy efficiency is in line with China's primary goal of high-quality economic development, and is of great significance for improving people's well-being and implementing green and sustainable development.

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