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Article

Research on Chinese Enterprises' Coping Strategies for Technical Barriers to Trade in the Data-Driven Era: A Case Study of the Electric Vehicle Battery and Electronic Appliance Industries

Gilbert Tu [1,*]

[1] International school of Curitiba, Curitiba, Brazil
* Correspondence: Gilbert Tu, International school of Curitiba, Curitiba, Brazil

Abstract: In the data-driven era, technical barriers to trade have become the primary barrier for Chinese electric vehicle battery and electronic appliance products seeking to enter the highly regulated European market. Furthermore, the frequent occurrence of extreme weather events in Europe significantly amplifies supply chain vulnerabilities and compliance risks for cross-border trade operations. This study takes these two critical manufacturing industries as primary research objects, adopting a comprehensive mixed-methods approach that combines in-depth case studies with rigorous empirical analysis. The primary objective is to explore the joint impact mechanisms of stringent European Union technical regulatory requirements and unpredictable European climatic factors on Chinese enterprise export dynamics. The research systematically quantifies the differentiated impacts of these dual risks on the two industries from the multifaceted perspectives of compliance costs, logistics disruption, enterprise response capacity, and overall export performance. Empirical results demonstrate that Chinese enterprises currently exhibit obvious deficiencies in climatic risk early warning systems and the application of data-driven management frameworks, with the electric vehicle battery industry bearing substantially greater dual risk pressure. Consequently, this study further proposes targeted, data-driven coping strategies, including compliance system optimization, robust risk early warning construction, and comprehensive supply chain resilience improvement. Ultimately, this research provides practical operational references for Chinese export-oriented enterprises to successfully break through technical barriers to trade and mitigate climatic trade risks, while also offering valuable strategic insights for the high-quality, sustainable development of international trade relations in related manufacturing fields.

Keywords: technical barriers; electric vehicles; electronic appliances; international trade; data-driven strategy; supply chain

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1. Introduction

In the data-driven era, technical barriers to trade have become the primary constraint for Chinese electric vehicle battery and electronic appliance enterprises expanding in the European market, with carbon emission and product sustainability requirements emerging as core regulatory focus [1, 2]. Digital and intelligent technologies are gradually becoming key support for enterprises to cope with trade barriers, and the application of big data frameworks is effectively optimizing the industrial chain operation efficiency of electric vehicle related industries. The technical upgrading of battery products and the

improvement of management systems have become inevitable paths for enterprises to meet EU technical standards, yet the industry still faces multiple challenges in technology adaptation and risk response.

Electric vehicle battery and electronic appliance industries are important pillars of China's export manufacturing, and the European market is their core overseas layout direction, with electric mobility industrial development closely linked to cross-border trade and technical standard compliance. EU technical barriers to trade impose strict requirements on product carbon footprint, safety performance and recycling systems, and the competition of sustainable transport technologies further raises the market access threshold for Chinese battery products. Climatic factors in Europe add additional risks to cross-border logistics and supply chain operation of temperature-sensitive products such as electric vehicle batteries, exacerbating the operational pressure of export enterprises [1, 3].

Existing research mostly focuses on technical upgrading and industrial development of the electric vehicle battery industry, with few studies integrating technical barriers to trade and climatic risk factors to explore targeted coping strategies for Chinese export enterprises [4]. This study takes Chinese electric vehicle battery and electronic appliance enterprises as the research object, explores the joint impact of EU technical barriers to trade and European climatic factors on their export trade, and constructs data-driven coping strategies. The research is of practical significance for enhancing the risk response capacity of Chinese enterprises and promoting the stable development of China-Europe trade in related industries.

The paper is structured into five chapters: Chapter 2 reviews relevant literature and clarifies research gaps; Chapter 3 constructs the theoretical framework and elaborates on the research methodology; Chapter 4 presents empirical findings and in-depth discussion through case and data analysis; Chapter 5 summarizes core conclusions, proposes targeted coping strategies and points out research limitations and future directions [5].

2. Literature Review

Research on electric vehicle industry development has increasingly focused on the synergy between renewable energy and vehicle integration, a core factor that also shapes green technical regulatory requirements for imported electric vehicle battery products [6]. Bibliometric analyses of electric vehicle power electronics research confirm the global trend of technological upgrading in the industry, while also revealing the technical gaps that Chinese enterprises face in meeting advanced technical standards. The optimization of battery operation and management strategies has become a key research direction for improving product compliance, with battery degradation and operational efficiency emerging as critical points for technical barrier compliance.

Battery digital passports have become an important regulatory tool, with relevant standards and regulations forming new technical requirements for cross-border trade of battery products and pushing enterprises to improve product data traceability systems. Comprehensive reviews of electric vehicle development highlight the multi-dimensional constraints of environmental and economic factors on export trade, which align with the dual requirements of technical barriers in environmental protection and cost efficiency. AI-powered routing and infrastructure integration technologies provide technical support for optimizing cross-border logistics of electric vehicle-related products, offering solutions for mitigating climatic and transportation risks in China-Europe trade.

The transformation of electric vehicle transport infrastructure is closely linked to market access standards, with the construction of recharging systems becoming an additional technical consideration for Chinese battery enterprises entering the European market. National-level policy research on electric vehicle adoption shows that industrial policy formulation can effectively support enterprises in coping with technical trade barriers, providing a reference for policy guidance in related export industries. Case studies on electric vehicle integration into transportation and energy systems verify the industry-specific impacts of technical regulations on cross-border trade, reflecting the

differentiated compliance challenges of different regions and industries. Scenario-based analyses of automotive technological trends reveal the dynamic evolution of technical barriers, which require Chinese enterprises to maintain continuous technological adaptation and innovation capacity [7].

Existing literature has fully explored the technological development and regulatory compliance of the electric vehicle battery industry and provided technical and policy references for coping with single technical trade barriers. However, there is a lack of research that integrates climatic risk factors with technical trade barriers, and few studies focus on the joint impact of these two factors on China's electric vehicle battery and electronic appliance export industries. In addition, the practical application of data-driven technologies in simultaneously addressing technical barriers and climatic risks remains under-researched, leaving a research gap in targeted coping strategies for export enterprises, which this study aims to address.

3. Theoretical Framework and Methodology

This chapter establishes the theoretical framework for analyzing Chinese enterprises' responses to technical barriers to trade under the dual influence of EU regulatory requirements and European climatic factors. It elaborates on the research methods and implementation steps adopted in the study. The research combines qualitative and quantitative analysis, with a case study approach centered on the electric vehicle battery and electronic appliance industries, to systematically explore the impact of technical barriers to trade and climatic risks on exports and design targeted coping strategies.

3.1. Theoretical Framework

The theoretical foundation of this study is built on the integration of international trade barrier theory, supply chain risk management theory, and data-driven management theory. International trade barrier theory provides the analytical basis for identifying the types and impact paths of EU TBTs on China's export industries, focusing on the regulatory constraints of technical standards, environmental requirements, and carbon accounting rules on market access and trade costs [8]. Supply chain risk management theory serves as the core framework for analyzing climatic risk transmission, clarifying how European extreme weather affects cross-border transportation, logistics storage, and cargo safety, and constructing the evaluation system for supply chain resilience of export enterprises.

Data-driven management theory runs through the entire research framework, providing the theoretical support for designing coping strategies [9]. This theory emphasizes the application of digital technologies and data analysis methods in trade decision-making, supply chain optimization, and risk early warning, and it is used to explore how to integrate data resources to improve enterprises' TBT compliance capacity and climatic risk mitigation capacity. The three theories are interrelated and complementary, forming a comprehensive analytical framework for studying the dual impact of TBTs and climatic factors on China-Europe trade, and providing the theoretical guidance for the construction of multi-dimensional coping strategies for enterprises.

3.2. Methodology

The study adopts a mixed-methods approach combining case study and empirical analysis, taking China's electric vehicle battery and electronic appliance industries as the research objects, and focusing on their export trade to the European market [10]. The research is divided into four core steps, with the entire process emphasizing the authenticity and validity of data, as well as the rationality and practicality of the analysis results.

3.2.1. Case Selection and Data Collection

The electric vehicle battery and electronic appliance industries are selected as research cases due to their dual characteristics of high sensitivity to EU TBTs and climatic factors. These industries are core export sectors of China's manufacturing industry with

strong trade connections to Europe, and their product characteristics necessitate stringent technical compliance and specific transportation environmental conditions. Data collection is categorized into secondary data and empirical data [11]. Secondary data includes EU technical regulation documents, China-Europe trade export statistics, European climatic disaster records, and industry development reports. Empirical data is derived from the collation of enterprise export operation data, focusing on indicators such as compliance costs, logistics delays, cargo damage rates, and export volume fluctuations of representative enterprises in these two industries.

3.2.2. Research Variable Definition and Measurement

Key research variables are categorized into independent variables and dependent variables. Independent variables include EU TBT intensity and European climatic risk degree. TBT intensity is measured by indicators such as regulatory update frequency, compliance testing items, and carbon footprint accounting requirements. Climatic risk degree is assessed through metrics like extreme weather occurrence frequency, transportation channel disruption duration, and logistics cost change rate. Dependent variables focus on the export performance of Chinese enterprises in the two industries, evaluated using core indicators such as export volume, export profit margin, and market share in the European market. Control variables, including enterprise scale, R&D investment, and digital transformation degree, are incorporated to ensure the accuracy of the impact analysis of the core independent variables.

3.2.3. Qualitative and Quantitative Analysis

Qualitative analysis is primarily employed to examine the evolution characteristics of EU TBTs in the two industries, investigate the transmission pathways of climatic risks in cross-border supply chains, and summarize the current status and challenges faced by enterprises in addressing dual risks through case studies. Quantitative analysis is utilized to assess the correlation between TBT intensity, climatic risk levels, and enterprise export performance [12]. This is achieved by applying statistical analysis methods to process the collected panel data and calculate the impact coefficients of various risk factors on export indicators, thereby quantifying the actual effects of dual risks on the two industries.

3.2.4. Strategy Formulation and Validation

Based on the results of qualitative and quantitative analysis, the study designs data-driven coping strategies from the perspectives of TBT compliance, supply chain optimization, and risk early warning. The rationality and operability of the strategies are verified by combining the actual operation status of typical enterprises in the two industries. The strategy framework is adjusted and improved according to the verification results to ensure that the proposed strategies can effectively address the practical challenges faced by enterprises in export trade.

3.3. Research Flowchart

The overall research process follows a systematic and sequential analytical framework, illustrated in Figure 1, which integrates data collection, variable analysis, empirical testing, and strategy construction to ensure the scientific rigor and logical consistency of the research.

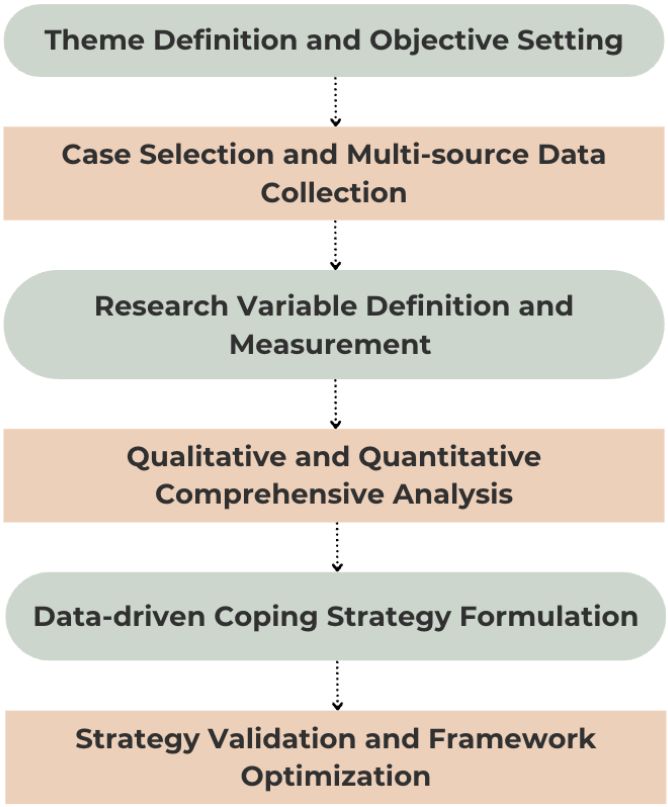

Figure 1. Research Methodology Flowchart for Chinese Enterprises' TBT Coping Strategies in the Electric Vehicle Battery and Electronic Appliance Industries

The flowchart outlines the six core stages of the research [13]. The research begins with Theme Definition and Objective Setting, clarifying the research focus on the dual impacts of EU TBTs and European climatic factors on the target industries, as well as the research goal of constructing data-driven coping strategies. This is followed by Case Selection and Multi-source Data Collection, where the electric vehicle battery and electronic appliance industries are confirmed as research cases, and secondary and empirical data are collated for subsequent analysis. The third stage is Research Variable Definition and Measurement, which classifies and quantifies independent, dependent, and control variables to lay the foundation for empirical analysis. The fourth stage involves Qualitative and Quantitative Comprehensive Analysis, combining case sorting and statistical analysis to identify the impact mechanisms of dual risks on export performance and summarize enterprise response challenges. The fifth stage is Data-driven Coping Strategy Formulation, designing targeted strategies for TBT compliance and climatic risk mitigation based on the preceding analysis results. The research concludes with Strategy Validation and Framework Optimization, verifying the operability of the proposed strategies with enterprise practical operation data and adjusting the strategy system to enhance its practical value.

4. Findings and Discussion

This chapter presents the research findings through empirical analysis of the electric vehicle battery and electronic appliance industries, focusing on the impact of EU technical barriers to trade and European climatic factors on Chinese enterprise exports [7]. Core results are quantified in four analytical tables, presented across corresponding analysis sections, and the key challenges faced by enterprises in addressing dual risks are summarized and discussed in combination with qualitative analysis results.

4.1. EU TBTs Impact on Chinese Export Enterprises

Analysis of the EU technical regulatory system for the electric vehicle battery and electronic appliance industries shows that technical barriers to trade (TBTs) have formed multi-dimensional constraints on Chinese enterprises, mainly reflected in compliance cost increases and market access threshold improvements. The differences in regulatory requirements for the two industries lead to varying degrees of impact, with electric vehicle battery enterprises facing more stringent carbon accounting and environmental protection testing requirements, and electronic appliance enterprises bearing continuous pressure from product safety and recycling system construction. The quantified impact of TBTs on the compliance costs of the two industries is shown in Table 1.

Table 1. EU TBT Intensity and Compliance Cost of Chinese Target Industries

Industry Type	TBT Core Regulatory Norms	Compliance Cost Increase Rate	Main Cost Composition
Electric Vehicle Battery	Carbon footprint accounting, environmental protection testing, recycling system	32%	Testing and certification, R&D transformation, carbon data collection
Electronic Appliance	Product safety standard, RoHS update, WEEE compliance	21%	Component replacement, testing verification, recycling channel construction

The data reflects that the electric vehicle battery industry faces higher TBT intensity, with a compliance cost increase rate nearly 50% higher than that of the electronic appliance industry. The main cost drivers also differ by industry, reflecting the targeted nature of EU technical regulations for different product categories and the differentiated compliance pressure on Chinese export enterprises [14].

4.2. European Climatic Risk Impact on Cross-Border Trade

European extreme weather directly affects the cross-border supply chain of the two industries, with the greatest impact on transportation and logistics. The temperature and humidity sensitivity of electric vehicle battery products leads to a high risk of cargo damage under extreme climatic conditions, while electronic appliance products are primarily affected by transportation delays and fluctuations in logistics costs. Climatic risk impact also exhibits seasonal characteristics, with a higher probability of occurrence in winter and summer, creating periodic operational pressure for export enterprises. The specific impact of different climatic risk types on China-Europe trade logistics is quantified in Table 2.

Table 2. European Climatic Risk Impact on China-Europe Trade Logistics

Climatic Risk Type	Transportation Channel Disruption Rate	Logistics Cost Fluctuation Range	Cargo Damage Rate (Target Industries)
Extreme low temperature/snowstorm	45%	28%-35%	12% (battery), 3% (electronic appliance)

Extreme high temperature/heavy rainfall	38%	20%-26%	8% (battery), 2% (electronic appliance)
Continuous cloudy and rainy weather	22%	10%-15%	1% (battery), 1% (electronic appliance)

Extreme low temperatures and snowstorms are the most disruptive climatic factors, resulting in the highest rates of transportation channel disruption and cargo damage for battery products. The disparity in cargo damage rates between the two industries is significant, which is closely related to the stringent storage and transportation environmental requirements of electric vehicle battery products. This also highlights the differentiated climatic risk resistance characteristics of the two industries.

4.3. Enterprise Response Status to Dual Risks

Chinese enterprises in the two industries have taken preliminary measures to cope with EU TBTs and climatic risks, such as improving product testing standards and adjusting logistics plans. However, the overall response capacity remains insufficient, with notable issues such as reliance on single coping methods, the absence of data-driven risk early warning mechanisms, and inadequate supply chain resilience. Small and medium-sized enterprises exhibit more pronounced deficiencies in R&D investment and digital infrastructure compared to large enterprises, resulting in a relatively weaker ability to withstand dual risks [15]. The comprehensive response capacity of enterprises in the two industries across core dimensions is scored and compared in Table 3.

Table 3. Chinese Enterprises' Response Capacity to Dual Risks

Response Dimension	Electric Vehicle Battery Industry	Electronic Appliance Industry	Industry Average
TBT compliance system construction	68	75	71.5
Climatic risk early warning capacity	42	48	45
Supply chain resilience level	55	62	58.5
Data-driven management application	39	45	42

Note: Full score is 100, higher scores indicate stronger response capacity

The scoring results indicate that the electronic appliance industry demonstrates a relatively higher response capacity across all dimensions, attributed to its longer presence in the European market and a more mature risk management system. Both industries, however, score poorly in climatic risk early warning and data-driven management application, with the average score for these two dimensions falling below 50. These shortcomings have emerged as critical barriers limiting the overall risk response capacity of Chinese enterprises.

4.4. Dual Risk Impact on Enterprise Export Performance

The combined influence of EU TBTs and European climatic factors has significantly affected the export performance of Chinese enterprises in the two industries. This impact is evident in export volume growth, profit margins, and market share stability [16]. Table 4 quantifies the differentiated effects of these dual risks on the export performance

indicators of the two industries, directly illustrating the actual business consequences of policy and environmental risks on export enterprises.

Table 4. Dual Risk Impact on Enterprise Export Performance

Industry Type	Export Volume Growth Rate Decline	Export Profit Margin Reduction	European Market Share Fluctuation
Electric Vehicle Battery	8.2%	5.6%	±3.1%
Electronic Appliance	5.4%	3.2%	±1.8%

Note: Data is the average annual change under the dual influence of TBTs and climatic factors

The electric vehicle battery industry has experienced a more pronounced decline in export volume growth and profit margins, along with greater fluctuations in European market share. This aligns with the higher compliance pressures from TBTs and the industry's sensitivity to climatic risks. In contrast, the electronic appliance industry, which possesses a relatively mature risk response capacity, demonstrates better stability in export performance under these dual risks. However, it still faces noticeable declines in growth and profit margins.

4.5. Discussion

The quantified findings confirm the significant joint impact of EU TBTs and European climatic factors on the export of Chinese electric vehicle battery and electronic appliance enterprises, with the electric vehicle battery industry bearing a greater impact due to higher product sensitivity and more stringent regulatory requirements. The compliance cost increase caused by TBTs directly compresses enterprise profit margins, while climatic risks further disrupt supply chain stability and increase operational uncertainty, forming a superposition effect of policy and environmental risks.

The low scores of enterprises in climatic risk early warning and data-driven management application reflect the core shortcomings of current response work. Most enterprises still adopt passive coping methods for climatic risks, lacking proactive early warning and pre-judgment capacity. The insufficient application of digital technologies makes it difficult for enterprises to effectively integrate trade data, regulatory data, and climate data, which restricts the optimization of TBT compliance strategies and the construction of resilient supply chains.

The gap in response capacity between the two industries is mainly due to the differences in industrial development stage and enterprise scale structure. The electronic appliance industry has a longer export history to the European market and a more mature compliance system, while the electric vehicle battery industry is in a rapid development stage, with the construction of EU TBT compliance capacity lagging behind the speed of market expansion [17]. In addition, the proportion of small and medium-sized enterprises in the electric vehicle battery industry is relatively high, and the resource constraints lead to slower progress in digital transformation and risk management construction.

The fluctuation of European market share shows that the dual risks have not yet had a fundamental impact on the competitive position of Chinese enterprises in the two industries, which means there is still room for improvement in enterprise response capacity [2]. By optimizing the compliance system, constructing a data-driven risk early warning mechanism, and enhancing supply chain resilience, Chinese enterprises can effectively mitigate the impact of dual risks and maintain stable development of export trade to the European market.

5. Conclusion

This study verifies that EU technical barriers to trade and European climatic factors form a superposed risk impact on the exports of Chinese electric vehicle battery and electronic appliance enterprises to the European market, with the electric vehicle battery industry bearing greater pressure due to higher regulatory compliance requirements and higher product environmental sensitivity. Both industries exhibit significant deficiencies in climatic risk early warning and data-driven management application, which have become the main constraints on their overall risk response capacity. Meanwhile, the core competitive position of Chinese enterprises in the European market remains stable, indicating that the rational optimization of coping strategies can effectively mitigate the dual risk impact and maintain the stable development of export trade.

Based on the above research conclusions, three targeted data-driven coping strategies are proposed for the two industries. First, construct a unified EU TBT compliance data platform, integrating regulatory updates, product testing data, and carbon accounting information to reduce compliance costs and improve the efficiency of regulatory adaptation. Second, build a targeted climatic risk early warning system, combining real-time European climate data and cross-border logistics route information to enable proactive adjustment of transportation and storage plans. Third, optimize supply chain resilience through digital means, comprehensively mapping supply chain nodes and developing alternative transportation channels to respond to sudden disruptions caused by TBTs and climatic risks.

This study is limited by the use of aggregated industry data, which lacks in-depth micro-analysis of individual enterprise cases. Future research can conduct targeted studies on typical export enterprises to formulate customized risk coping strategies and further explore the application effects of emerging digital technologies in trade risk response. Follow-up research can also track the dynamic evolution of EU TBTs and European climatic characteristics to continuously optimize and improve the proposed coping strategies, enhancing their sustainability and practical application value for export enterprises.

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