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Research on the Impact of the Industrial Cluster Effect on the Profits of New Energy Enterprises in China: Based on the Moran's I Index and the Fixed-Effect Panel Stochastic Frontier Model

Jialiang Sun, Pengxiang Fan *, Ke Wang and Zixuan Yu

School of Economics and Management, Beijing Jiaotong University, Beijing 100089, China
* Correspondence: 22110220@bjtu.edu.cn; Tel.: +86-159-0110-1670

Abstract: The new energy industry is an imperative method through which to achieve sustainable development. Industrial clusters are one of the main states in the development of the new energy industry. However, few existing studies discuss the impact of industrial clusters on the relevant indicators of new energy enterprises. Based on panel data for the period 2011–2021 of 39 sample enterprises listed in China in 2011 and before, this empirical study first analyzes the spatial autocorrelation of the sample enterprises using the Global Moran's I and Local Moran's I, and then treats the Local Moran's I of enterprises as a perturbation factor of the inefficiency term, using a fixed-effects panel stochastic frontier model to empirically analyze the effect of industrial clusters on the profits of the sample enterprises. The following is found: (1) The layout of new energy enterprises in China presents a specific physical spatial agglomeration phenomenon. Additionally, the layout of profit indicators shows spatial correlation to some extent. (2) When the homogeneity of clustering enterprises increases, the cluster effect can improve profits by reducing inefficiencies in enterprise production. This study provides valuable academic suggestions for the development of the new energy industry.

Keywords: new energy industry; industrial cluster; Moran's I index; fixed-effect panel stochastic frontier model

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1. Introduction

Energy is the basis of the sustainable development of society and an important supporting factor for modern economies. With rapid economic development and population growth, China's demand for energy is increasing. This greatly increased energy consumption leads to a reduction in traditional energy sources, forming a potential obstacle to the development of the national economy. The high consumption of traditional energy sources is more likely to cause a series of severe weather conditions, such as warming, droughts, and heavy rainfall. Studies show that the average surface temperature in China has increased by 1.1 °C over the past 100 years, and China has experienced dozens of warm winters since 1986 [1]. At the international level, major industrial countries attach great importance to the development and utilization of new energy sources [2], and the search for a low-carbon economic development model, aimed at carbon reduction, has gradually become a consensus. The development of the new energy industry has become an important initiative for countries to improve their energy efficiency and reduce their emissions. Therefore, as a major energy-consuming country, China vigorously develops new energy industries and promotes carbon neutrality and carbon peaks, which is the only way to achieve long-term sustainable economic development [3].

In some areas of China, the new energy industry shows the characteristic of developing in clusters, shown in Figure 1. There are 37, 12, and 16 listed new energy enterprises, respectively, in Jiangsu, Shanghai, and Zhejiang, three major regions in the Yangtze River Delta, but China's new energy industry cluster is still in its infancy, and related research is less than adequate [4]. However, there is no firm consensus among the business and academic communities on the question of whether clusters affect new energy enterprises. There are mainly two different views: one is that the effect of industrial clusters is positive and that new energy enterprises need industrial clusters [5]; the other is that the effect of industrial clusters of new energy enterprises is negative [6]. In addition, most of the research on the relationship between industrial clusters and new energy enterprises in China has focused on the formation mechanism of new energy industry clusters [7], and there is a lack of empirical research related to the role of industrial clusters.

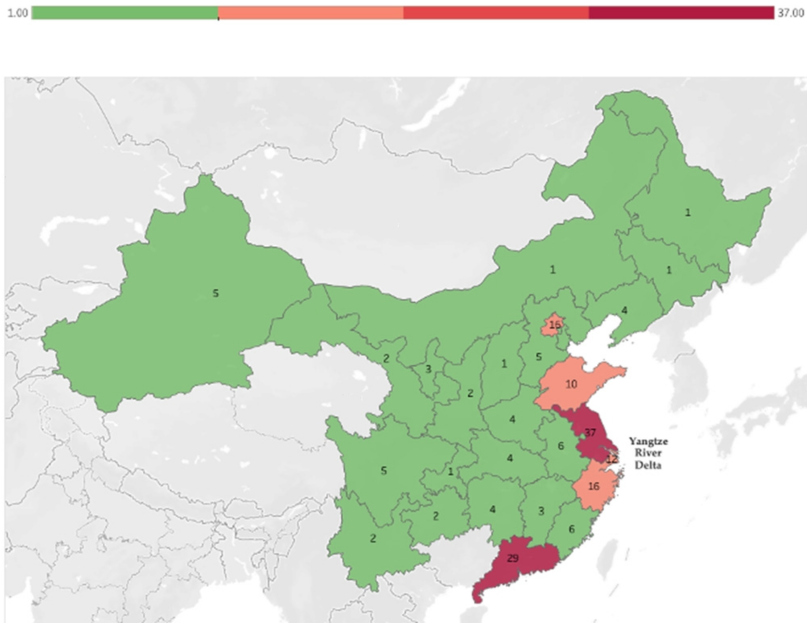

Figure 1. Distribution of China's listed new energy enterprises.

Based on this research background, this study proposes a research question. In the current situation, where the new energy industry is becoming a strategic pillar of industry, this study attempts to prove the role of industry clusters in the sustainable development of the new energy industry through empirical data, and to analyze whether new energy enterprises in specific regions form industry clusters, as well as whether industry clusters have a positive impact on new energy enterprises.

Given the fact that there is a lack of understanding of the impact of industry clusters on new energy enterprises in the academic world, as well as the possible misunderstanding of the role of industrial clusters by government and enterprises, this study has two main purposes: First, this study hopes to innovatively present conclusions about whether an industrial cluster status exists for new energy enterprises in a given region and whether an industrial cluster status affects the profits of new energy enterprises. Second, this study attempts to promote the awareness of relevant decision makers about the results of the role of industrial clusters, in order to improve the profits of new energy enterprises. We address these two questions in a novel way via the perspective of using the Local Moran's I index of new energy enterprises as a disturbance factor of the inefficiency term.

This study attempts to explore the impact of industrial clusters on the profits of new energy enterprises. The focus of this study is divided into two components: First, this study uses the Global Moran's I index and the Local Moran's I index to analyze the spatial autocorrelation of the sample enterprises. Second, based on the previous stage of research, this study uses a fixed-effects panel stochastic frontier model, using the Local Moran's I index of the enterprises as the disturbance factor of the inefficiency term, and discusses the impact of industrial clusters on the profits of the sample enterprises from the perspective of the spatial layout of profits in the cluster through an empirical analysis.

Based on the findings of the empirical analysis, this study further analyzes and presents the corresponding research values and implications at both theoretical and practical levels.

This study helps to further understand the logic of regional new energy enterprise cluster development, so as to explore the current situation and problems of new energy enterprise cluster development in a more rational and intuitive way. The main contributions of this study are as follows.

(1) This study analyzes the influence of the layout among enterprises in the cluster on enterprises mutually from a micro-perspective, which expands the scope of research on cluster enterprises, enriches the research dimension of cluster enterprises, and to a certain extent, makes up for the shortcomings of previous research on cluster enterprises.
(2) This study reveals the mechanism of the spatial autocorrelation of cluster enterprises in the profits of enterprises, and dialectically views the effects of homogeneous, disordered, or heterogeneous enterprise clustering on the profits of enterprises within a cluster. It provides new theoretical support and research ideas for future research on clustered enterprises.
(3) This study further enhances the application value of the Moran's I index model by innovatively combining the Local Moran's I index with a fixed-effects panel stochastic frontier model and incorporating the spatial layout of the profits of enterprises reflected by spatial autocorrelation into the inefficiency term for analysis, which provides a reference model for subsequent studies.
(4) This study provides a reference basis and theoretical support for the development of the new energy industry and the construction of industrial patterns in various regions.

2. Literature Review

The concept of industrial clusters was proposed by Michael E. (1990), who argued that industrial cluster development is a phenomenon that accompanies the development of an industrial economy. Industrial clusters consist of multiple enterprises with the same, or similar, competitive and cooperative relationships, such as inter-related producers, suppliers of raw materials and intermediate finished products, service institutions, financial institutions, R & D institutions, and counterpart government services within the industry [8]. With due consideration of the current situation of industrial cluster development in China, Chinese scholars have divided Chinese industrial clusters into township enterprise cluster areas, high-tech industrial clusters, and various types of development districts in practice [9]. Previous studies have pointed out that industrial clusters have positive effects in three main aspects: first, they are conducive to obtaining external economies of scale and scope; second, they are conducive to promoting the formation of a learning- oriented economy [10]; and third, they are also conducive to the formation of competition and innovation effects. At the same time, many countries and international organizations around the world have paid much practical and policy attention to industrial clusters. For example, studies have found that the environmental policies formulated by the European Union have increased the size of the new energy industry by 6% [11], and industrial clusters are considered to be an effective form of regional economic organization for industrial development. Generally speaking, most industries can form clusters under appropriate conditions. However, compared to traditional industries, new energy clusters are very different. New energy industry clusters are innovation-oriented clusters. Since the externalities of innovation-oriented clusters are more significant than those of traditional clusters, new energy clusters have stronger public attributes with which to coordinate the relationship between cluster development and enterprise development [12]. Therefore, there is a lack of research on whether the new energy industry, which is a strategic emerging industry, can also benefit from industrial clusters.

Most of the existing studies on the relationship between industrial clusters and the new energy industry revolve around the formation mechanism, intrinsic driving force, and distribution status of new energy industry agglomeration. In terms of the formation mechanism and intrinsic drivers of industrial clusters, Ye (2011) analyzed the impact of spatial heterogeneity on industrial clustering through the proximity of geographic units and temporal dimensions [13]; Li (2015) focused on the evolutionary pattern of Chinese new energy industry clustering from a spatiotemporal coupling perspective and found that China's new energy industry, in general, exhibits a high level of geographic clustering characteristics [14]; Zhang (2016) focused on the dynamics mechanisms and evolutionary paths of new energy industry clusters [15]; Li (2016) established an industrial innovation chain and "supply and demand" policy framework with which to analyze the characteristics of the new energy automotive industry by comparing the differences between regions [16]; and Zhang (2020) took single cities as examples with which to explore the characteristics of the development of innovative new energy industry clusters and their upgrading paths in single cities [17]. In terms of the distribution of new energy industry clusters in China, Guo (2018) focused on the clustering of the new energy industry in provinces in China [18], and Wang (2019) focused on the scale of the new energy industry in China [19]. In addition, most studies on the role of industrial clusters in the energy sector are related to traditional energy; Su (2022) investigated the impact of energy industry agglomeration on green innovation performance [20], and Zhao (2020) studied the role of energy industry agglomeration on economic growth [21].

Overall, this study finds that previous studies have room for improvement in several directions. First, there are many previous studies on the effects of industrial clusters, but most of them are concentrated on traditional industries. Theoretical research on the relationship between industrial clusters and the new energy industry lacks empirical analyses to support it. Second, existing studies that combine industrial clusters and the new energy industry often focus on how new energy industry clusters are formed. However, there is less empirical research on the impact of new energy industry clusters on the development of the enterprises themselves. Whether such a cluster has a positive impact on the development of new energy enterprises, or whether it reduces productivity through factors within the cluster, remains a direction to be explored in current academic research. Thirdly, most of the existing literature analyzes the positive effects of the clusters on the enterprises through improving overall cluster synergy, sharing knowledge spillover, and improving resource utilization efficiency from a macro-level, but still lacks any observation of the mutual influences between enterprises from a micro-perspective, from an individual enterprise perspective, or from an enterprise layout perspective.

Based on this, this study observes the characteristics of neighboring cluster enterprises through the Local Moran's I index, or, in other words, the neighboring enterprise layout of individual enterprises, and then analyzes the impacts of the environments in which enterprises are located on the profits of enterprises through a fixed-effects panel stochastic frontier model to observe the impacts of homogeneous or heterogeneous characteristics among enterprises on the profits of enterprises in industrial clusters.

3. Materials and Methods

3.1. Sample Selection

In this study, panel data from 2011 to 2021 of 39 new energy enterprises listed in the Yangtze River Delta in 2011 and before were selected for empirical estimation. We take each 0.5 years as our unit of observation; in total, we obtain 22 time series and 858 sample observation points. The sample selection is mainly based on the following considerations: 1. The Yangtze River Delta area is an important economic region in China, and "industrial convergence-industrial synergy—industrial cluster" is an important path for the high-quality development of the Yangtze River Delta [22]. Therefore, a study on samples from the Yangtze River Delta is a better representation of the cluster effect of the new energy industry in China. 2. The samples of new energy enterprises from the Yangtze River Delta belong to the same industrial cluster [4], which is helpful for subsequent research on the effects of industrial clusters.

The data were obtained from the WIND database.

3.2. Moran's I Model

The Global Moran's I and Local Moran's I are used to determine the spatial autocorrelation between the observed sample enterprises according to the research paradigm of spatial econometric analysis.

$$\text{GlobalMoran}'\text{I} = \frac{\sum_{j=1}^{n}\sum_{j=1}^{n} W_{ij}(Y_i - \overline{Y})(Y_j - \overline{Y})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \quad (1)$$

$$\text{LocalMoran}'\text{I} = \frac{(Y_i - \overline{Y})}{S^2} \sum_{j=1}^{n} W_{ij}(Y_j - \overline{Y}) \quad (2)$$

In Equations (1) and (2), Y_i and Y_j represent the natural logarithm of the total profits of sample enterprise i and sample enterprise j, respectively; W_{ij} is the spatial weight matrix, which represents the spatial relationship between enterprise i and enterprise j. In this study, referring to Lee et al. and Liu et al.'s method, we take the inverse number of the geographic linear distance generated by the longitude and latitude coordinates of sample enterprises as the spatial weight between the two enterprises to form the geographic distance spatial weight matrix W [23,24]. The data are from the national basic geographic database published by the National Geographic Information Public Service Platform. $S^2 = \sum_{j=1}^{n} (Y_i - \overline{Y})^2 / n$ indicates the variance in the observed data; $\overline{Y}$ indicates the mean value of the sample observed index; and $\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}$ indicates the sum of the spatial weights.

The global and Local Moran's I indices typically fluctuate between −1 and 1. The closer the Global Moran's I index is to 1 or −1, the stronger the spatial correlation is in the sample space, indicating that the effect of an industrial cluster in the physical space also makes the enterprise profit index an agglomeration or dispersion phenomenon in the spatial distribution. The closer the value of the Global Moran's I index is to 0, the lower the spatial autocorrelation of sample enterprises, indicating that, even if there is a phenomenon of an industrial cluster, to some extent, in the Yangtze River Delta area, the cluster effect is relatively low, and there is no obvious spatial correlation characteristic of the profit index. The closer the value of the Local Moran's I index is to 1 or −1, the stronger the spatial homogeneity or heterogeneity of the sample enterprise is, that is, the closer or the more different the profit index is to the neighboring enterprise. The closer the value of the Local Moran's I index is to 0, the more that it indicates that there is no obvious spatial correlation between the profit value of the sample enterprise and that of the neighboring enterprise.

3.3. Fixed-Effect Panel Stochastic Frontier Model

Most of the existing literature uses the modeling ideas of Battese and Coelli (1992) when analyzing efficiency using stochastic frontier models. However, they do not incorporate the heterogeneity between production units when constructing models. Considering the actual situation of new energy enterprises, the technology or the core mastery varies greatly among different enterprises, and the production frontiers are obviously not the same; therefore, if the same production frontier boundary is used for different enterprises, and the efficiency differences among individual enterprises are ignored, it may lead to bias in the estimation results. This paper draws on the modeling idea of Greene (2005) to build a panel stochastic frontier model that includes an individual firm's fixed effect. As for the distribution selection of the compound error, the normal–truncated normal distribution, rather than the half-normal distribution, is chosen as the distribution form of the compound error term in this paper, because the production efficiency of most production units cannot reach the best efficiency frontier when it comes to actual production activities. As for the selection of the production model, this paper comprehensively investigated the Cobb–Douglas production function model and the translog production function model. However, considering the fact that the translog production function model is more elastic when measuring complex models, this paper set the translog model as the benchmark model and comprehensively investigated the test results of both of the models. The model setup is shown below.

$$lnY_{it} = \alpha_i + \beta_1\, lnK_{it} + \beta_2\, lnL_{it} + \beta_3 lnK_{it} \times lnK_{it} + \beta_4 lnL_{it} \times lnL_{it} + \beta_5 lnK_{it} \times lnL_{it} + \nu_{it} - u_{it} \quad (3)$$

where Y_{it}, K_{it}, and L_{it} represent, respectively, the total profit, capital input and human input of the i th enterprise in the t th observation period, respectively. α_i is an individual effect characterized by n − 1 dummy variables, ν_{it} is a random perturbation term, and u_{it} is an inefficiency term. In this paper, the total profit, total assets, and number of employees of the firm are used to represent the profits, capital input, and human input of the firm.

$$\nu_{it} \sim N\left(0,\, \sigma_v{}^2\right) \quad (4)$$

$$u_{it} = h_{it} u_i{}^* \quad (5)$$

$$u_i{}^* \sim N^+\left(\mu,\, \sigma_u{}^2\right) \quad (6)$$

$$h_{it} = f\left(z_{it}{}', \delta\right) \quad (7)$$

$$z_{it}{}' = \lambda_1 z_{1_{it}} + \lambda_2 z_{2_{it}} + \lambda_3 z_{3_{it}} + \lambda_4 z_{4_{it}} + \lambda_5 z_{5_{it}} + \lambda_6 z_{6_{it}} \quad (8)$$

where z_1, z_2, z_3, z_4, z_5, and z_6 represent the perturbation factors in the inefficiency term. In this paper, we use the Local Moran's I indices of profits, overhead costs, selling costs, enterprise leverage, government subsidies, and location factors as the perturbation variables in the inefficiency term.

The local Moran's I index of total profit is the key factor that this study focuses on. The value of the local Moran's index characterizes the heterogeneity or homogeneity of the proximity enterprises and the observed enterprise itself, normally fluctuating between −1 and 1. The index tends to 1 when the proximity enterprises and the observed enterprise tend to be homogeneous and tends to −1 when they tend to be heterogeneous. Overhead and cost of sales: The inefficiency of enterprise production may be due to personnel management inefficiency and sales inefficiency; Korchagin argues that advertising expenditure can have a positive effect on efficiency, and, referring to Cai's method of putting the overhead rate to represent management efficiency, this paper selects overhead and sales expenses as the factors influencing inefficiency [25–28]. Enterprise leverage: the cash flow hypothesis suggests that enterprise leverage is negatively correlated with enterprise efficiency. This paper uses the ratio of total liabilities to total fixed assets to characterize enterprise leverage [29–31]. Government subsidies: According to Park, government subsidies have an effect on the production and efficiency of enterprises [30]. This study also includes government subsidies in the consideration of the inefficiency term [32–34]. Location factor: Due to the uneven development status among regions in China, the city or city cluster in which an enterprise is located can affect the production and operation activities of the enterprise in terms of resource sharing, industrial co-prosperity, and policy factors [35]. The variable is 1 for enterprises located in Shanghai and provincial capitals, while it is 0 for others.

4. Results and Discussion

4.1. Descriptive Statistics

The descriptive statistics of the relevant variables are shown in Table 1.

Table 1. Descriptive Statistics.

Variable Name	Variable Meaning	Mean	Standard Deviation	Maximum	Minimum
Y_{it}	Total profit (in millions)	325.2465987	777.3452668	9054.224903	−5764.194
K_{it}	Fixed assets (in millions)	16,697.08726	33,472.66837	315,402.734	10.44193309
L_{it}	Number of employees	4390.628205	6728.020177	60,224	13
z1	Local Moran's I index of total profit	0.048290548	0.462417503	2.936	−2.344
z2	Overhead costs (in millions)	257.0110332	717.7930018	7906.569	1.87

Table 1. *Cont.*

Variable Name	Variable Meaning	Mean	Standard Deviation	Maximum	Minimum
z3	Selling expenses (in millions)	114.1322998	258.0422616	2644.243	0.014
z4	Government subsidies (in millions)	8.841699469	96.53290932	1669.8393	0
z5	Financial leverage	26.82498355	71.63941821	804.389	0.1684
z6	City scale	0.384615385	0.486504255	1	0

4.2. Moran's I Test Results and Analysis

The test results of the Global Moran's I index are shown in Table 2 below. The test results of the Global Moran's I index show that, except for the individual observation time, the total profit distribution of the new energy cluster in the Yangtze River Delta shows obvious positive spatial autocorrelation, and the test results are statistically significant. They show that the closer the geographical location of enterprises in the Yangtze River Delta, the closer the profits indices of the enterprises. The fluctuation range of the Global Moran's I index value of the observed enterprises gradually increased during the sample period, indicating a certain degree of an industrial cluster effect on the enterprises among the Yangtze River Delta; the industrial cluster effect increases, but the effect on the profits of the sample enterprises is uncertain.

Table 2. Global Moran's I test results.

Time	Global Moran's I	Time	Global Moran's I
t1	0.113 *	t12	−0.01
t2	0.072	t13	0.113 *
t3	0.055	t14	−0.013
t4	0.153 **	t15	0.102
t5	0.266 ***	t16	0.205 **
t6	0.137 *	t17	0.198 **
t7	0.285 ***	t18	−0.068
t8	0.278 ***	t19	0.153 *
t9	0.346 ***	t20	−0.151
t10	0.238 ***	t21	−0.250 ***
t11	0.273 ***	t22	0.298 ***

Significance level of 0.1 is indicated by *, a level of 0.05 by **, and a level of 0.001 by ***.

However, in the later period of the sample, the Global Moran's I index results were all less than 0 in observation periods 12, 14, 18, 20, and 21, showing obvious spatial heterogeneity. The decreasing trend in spatial homogeneity reached an extreme value in the penultimate observation period, with a Global Moran's I index equal to −0.25, showing strong spatial heterogeneity at a significance level of 1%. One explanation for this phenomenon is that new energy enterprises are greatly influenced by scientific and technological innovation. During this observation period, some enterprises mastered the core technologies in the field of new energy, which made them stand out in the regional competition. However, due to the knowledge spillover effect of clusters, the proximity in geographical location encourages enterprises to learn from each other and spread knowledge rapidly [36], which makes the profits of enterprises within clusters tend to be homogeneous at the last observation period.

Strictly speaking, the Global Moran's I index provides information on whether the observation sample as a whole has a tendency of clustering or dispersing among enterprises with similar profits, namely, whether there is spatial autocorrelation in the sample as a whole, but it is impossible to assess the information of enterprises adjacent to a single unit in a certain area. Therefore, if we want to observe whether there is spatial autocorrelation in the region based on each observation unit, namely, whether there is homogeneity or heterogeneity, we need to do so with the help of the Local Moran's I index. The test results of the Global Moran's I index are shown in Figure 2 below. Lines in different colors represents the range of Local Moran's I index of different sample enterprises in the sample period.

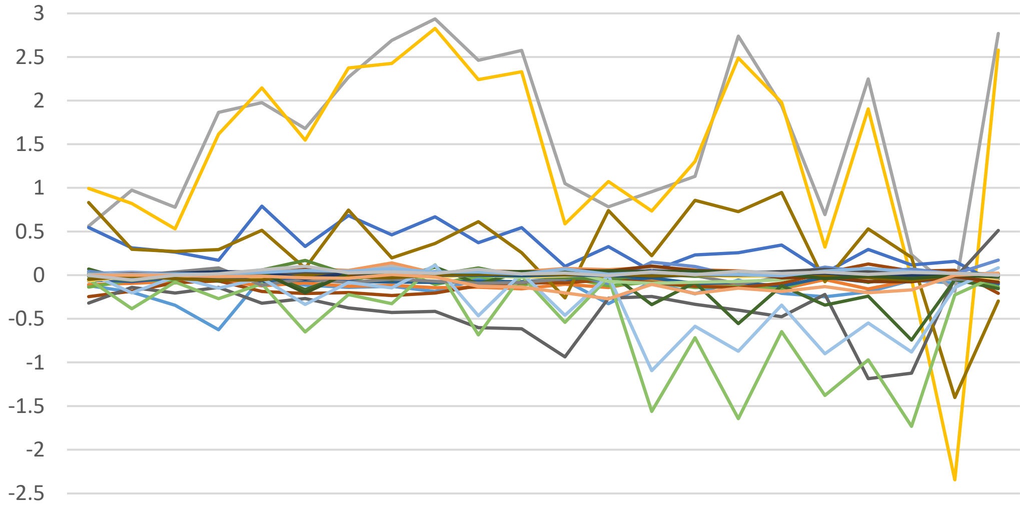

Figure 2. Local Moran's I index line chart.

Based on the nature of the Local Moran's I index, we grouped the new energy enterprises in the Yangtze River Delta into three main dimensions, from 1 to 0 to −1, namely: (1) the "alliance between giants" dimension, where the output levels of the observed sample and other adjacent enterprises in its location are strong, showing a trend of synergistic innovation development; (2) the "mutual help" dimension, where the sample is located in a region with enterprises with different strengths, and some enterprises with strong innovation and development strengths drive the development of enterprises with relative development weaknesses; and (3) the "one and only leader" or the "one and only lagging behind" dimension, where the observed enterprise is either stronger or weaker than other enterprises in the region, showing the spatial clustering phenomenon of "one leader" or "one lagging behind".

The distribution of the Local Moran's I index results in the Yangtze River Delta being similar to that of the Global Moran's I index, showing the following characteristics: (1) For some enterprises, the Local Moran's I index values are close to zero, namely, that they are in the "mutual help" dimension, which indicates that both strong and weak new energy enterprises are in the Yangtze River Delta; in particular, there are no obvious homogeneous clustering or heterogeneous clustering characteristics for these enterprises. This indicates that these enterprises themselves fail to produce a strong radiation effect or that the ability to accept the radiation effect of other enterprises in the cluster is low, and the effect of the cluster on enterprise profits is not obvious. (2) In the early period of the sample, the spatial effect of profits among enterprises is not obvious. The distribution of enterprises presents a certain disorder, which may be related to the strong spatial barriers among enterprises in the early period of sample observation. With the passage of observation time, the influence among enterprises in the cluster continues to deepen, and the volatility of the Local Moran's I index in the sample gradually increases. In the new energy enterprise cluster in the Yangtze River Delta, the spatial effect of enterprises gradually increases, and the mutual influence among enterprises with similar geographical locations in the sample gradually increases. (3) The Local Moran's I index of some enterprises always maintained a high value during the observation period, showing spatial homogeneity, and showed a strong linkage characteristic. To some extent, this indicates that when enterprises with similar profit levels are close to each other in the cluster they tend to develop cooperatively. Healthy competition between enterprises makes the neighboring enterprises continuously benefit and thus develop, as well as progress, together [36].

4.3. Fixed-Effect Stochastic Frontier Model (SFM) Results and Analysis

Although we found that the profit indicators of the sample new energy enterprises showed certain spatial correlation through the Moran's I index, the Global Moran's I index test or Local Moran's I index test could not be used to evaluate whether the profits of sample enterprises would be affected by the profit levels of neighboring enterprises. In other words, the Moran's I index test reflects the static spatial agglomeration or dispersion phenomenon, reflecting whether the enterprises in a certain area of the sample have homogeneity or heterogeneity. To observe the dynamic impact of the attributes of enterprises adjacent to the sample on the attributes of the observed sample, the panel stochastic frontier model needs to be used for evaluation. The results are shown in Table 3.

Table 3. Fixed-effect panel stochastic frontier model test results.

Production Function	**Model (1)**	**Model (2)**
lnK	0.129 (0.604)	0.628 *** (0.091)
lnL	0.088 (0.676)	−0.166 (0.117)
$[\text{lnK}]^2$	−0.081 (0.084)	
$[\text{lnL}]^2$	−0.168 *** (0.059)	
lnK × nL	0.282 ** (0.127)	
Inefficiency	Model (1)	Model(2)
z1	−0.144 *** (0.044)	−0.372 *** (0.064)
z2	0.231 *** (0.033)	0.500 *** (0.052)
z3	−0.071 *** (0.025)	−0.152 *** (0.031)
z4	−0.000 (0.000)	−0.000 * (0.000)
z5	−0.049 ** (0.023)	−0.133 *** (0.028)
z6	−0.052 (0.067)	−0.088 (0.070)

Significance level of 0.1 is indicated by *, a level of 0.05 by **, and a level of 0.001 by ***.

The coefficients of key variables of both the translog model and the Cobb–Douglas model are the same, and the coefficients of key variables such as the Local Moran's I index of profit, as well as the variables in the perturbation factor term, have the same sign for both the translog production function model and the Cobb–Douglas production function model, which also proves the robustness of the model and the results to some extent. The translog function results are used for analysis in the following part.

The sign in front of the whole inefficiency term, u_{it}, is negative, so when the results of the inefficiency perturbation variables are analyzed, a negative coefficient indicates that the variable is negatively correlated with inefficiency and positively correlated with efficiency; a positive coefficient indicates that the variable is positively correlated with inefficiency and negatively correlated with efficiency.

The coefficient of the Local Moran's I index (z1) is −0.144, which shows that, as the Local Moran's I index increases, the inefficiency term tends to decrease and the profit tends to increase, such that the heterogeneous agglomeration of the new energy industry has a positive effect on improving profits. This indicates that, when the enterprises with a geographical location close to the observed sample have the homogenous profit indicators as the observed enterprises, that is, when the region presents the dimension of "combination of strong and strong", neighboring enterprises have a positive impact on the profits of the observed sample. For this phenomenon, we believe that homogeneous enterprise agglomeration can give full play to the competition and innovation effect, as well as the knowledge spillover effect among enterprises, and develop benign competition among enterprises, forming a virtuous cycle dominated by absorbing new enterprises into the cluster and advocating technological innovation [36,37]. When the characteristic of strong enterprise clustering is present in the region, the innovation and R&D abilities of new energy enterprises are fully stimulated. The proximity of geographical location enables strong enterprises to have sufficient healthy competition, thus helping to improve the technological progress ability of enterprises. When the characteristic of weak enterprise clustering is present in the region, the agglomeration of weak enterprises can help enterprises to get rid of the encroachment of strong enterprises on the limited resources and unfair competition in a particular area, carry out research and development stably, and improve production efficiency.

The coefficient of overhead costs (z2) is 0.231 and significant at a 1% significance level. This shows that, with the improvement of overhead costs, the inefficiency of enterprises rises, leading to a decline in profits. We believe that, because Chinese new energy enterprises are innovation-oriented [38], blindly raising overhead costs may not be able to direct positive effects to the promotion of enterprise profits. At the same time, this may also be caused by some internal management problems caused by the ineffective use of overhead costs, such that the increase in operation and management costs cannot effectively improve profits. The coefficient of sale costs (z3) is −0.071 and is significant at a 1% level of significance, which is a good confirmation of previous studies on sale costs in the literature. There is another explanation for the positive effect of selling costs on the efficiency of enterprises' economic output, as new energy has emerged as an innovative method in recent years; higher marketing and advertising expenses can increase consumer recognition of firms' products, which can have a positive effect on product sales and profit improvement [28].

5. Conclusions

This study first measures the clustering effect of new energy enterprises listed in China's Shanghai and Shenzhen A-share markets from 2010 to 2011 through the Moran's I index, a research paradigm of spatial measurement; subsequently, a fixed-effects panel stochastic frontier model is used to observe the effect of the clustering effect of the new energy industry on its output performance indicators, and the results are statistically significant.

The results of this study show that: (1) The test results of the Global Moran's I index show that the spatial autocorrelation of profit indicators in the Yangtze River Delta area of China is positive. However, this homogeneity shows a decreasing trend in the observation period. The results of the Local Moran's I index test show that some of the sample enterprises show different degrees of spatial homogeneity or heterogeneity. However, quite a number of enterprises are still shown to be disorderly. With the passage of time, the spatial autocorrelation of sample enterprises gradually increases. (2) The fixed-effects panel stochastic frontier model analysis indicates that the industry cluster effect does not necessarily have a positive effect on the improvement of the economic output indicators of enterprises, and the positive effect of industry clusters can only be given full play when homogeneous enterprises undergo clustering, forming a situation of win–win co-operation. Therefore, this study concludes that, although the layout of new energy enterprises in the Yangtze River Delta area of China shows a certain physical spatial agglomeration, the agglomeration shows a decreasing homogeneity in the observation period. Only when homogeneous enterprises gather can the positive effect of industrial clusters on the profit of new energy enterprises be brought into full play. On this basis, this study proposes countermeasures for the sustainable development of new energy enterprises.

First, pay attention to the new energy industry layout; optimize the industrial layout planning of existing new energy enterprises; guide the new energy enterprise agglomeration development trends in the future; utilize the positive cluster effect of heterogeneous enterprise agglomeration; promote benign interaction among market players; and strive to build a new energy industry cluster with advantageous competitiveness.

Second, cultivate the endogenous momentum of the development of new energy industrial clusters; promote the synergistic development of enterprises in different modes; improve the efficiency of collaboration among enterprises; enhance the degree of specialization and agglomeration of the new energy industry, while integrating the advantages in the clustering area; enrich the diversification of the new energy industry to increase the total profit of new energy enterprises; and drive the comprehensive economic performance of the clustering area.

Third, strengthen the guidance role of policy for the new energy industry. Governments at all levels should not only consider inherent conditions, such as industrial base and resource endowment, but also fully consider and make use of the cluster effect of the new energy industry, strengthening and guiding the exchange and cooperation of new energy enterprises with similar profit levels, as well as realize the win–win development of regional enterprises.

Our work has some potential limitations that should be noted and can be addressed in future research. First, we do not consider the spatio-temporal model. In future research, we will try to directly use some spatio-temporal model to analyze the impact of nearby firms' profits on firm profits. Second, at present, there is no uniform statistical catalog of China's new energy industry and its related industries [39], and it is difficult to accurately obtain the data of related industries from the statistical yearbook or statistical bulletin, which has produced certain obstacles for quantitative research. Future research can carry out further in-depth analyses of the refined statistical data. Finally, this study focuses on the new energy industry as a whole. As the industrial division becomes more and more detailed, future research can be carried out on specific new energy industry sectors, such as photovoltaic industry clusters and wind power industry clusters.

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