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Analysis of China's New Energy Vehicle Export Competitiveness in a Dual-Carbon Context

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Abstract: In the context of the dual-carbon goals (carbon peaking and carbon neutrality), China's new energy vehicle industry, as a key component of the green economy, has increasingly attracted international attention for its export competitiveness. Drawing on the Porter Diamond Model, this paper selects four major variables—R&D investment, production factors, demand factors, and spare parts services—to establish a linear regression equation. Through this model, the trade competitiveness of China's new energy vehicles is analyzed in detail, and corresponding suggestions are proposed to enhance the competitiveness index. It is anticipated that Chinese new energy vehicle enterprises can strengthen overseas competitiveness by advancing core technology innovation, improving comprehensive industrial chain management, and diversifying sales channels.

Keywords: Dual-carbon context; New energy vehicles; Export competitiveness

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1. Introduction

In response to the global challenge of climate change, China announced the dual-carbon goals of carbon peaking and carbon neutrality in 2020, aiming to drive a green transformation of its economy and society through the reduction of greenhouse gas emissions. This strategy not only aligns with international climate governance objectives but also presents unprecedented development opportunities for China's domestic new energy vehicle industry.

As a representative of green and low-carbon development, the sustained growth in exports of China's new energy vehicles has become a focal point in the transformation and upgrading of the country's manufacturing sector. With increasing global demand for new energy vehicles, China has rapidly emerged as a significant player in the international market, leveraging its strengths in battery technology, cost efficiency, and supply chain integration.

The comprehensive implementation of the dual-carbon strategy has further spurred innovation and development within the new energy automobile industry, enhancing the international competitiveness of Chinese products. Simultaneously, the rising global demand for green and low-carbon products has created expansive market opportunities for the export of new energy vehicles. Accordingly, studying the intersection of the dual-carbon strategy and the export of new energy vehicles is particularly valuable for exploring green transformation pathways in China's manufacturing sector and advancing cooperation in global climate governance.

2. Export status of China's new energy vehicles under the background of "dual carbon"

2.1. Situation of China's new energy vehicle export regions

With continuous advancements in scientific and technological development, coupled with policy support from the Chinese government, China's new energy vehicle industry has achieved remarkable progress that has garnered global attention.

From the perspective of export types and regional distribution, as shown in **Table 1**, the primary export models of China's new energy vehicles include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs) [1]. Notably, the export distribution of China's new energy vehicles in 2023 spans six continents, with significant export volumes in Asia and Europe. In Asia, the number of pure electric vehicles exported reached 450,000 units, accounting for approximately 40% of the total exports. Similarly, Europe received about 500,000 pure electric vehicles, representing nearly 50% of the total export volume. This indicates a particularly high acceptance and popularity of new energy vehicles in Europe.

Currently, China's new energy vehicle industry is in a phase of rapid growth. It is anticipated that in the coming years, numerous automobile enterprises and technology companies in China will enter the new energy vehicle sector. This will not only intensify competition within the domestic industry but also present foreign automobile companies with expanded market opportunities [2].

Table 1. Types and regional distribution of China's new energy vehicle exports in 2023 (10,000 units)

	Battery electric vehicles (BEVs)	Plug-in hybrid electric vehicles (PHEVs)	Hybrid electric vehicles (HEVs)	Proportion (%)
Asia	45	1.2	1.4	40
Europe	48.5	8	0.3	48
South America	6.5	5.1	0.1	3
North America	5.1	2	0.05	4
Oceania	4.9	1.7	1.2	3
Africa	1.2	0.5	0.1	2

Data source: China Association of Automobile Manufacturers

From the perspective of export volumes by country (**Figure 1**), Belgium, Thailand, the United Kingdom, the Philippines, and Spain represented the largest demand for China's new energy vehicles in 2023 [3]. Belgium accounted for the highest proportion of exports, at 11%, corresponding to Europe as the primary hub for China's

new energy vehicle exports. In Asia, Thailand and the Philippines collectively accounted for approximately 20% of the export volume, with a total of 200,000 units exported. Additionally, Australia, India, the Netherlands, Israel, and Bangladesh contributed a combined export volume of 300,000 units, also representing 20% of the total. These figures highlight the vibrant activity in both the European and Asian automotive markets.

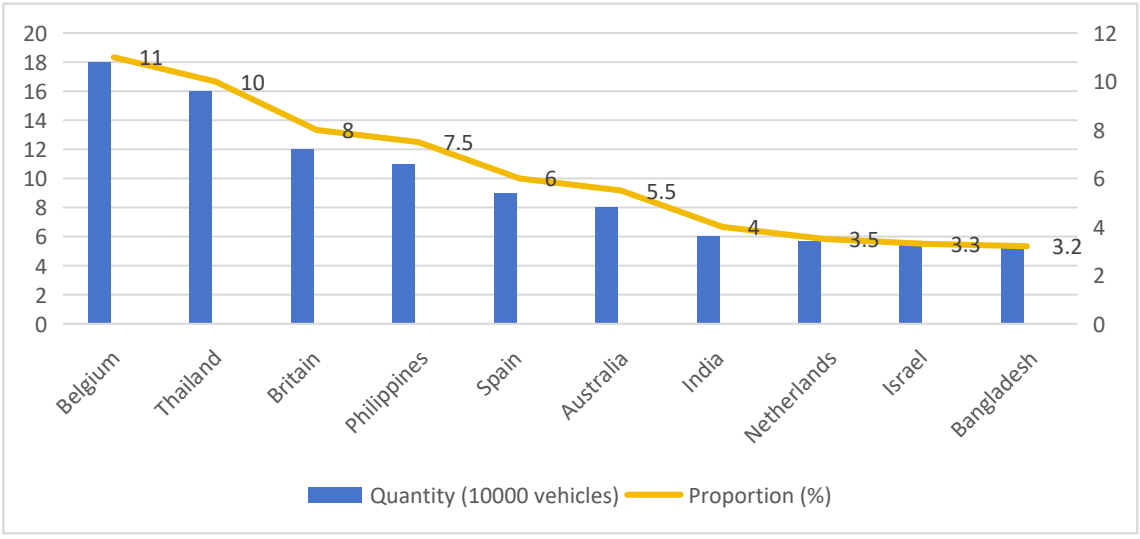

Figure 1. Export volume of China's new energy vehicles by country

2.2. Export quantity and export value of China's new energy vehicles

The scale of China's new energy vehicle exports has shown significant growth in recent years. While both export volumes and growth rates declined from 2019 to 2020, exports surged from 550,000 units in 2021 to 1.77 million units in 2023, representing a more than threefold increase. Concurrently, total export value rose from $10.8 billion in 2021 to $41.837 billion in 2023, achieving a remarkable leap and maintaining a growth rate exceeding 70%, as illustrated in **Figures 2** and **3**.

These trends indicate a substantial and growing demand for China's new energy vehicles in the international market, underscoring their strong market potential [4].

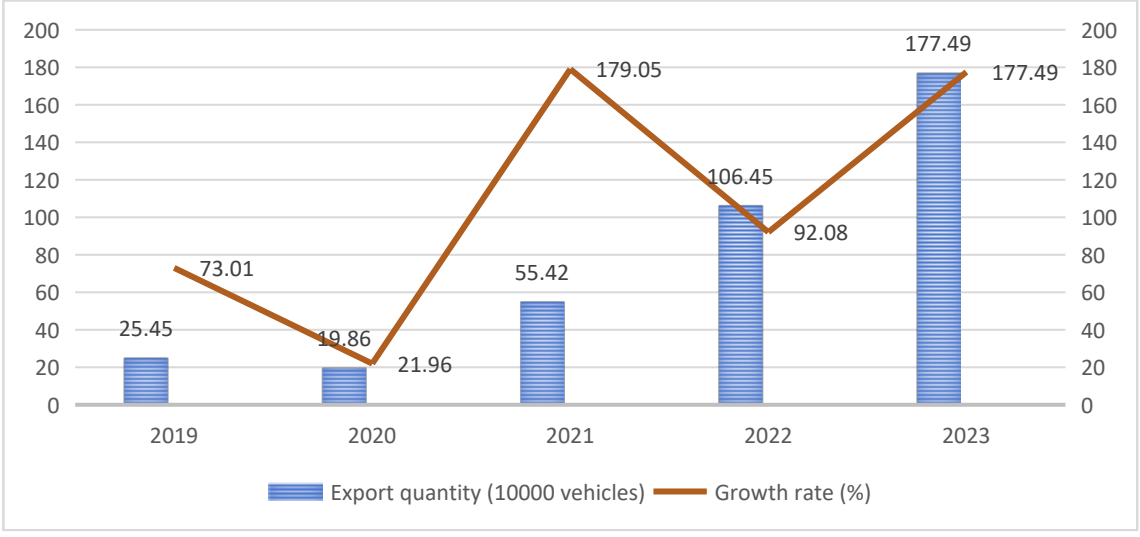

Figure 2. Export volume of China's new energy vehicles, 2019–2023 (Source: General Administration of Customs of China)

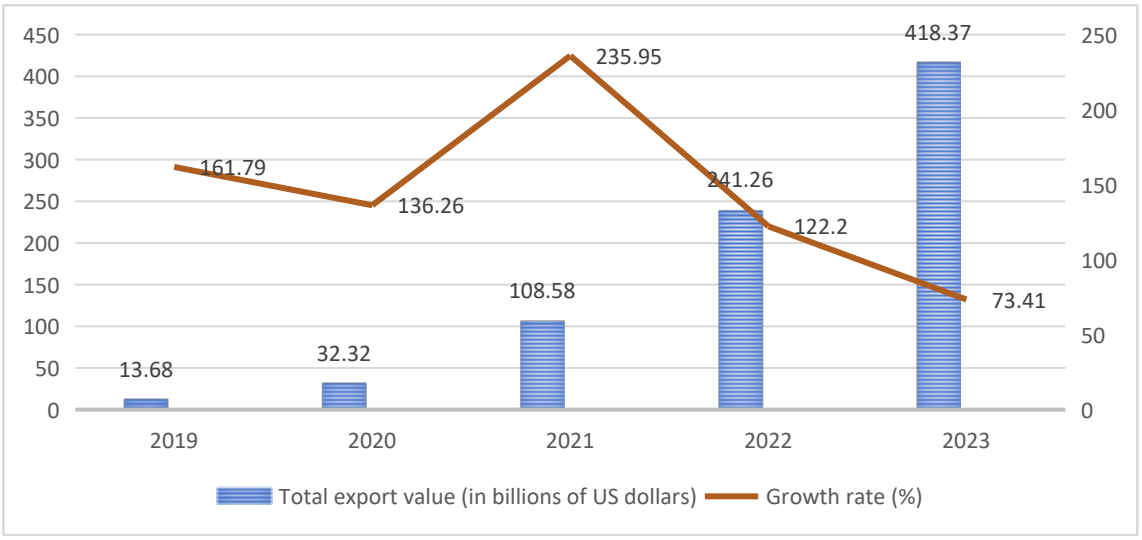

Figure 3. Total exports of new energy vehicles in China, 2019–2023 (Source: General Administration of Customs of China)

3. Analysis of the trade competitiveness index of China's new energy vehicles

3.1. Selection of variable indicators

Using Porter's "diamond model," a variable index system was developed to evaluate the trade competitiveness of China's new energy vehicles [2]. A linear regression equation was established based on four primary variable indicators: R&D investment, production factors, demand factors, and spare parts services. Sub-variable indicators were also selected to provide a more detailed analysis of the trade competitiveness of China's new energy vehicles (**Table 2**).

Table 2. Selection of variables for export competitiveness of China's new energy vehicle trade

Primary variable index	Serial number	Sub-variable indicators
R&D investment	1	R&D investment (ten thousand Chinese yuan)
	2	R&D personnel (thousands of people)
Production factors	3	Labor productivity (%)
	4	Employment in the new energy vehicle industry (thousands of people)
Demand factors	5	Annual output of new energy vehicles (ten thousand units)
	6	Annual sales of new energy vehicles (ten thousand units)
Spare parts services	7	Number of charging piles (units)
	8	New energy vehicle battery recycling stations (units)

3.2. Data sources

The data utilized in this analysis, including R&D investment, annual output of new energy vehicles, and annual sales of new energy vehicles, were sourced from the China Association of Automobile Manufacturers and the "China New Energy Vehicle Statistical Yearbook."

3.3. Analysis of export competitiveness data

A multiple linear regression equation was established using five sub-variables: R&D investment, employment in the new energy vehicle industry, annual output of new energy vehicles, annual sales of new energy vehicles, and the number of charging piles. The regression equation can be expressed as:

$$X = A + r_1 k_1 + r_2 k_2 + r_3 k_3 + r_4 k_4 + r_5 k_6 + b$$

where X represents the export competitiveness of trade, A is the intercept, r_1 to r_5 are the correlation coefficients for R&D investment, labor productivity, annual output of new energy vehicles, annual sales of new energy vehicles, and the number of charging piles, respectively, and b represents the error term.

Table 3. Correlation analysis

Variable	Export competitiveness	R&D investment	Employment in the new energy vehicle industry	Annual sales of new energy vehicles	Number of charging piles
Export competitiveness	1.00				
R&D investment	0.667	1.00			
Employment in the new energy vehicle industry	0.6648	0.3352	1.00		
Annual sales of new energy vehicles	0.2921	0.0431	0.6648	1.00	
Number of charging piles	-0.2723	0.3154	0.6648	0.2921	1.00

From **Table 3**, it can be observed that variables such as R&D investment and employment in the new energy vehicle industry have significant positive correlations with export competitiveness, demonstrating their importance as influential factors [5].

The export competitiveness index for China's new energy vehicles from 2013 to 2023 is estimated in **Figure 4**.

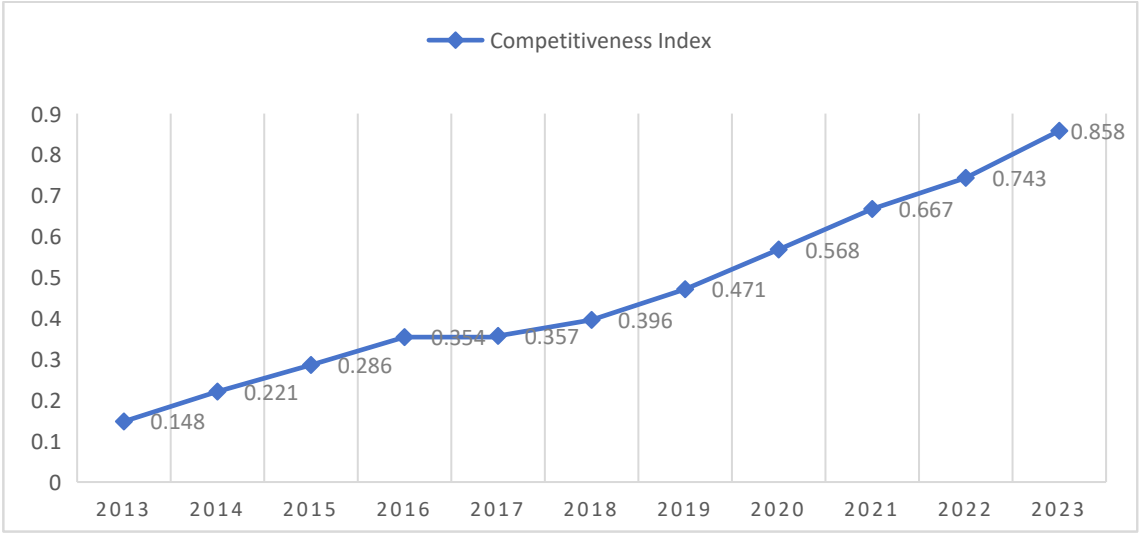

Figure 4. Estimated export competitiveness index of new energy vehicles, 2013–2023

According to the analysis of the competitiveness index chart, the trade competitiveness of China's new energy vehicles has been continuously enhanced in the past ten years, and the international market share has been continuously increased [6].

3.4. Conclusion of trade competitiveness data

Based on the established model and the data illustrated in **Figure 4**, the overall export competitiveness of China's new energy vehicles is robust. However, competitiveness varies across different factors:

(1) Demand factors: This category has the highest coefficient, indicating that market demand significantly drives competitiveness.

(2) R&D investment: While substantial, its coefficient is lower than that of demand factors, showing room for improvement in technological innovation.

(3) Spare parts services: This aspect has the smallest coefficient, indicating limited competitiveness in this area [7].

To address these findings, further analysis of the four key variables and corresponding recommendations are outlined below.

(1) R&D investment: The regression coefficient for R&D investment is 0.667, indicating a strong positive correlation with export competitiveness. R&D investment significantly impacts technological innovation and breakthroughs in new energy vehicle development [8]. Currently, efforts to enhance innovation in R&D remain crucial.

(2) Production factors: The coefficient for employment in the new energy vehicle industry is 0.6648, demonstrating a strong positive correlation. The availability of a substantial labor force in manufacturing directly affects production efficiency. China possesses a competitive advantage in this area, which should be maintained and leveraged further [9].

(3) Demand factors: The coefficient for annual sales volume is 0.2921, reflecting a positive but relatively lower correlation with competitiveness. Sales volumes are vital as they influence market acceptance, brand reputation, and competitiveness in global markets. Efforts to increase sales volumes could further enhance competitiveness [10].

(4) Spare parts services: The regression coefficient for the number of charging piles is -0.2723, indicating weak competitiveness in this area. Charging infrastructure is a critical component supporting the growth of new energy vehicle exports. To enhance competitiveness, it is essential to improve and expand the charging network [11].

4. Suggestions for improving the trade competitiveness index in the context of "dual carbon"

Based on the analysis of the four primary variables—R&D investment, production factors, demand factors, and spare parts services—it can be concluded that core technological innovation, comprehensive industry chain management, diversified sales channels, and high-quality value-added services directly influence the export competitiveness of China's new energy vehicle trade. Accordingly, the following suggestions are proposed from these four perspectives.

4.1. Strengthen core technological innovation

In the context of the expanding market for new energy vehicles, maintaining competitiveness requires increased investment in the innovation of key technologies such as batteries, motors, and electronic control systems. It is essential to integrate advanced technologies, including artificial intelligence, big data, and cloud computing, to drive core technological advancements and enhance international competitiveness. Efforts should also focus on promoting the intelligent development of new energy vehicles and the production of cutting-edge products, such as autonomous driving systems and connected vehicles, to cater to the growing demand for high-end models in the global market [12].

4.2. Develop comprehensive industry chain management

To meet the growing market demand for new energy vehicles, China's new energy vehicle industry should establish a complete industrial chain encompassing raw materials, components, vehicle manufacturing, infrastructure, and production equipment. A comprehensive industrial chain not only facilitates large-scale industry development but also significantly boosts international competitiveness [13]. Effective supply chain management is crucial for ensuring smooth production processes and promptly meeting customer needs.

4.3. Expand diversified sales channels

Given the increasing popularity of new energy vehicles in the European market, Chinese new energy vehicle enterprises should leverage digital platforms to develop diversified sales channels and enhance global market competitiveness. Strategies may include establishing multilingual official websites and utilizing social media for marketing to attract international consumers' attention [14]. Additionally, offline channels such as participation in international auto shows and the establishment of overseas pop-up experience stores can provide hands-on opportunities for consumers, thereby promoting purchasing intent. Leveraging favorable policies from both China and overseas markets, enterprises should also seek collaborations with international companies and institutions and offer subsidized or preferential car purchase services to consumers.

4.4. Enhance value-added services

As the internationalization of new energy vehicles progresses, high-quality after-sales services and guarantees are critical for building brand reputation and improving user satisfaction. Chinese new energy vehicle enterprises should establish a global after-sales service network, including official service centers and offline operational outlets, to cover multiple international markets. This network would provide convenient maintenance services and foster trust among overseas users of Chinese new energy vehicle brands.

Implementing differentiated services is another key strategy to enhance the level of value-added after-sales support. Tailored service solutions can be offered based on the specific needs of diverse user groups [15]. Moreover, enterprises should implement robust after-sales warranty policies, such as deploying professional service teams for on-site assistance or creating accessible service systems available via phone. Timely collection of user feedback and responsive adjustments based on customer input are also crucial to maintaining high service standards.

Disclosure statement

The authors declare no conflict of interest.

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