Analysis of Factors Affecting the Import and Export of New Energy Products

-- Based on the Contour Empirical Analysis Model

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Abstract. With global warming and climate change becoming more and more serious, countries around the world have begun to pay attention to emission reduction and environmental protection, and the concept of 'dual carbon' has further penetrated into people's hearts, bringing new opportunities for the export of power lithium batteries from China. This paper aims to conduct a digital analysis of the export trade of the top seven countries (regions) in terms of the volume of power lithium battery trade in China, and to explore the influencing factors of the export volume of power lithium batteries from China. This paper first conducts a contour analysis based on the data fluctuations of five indicators in 32 provinces (excluding Hong Kong, Macao and Taiwan) from 2019 to 2021: total carbon dioxide emissions (mt), lithium iron phosphate production (10,000 tons), lithium battery electrolyte (10,000 tons), two-wheeled electric vehicles (100,000 vehicles), and lithium battery separators (10,000 tons). The final conclusion is that the 'dual carbon' background has a significant impact on China's power lithium battery industry. Furthermore, based on a panel data regression model, the factors affecting trade between China and the major countries (regions) exporting power lithium batteries are explored in depth. The results of the analysis found that the power generation, economic freedom, number of charging piles, population size, and per capita GDP of the exporting countries significantly affect the export volume of power lithium batteries in China. Among them, the population size and per capita GDP growth rate of the exporting countries have a negative impact, while the rest have a positive impact on the export volume of power lithium batteries in China.

Keywords: Power lithium battery; Double carbon; Contour analysis; Influencing factors; Panel data model.

1. Introduction

As governments around the world actively promote the rapid development of the new energy vehicle industry, they have had a sustained and highly positive effect on the power battery industry. The International Energy Agency (IEA) released the Global Electric Vehicle Outlook 2022, which pointed out that by 2022, 40 countries (regions) around the world had issued bans on fuel vehicles and formulated comprehensive electrification timetables. It is expected that by 2035, most countries (regions) will ban the sale of fuel vehicles. In September 2020, China clearly proposed the goals of 'carbon peak' by 2030 and 'carbon neutrality' by 2060, which will greatly promote the process of green and sustainable development of human society [1]. With the proposal of the 'double carbon' goal, the lithium battery industry will trigger huge investment opportunities and market demand, promote the transformation and upgrading of the lithium battery industry, and inject new impetus into the sustainable development of the new energy industry. As a key component of new energy vehicles, the development of new energy vehicles in China will also promote the export trade of power lithium batteries [2]. With the support of national policies and the trade environment, the export of power batteries in China is ushering in a blue ocean.

If China's new energy vehicles want to seize international market share, they must build a technology supply system for key components, mainly power batteries and management systems, and continuously improve their international competitiveness [3]. Europe's power battery certification regulations and supervision are stricter for Chinese manufacturers. Chinese electric vehicle battery

export enterprises should improve the safety performance of the battery system so that better products can go beyond China and reach the world. Therefore, this paper will combine panel data from the seven countries (regions) with the largest exports of power batteries. In the following research, contour analysis and mixed estimation, individual fixed effects, time fixed effects, individual and time double fixed effects, and random effects models will be used, as well as some new variables such as trade freedom and the number of power battery patents to explore the factors affecting the export of power batteries.

2. 'Double Carbon' Background: Development and Changes in China's Power Lithium Battery Industry

2.1. Development status of China's power lithium batteries

According to data from the China Information News Agency Research Institute, in the context of 'dual carbon', not only has carbon dioxide emissions been further controlled, but new energy electric vehicles have also developed. From January to December 2021, China's power lithium battery production reached a total of 219.7 GWh, a year-on-year increase of 163.4%. In 2022, China's power lithium battery production and sales increased exponentially [4]. The annual cumulative production reached 545.9 GWh, a year-on-year increase of 148.5%. The structure of a power lithium battery generally includes five parts: positive electrode material, negative electrode material, electrolyte, separator and shell. Therefore, this article mainly analyzes the development of China's power lithium battery industry based on five indicators in 32 provinces in 2019 and 2021: total carbon dioxide emissions, lithium iron phosphate production, lithium battery electrolyte, two-wheeled electric vehicles, and lithium battery separators. The general linear model contour analysis method is used to analyze the impact of the 'double carbon' context, which has a significant impact on the development of China's power lithium battery industry.

2.2. Development trends of China's power lithium battery industry

The factors in Table 1 include five indicators: total carbon dioxide emissions (mt), lithium iron phosphate production (10,000 tons), lithium battery electrolyte (10,000 tons), two-wheeled electric vehicles (100,000 vehicles), and lithium battery separators (10,000 tons). The years include all provinces and cities in 2019 and 2021. It can be seen from the multivariate test that the significance p-value of the factor and the year is 0.059. It can be considered that the contours of the two populations are parallel to each other, which means that the contours of the the fluctuation profiles of the data for each indicator are basically the same, which proves that the data for each indicator is valid and the trend of change is reasonable. At the same time, combined with the contour map in Figure 1, it can be seen that the mean value for 2021 is higher than that for 2019 [5]. Therefore, it can be proved that under the background of 'double carbon', the development of the lithium battery industry has a significant impact. The specific impact is expressed as: carbon emissions are further controlled, the production of lithium iron phosphate, lithium battery electrolytes, two-wheeled electric vehicles, and lithium battery separators has all increased significantly [6]. Under the influence of the 'double carbon' background, the following will analyse the influencing factors of power lithium battery exports from the three aspects of foreign environmental factors, economic factors and technological factors through a panel data model.

3. Analysis of Factors Promoting China's Power Lithium Battery Exports Under the Background of "Dual Carbon"

3.1. Model construction and description

This paper adopts a panel data model. Based on a broad literature review, it explores the impact of environmental factors, economic factors, and technical factors on China's power lithium battery

exports to foreign countries. In order to eliminate the error caused by inconsistent units in the original variables, this paper standardizes all variables and uses the robust method to reduce the impact of heteroscedasticity between variables [7].

Table 1. Multivariate test

Effect		Value	F	Assuming degrees of freedom	Error degrees of freedom	Significance
factor	Bailey track	.624	16.864b	4.000	15.000	.000
	Wilk Lambda	.376	16.864b	4.000	15.000	.000
	Holtlin track	4.663	16.864b	4.000	15.000	.000
	Roy Max root	4.663	16.864b	4.000	15.000	.000
factor * Year	Bailey track	.396	2.790b	4.000	15.000	.059
	Wilk Lambda	.564	2.790b	4.000	15.000	.059
	Holtlin track	.721	2.790b	4.000	15.000	.059
	Roy Max root	.721	2.790b	4.000	15.000	.059

3.2. Sample selection and variable description

3.2.1 Sample selection

The scope of this paper is the data of the United States, Germany, Japan, India, Hong Kong, China, the Netherlands, and Vietnam from 2016 to 2021. Countries (regions) with sensitive factors and incomplete samples are excluded, so seven countries (regions) in the top ten export volumes are selected. Among them, Y represents the export volume of China's power lithium batteries, $x_1, x_2, x_3, x_4, x_5, x_6$, respectively represent the export volume of China's power lithium batteries, the power generation of the exporting country, the number of power lithium battery patents in the exporting country, the economic freedom of the exporting country, the population size of the exporting country, the per capita GDP of the exporting country, and the number of charging piles in the exporting country [8].

Table 2. Top ten countries or regions in terms of power battery exports

Ranking	Countries and regions	Export volume (unit)
1	Hong Kong, China	604249266
2	United States	155930922
3	Belgium	137689507
4	Germany	126139506
5	Vietnam	87185327
6	India	80522359
7	South Korea	50839618
8	Taiwan, China	31685769
9	Italy	21755776
10	Poland	19460631

Data source: Statistical data from the General Administration of Customs of China

3.2.2. Variable description

All data in this article come from public data platforms and networks, including data information platforms such as the World Bank, Statistical data from the General Administration of Customs of China, the International Energy Agency, and the State Intellectual Property Office. Specific variable descriptions are as follows:

Table 3. Variable description and explanation

Variable	Description	Variable description
Y	China's export volume of power lithium batteries/unit	China's export volume of power lithium batteries uses 7 representative countries (regions) among the top ten exporting countries and regions as samples, and the import volume of power lithium batteries from these 7 countries (regions) to China is used as the explained variable.
x_1	Electricity generation of exporting countries/TWH	The power generation of the exporting country reflects the degree of energy support and the stability of energy supply in the local country (region) to a certain extent. The normal use of power lithium batteries requires a sound power supply. Some emerging market opportunities can be found, which usually mean sufficient purchasing power, energy demand and policy support.
x_2	Number of power lithium battery patents in exporting countries/pieces	The number of power lithium battery patents in the exporting country can show the technical level of power lithium batteries in the exporting country, the construction level of the core technology system of power lithium batteries, and then reflect the technical capabilities and quantity scale of power lithium batteries in the exporting country.
x_3	Economic freedom of exporting countries/%	Economic freedom is an important indicator for international evaluation of the degree of marketization and an important basis for a country to define the development of foreign trade. The attitude of the exporting country towards the market economy status of the importing country has become an obstacle to the development of foreign trade in the importing country.
x_4	Population size of exporting countries/10,000 people	Population size has a positive role in promoting the economy. The population size of a country is an important factor affecting trade flows. The huge population size reflects the size and scale of the country (region) to a certain extent.
x_5	GDP per capita	GDP per capita is a comprehensive indicator of a country's (region's) production and income levels, and can accurately and truly reflect the country's (region's) potential for sustainable economic and social development.
x_6	Number of charging piles in exporting countries	The number of charging piles is one of the key factors in the development and promotion of electric vehicles. More charging piles mean more convenient charging services, which can increase consumers' acceptance of electric vehicles and increase electric vehicle sales.

3.2.3. Empirical model setting

This paper constructs the following regression model (see formula) and uses spss12.0 software for model regression.

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \varepsilon \quad (1)$$

Table 4. Regression model

	Power lithium battery export volume	Electricity generation of exporting countries	Number of power lithium battery patents of exporting countries	Economic freedom of exporting countries	Population size of exporting countries	GDP per capita of exporting countries	Number of charging piles in exporting countries
Power lithium battery export volume	1						
Electricity generation of the exporting country	0.014	1					
Power lithium battery patents of the exporting country	0.226**	0.592***	1				
Economic freedom of the exporting country	0.213*	-0.404***	0.110	1			
Population size of the exporting country	-0.105	0.865***	0.303***	-0.719***	1		
GDP per capita of the exporting country	0.105	-0.080	0.359***	0.860***	-0.544***	1	
Number of charging piles in the exporting country	0.694***	0.116	0.511***	0.055	0.010	0.055	1
* p<0.1 ** p<0.05 *** p<0.01							

As can be seen from Table 4 above, relevant analysis is used to study the power lithium battery and the power generation capacity of the exporting country, the number of power lithium battery patents in the exporting country, the economic freedom of the exporting country, the population size of the exporting country, the per capita GDP of the exporting country, and the total number of charging piles in the exporting country. For the correlation between the 6 items, the Pearson correlation coefficient is used to express the strength of the correlation. Specific analysis shows:

The correlation coefficient value between the export volume of power lithium batteries and the power generation of the exporting country is 0.014, close to 0, and the p value is 0.903>0.05, which shows that there is no correlation between power lithium batteries and the power generation of the exporting country. The correlation coefficient value between power lithium batteries and the number of power lithium battery patents in exporting countries is 0.226, and shows significance at the 0.05 level, which shows that there is a significant difference between power lithium batteries and the number of power lithium battery patents in exporting countries [9]. positive correlation. The correlation coefficient value between power lithium batteries and the economic freedom of exporting countries is 0.213, close to 0, and the p value is 0.062>0.05, which shows that there is no correlation between power lithium batteries and the economic freedom of exporting countries.

The correlation coefficient value between the export volume of power lithium batteries and the population size of the exporting country is -0.105, close to 0, and the p value is 0.362>0.05, which shows that there is no correlation between power lithium batteries and the population size of the exporting country. The correlation coefficient value between power lithium batteries and the per capita GDP of the exporting country is 0.105, close to 0, and the p value is 0.364>0.05, which shows that there is no correlation between the export volume of power lithium batteries and the per capita GDP of the exporting country. The correlation coefficient value between power lithium batteries and the number of charging piles in exporting countries is 0.694, and shows significance at the 0.01 level, which shows that there is a significant positive correlation between the export volume of power lithium batteries and the number of charging piles in exporting countries [10].

3.3. Empirical analysis

3.3.1. Model estimation results regression

Before formal regression, it is necessary to conduct Hausman test on each variable of the model. Use spss12.0 to conduct Hausman test on the variables. The test results are as follows in Table 5.

Table 5. Summary of test results (n=77)

Test type	Purpose of the test	Test value	Test conclusion
Hausman test	Comparison and selection between FE model and RE model	$\chi2(8) = -44.738$, p=1.000	RE model

This study uses the power generation capacity of the exporting country, the number of power lithium battery patents in the exporting country, the economic freedom of the exporting country, the population size of the exporting country, the per capita GDP of the exporting country, and the charging piles of the exporting country as explanatory variables, and the export volume of power lithium batteries as the explained variable [11]. A panel model was constructed and the robust standard error method was used for modeling. First, model testing is performed to find the optimal model. From Table 5 above, we can see that the Hausman test does not show significance chi(8)=-44.738, p=1.000>0.05, which means that compared with the fixed effects model, The random effects model is better, and finally the random effects model is used as the final result.

Table 6. Random effects model intermediate process values

Item	Coef	Std. Err	t	p	95% CI
Intercept	3.664	0.109	33.611	0.000***	3.451 ~ 3.878
Electricity generation of the exporting country	0.529	0.132	4.015	0.000***	0.271 ~ 0.787
Number of power lithium battery patents of the exporting country	-0.012	0.009	-1.453	0.151	-0.029 ~ 0.004
Degree of economic freedom of the exporting country	0.014	0.004	3.099	0.003***	0.005 ~ 0.023
Population size of the exporting country	-0.519	0.106	-4.904	0.000***	-0.726 ~ -0.311
GDP per capita of the exporting country	-0.467	0.133	-3.522	0.001***	-0.727 ~ -0.207
Number of charging piles of the exporting country	0.441	0.127	3.467	0.001***	0.192 ~ 0.690
$\chi2(6)=334.162$,p=0.000					
$R^2=0.701$,R^2(within)=0.678					
* p<0.1 ** p<0.05 *** p<0.01					

In Table 6, we present the intermediate process values of the random effects model, including the coefficients, standard errors, t-values and p-values of each variable. These results provide the basis for subsequent analysis and help us gain a deeper understanding of the impact of various factors on the results of the model. The data in Table 6 shows that variables such as electricity production, economic freedom, and the number of charging piles have a significant impact on exporting countries, while the number of battery patents, population size and GDP per capita show a negative correlation.

Next, in Table 7, we present the main results and statistical significance of a further analysis of the random effects model. This table highlights the overall goodness of fit of the model, with an R^2 of 0.701, indicating that the model can explain about 70.1% of the variation in the data. In addition, the χ^2 test result shows that the model as a whole is significant (p = 0.000), further verifying the validity of the model. These results provide a more comprehensive perspective on understanding the multiple influencing factors of countries exporting electricity.

Table 7. Random effects model analysis

Item	Random Effects Model
Intercept	3.664*** (33.611)
Electricity generation of exporting countries	0.529*** (4.015)
Number of power lithium battery patents of exporting countries	-0.012 (-1.453)
Degree of economic freedom of exporting countries	0.014*** (3.099)
Population size of exporting countries	-0.519*** (-4.904)
GDP per capita of exporting countries	-0.467*** (-3.522)
Number of charging piles of exporting countries	0.441*** (3.467)
R^2	0.701
R^2(within)	0.678
Sample size	77
Test	$\chi 2(6) = 334.162$, $p = 0.000$

3.3.2. Analysis of empirical results

This study uses the random effects model as the final result. From Table 6 and Table 7 above, it can be seen that the power generation of the exporting country is significant, which shows that the power generation of the exporting country has a positive impact on the export volume of power batteries. As an efficient energy storage device, power lithium batteries can effectively store and use electricity. The stronger the power generation capacity of exporting countries, it will help meet the growing power demand for power lithium batteries, thus promoting the export of China's power lithium batteries.

For the economic freedom of the exporting country, it shows significance at the 0.01 level (t=3.099, p=0.003<0.05), and the regression coefficient value is 0.014>0, which shows that the economic freedom of the exporting country has a significant impact on the export volume of power batteries. Significant positive relationship. The higher the degree of economic freedom, the better the bilateral trade between China and exporting countries. Exporting countries have a higher degree of economic freedom and greater market openness, which can attract more foreign investment and technology, thereby improving their own industrial level and product competitiveness, thereby increasing demand for high-tech products such as power lithium batteries.

Regarding the population size of the exporting country, it shows significance at the 0.01 level (t=-4.904), p=0.000<0.05), and the regression coefficient value is -0.519<0, indicating that the population size of the exporting country has an important impact on power battery exports. Quantity will have a significant negative impact. Among the countries (regions) selected for research in this article, most of the countries with large populations are developing countries with uneven development. Due to uneven economic development, it is difficult to popularize new energy vehicles in the country, so exports There is a negative correlation between the country's population size and the export volume of power batteries.

For the GDP per capita of the exporting country, it shows significance at the 0.01 level (t=-0.467, p=0.001>0.05), and the regression coefficient value is -0.467<0, which shows that the GDP per capita of the exporting country has a significant impact on power battery exports. Quantity has a significant negative impact on the relationship. As the economy of exporting countries grows, their domestic new energy industries may gradually transform into high value-added, technologically innovative

industries, thereby reducing the demand for low value-added Chinese power lithium batteries. In addition, due to the economic development of exporting countries, measures may be taken to protect the country's new energy battery industry, which will limit the demand for Chinese power lithium batteries. In addition, with the economic growth of exporting countries, more market competitors will participate in the country's new energy market, leading to a reduction in the exporting country's demand for Chinese power lithium batteries, thus reducing the demand for Chinese power lithium batteries.

Regarding the number of charging piles in exporting countries, it shows significance at the 0.01 level ($t=3.467$, $p=0.001<0.01$), and the regression coefficient value is $0.441>0$, indicating that the number of charging piles in exporting countries has a significant impact on the export volume of power batteries. will have a significant positive impact. More charging piles mean more convenient charging services, which can increase consumers' acceptance of new energy vehicles and increase sales of power lithium batteries, further promoting demand for power batteries. Therefore, the increase in the number of charging piles in China's export countries will have a positive impact on China's power battery exports. Therefore, the electric vehicle charging piles exported from China may be equipped with power batteries produced in China, thereby increasing the export volume of China's power batteries. This also reflects China's comprehensive competitive advantages in the fields of electric vehicle charging and power batteries.

Regarding the number of power lithium battery patents in exporting countries, it does not show significance ($t=-1.453$, $p=0.151>0.05$), thus indicating that the number of power lithium battery patents in exporting countries will not have an impact on power battery exports. relation.

4. Discussion

China has abundant lithium resources and a complete industrial chain. Its power lithium battery manufacturing technology and cost advantages are obvious, which can meet the global market's demand for high performance, high safety and high stability of batteries. In addition, the exporting countries (regions) have strong measures for energy conservation and emission reduction, the rapid development of new energy, high economic freedom and good foreign trade environment. In addition, the development of China's power lithium batteries conforms to the general trend of carbon peak and carbon neutrality. These favorable conditions have greatly promoted China's power lithium battery exports.

On August 17, 2023, the EU Battery and Waste Battery Regulation officially came into effect. According to the New Battery Law, from 2027, power lithium batteries exported to Europe must hold a "battery passport" that meets the requirements, recording information such as battery manufacturers, material composition, carbon footprint, and supply chain. Enterprises need to adapt to new regulatory requirements and enhance product quality and compliance with environmental standards to ensure that their products can enter the European market smoothly. At the same time, enterprises also need to strengthen cooperation with European customers, strengthen local industrial investment, and provide customized solutions to meet their requirements for environmental protection and sustainable development.

Industry insiders believe that after the implementation of the "New Battery Law", Chinese power lithium battery companies exporting to Europe must first supplement and improve their carbon footprint statements. At present, there is a general lack of understanding of battery carbon footprint and carbon management in China, and the accumulation of carbon footprint in the whole life cycle is weak. The recognition mechanism for the use of recycled raw materials has not yet been fully established. At the same time, there are still a series of problems in the carbon emission management policy of lithium batteries, such as unclear, inconsistent standard databases, and international mutual recognition. These will bring challenges to the future overseas expansion of Chinese power lithium battery companies.

Regarding the relevant content of the "Battery and Waste Battery Regulations", for example, Jiangsu Changshu Customs provides front-line services and actively helps companies to cope with new regulations. While strictly implementing inspection and identification, confirming that the applicability and use of packaging meet technical standards, and ensuring the safety of dangerous goods transportation, it optimizes the export inspection model and launches the "appointment inspection, immediate inspection, and hierarchical management" service package to help companies reduce logistics costs and shorten delivery cycles. Customs in China should also refer to this practice to form a dual cooperation between the government and enterprises and shorten the trade cycle.

5. Conclusion

In summary, the "dual carbon" background has a significant impact on the development of China's power lithium battery industry, and as the "dual carbon" concept is increasingly recognized by various countries, it also has a significant impact on the export trade level of power lithium batteries. promotion effect. The development of China's power lithium battery industry focuses on the improvement of the upstream and downstream of the industrial chain and the expansion of raw material production scale, in order to improve the development of related new energy industries. Therefore, each province must ensure the circulation of new energy raw materials and new energy product markets. Optimize the resource allocation of the new energy industry, build and improve the new energy market, promote economic transformation and upgrading, and reduce market information costs; according to this study, the power generation capacity of exporting countries, the economic freedom of exporting countries, and the number of charging piles in exporting countries are all important for promoting China's power lithium The significance of battery exports means that the more complete the new energy industry infrastructure is, the more conducive it is to promoting new energy industry trade. Therefore, it is conducive to positioning a new energy resource trading country and promoting the development of the dual cycle of China's new energy industry.

In the face of the gradually advancing "carbon neutrality" cause, this article studies the development status of the new energy industry from both domestic and foreign perspectives, and makes an explanation at the measurement level, which shows the timeliness and innovation of the article and is helpful Research to promote high-quality development of new energy.

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