Assessment of Sustainability and Risk Management of New Energy Vehicle Batteries

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Abstract. The global electric vehicle battery (EVB) industry is undergoing significant transformation amid geopolitical tensions, technological competition, and supply chain restructuring. This paper examines the sustainability and risk management strategies of Chinese and U.S. power battery enterprises, focusing on factors driving supply chain adjustments, enterprise competitiveness, industry risks, and mitigation approaches. Key drivers include geopolitical policies (the U.S. IRA vs China's industrial plans), market demands for high-energy-density and low-cost batteries, and divergent technological pathways (solid-state batteries in the U.S. vs. lithium-ion dominance in China). Risks such as lithium resource volatility, homogeneous competition, and ESG-related challenges like the "Battery Passport" are analyzed. The study predicts a "dual-track system," where China leads in low-cost production and scale, while the U.S., Europe, and Japan compete in high-end innovation. Findings emphasize the necessity of diversified supply chains, technological innovation, and international collaboration to stabilize the global EV battery ecosystem amidst geopolitical fragmentation.

Keywords: Electric Vehicle Battery, Lithium, Supply Chain, Geopolitics, Homogeneous Competition.

1 Introduction

In recent years, the issue of energy transition has gained prominence amid global climate change and uneven energy distribution. Among the current hot topics, new energy vehicles (NEVs) have seen significant market presence, with U.S.-based Tesla and Chinese company BYD holding substantial shares in their respective markets. As the core component of NEVs, new energy batteries have naturally become part of this competitive landscape. As shown in Table1. From January to December 2024, Tesla achieved a counter-cyclical growth of 6.0% in global electric vehicle (EV) sales outside the Chinese market, maintaining its position as the market leader. Although the Inflation Reduction Act (IRA) in the United States provides for tax credits for EV production, the announcement by the United States in its second term to repeal or reduce subsidies has inevitably slowed down the growth of EVs. Similarly, the pace of EV battery production has also decelerated. In contrast, the Chinese government has consistently promoted energy transition and the application of new energy vehicles, leading to rapid

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development in the battery industry. While securing a dominant position in its domestic market, China also focuses on expanding into overseas markets.

Table1. Annual Cumulative Global Electric Vehicles Imports (BEV+PHEV, including commercial vehicles)

Name	2023.1-12	2024.1-12	Growth Rate	2023 Point Rate	2024 Point Rate
TESLA	1205	1132	-6.0%	21.3%	18.8%
Volkswagen	773	787	1.7%	13.6%	13.1%
Hyundai & Kia	560	545	-2.7%	9.9%	9.1%
Stellantis Group	564	467	-17.3%	10.0%	7.8%
BMW	427	449	5.1%	7.5%	7.5%
Geely	324	396	22.2%	5.7%	6.6%
Mercedes-Benz	345	357	3.5%	6.1%	5.9%
R-N-M	334	289	-13.7%	5.9%	4.8%
BYD	112	254	125.4%	2.0%	4.2%
Ford	179	233	30.5%	3.1%	3.9%
Other	844	1104	30.8%	14.9%	18.4%
Total	5667	6011	6.%	100.0%	100.0%

Data Source: Global Monthly Tracking Report on Electric Vehicles and Batteries, SNE Research.

As lithium mines constitute one of the most crucial materials for electric vehicle batteries, they have naturally become pivotal mineral products in the energy transition. By 2020, Albemarle's share of the global lithium market had dropped from 85% to 25%. Meanwhile, Chinese companies Ganfeng Lithium and Tianqi Lithium, which were previously relatively unknown, had risen to hold 16% and 14% of the global market share respectively. In the global transition towards new energy sources, China has rapidly emerged as the world's largest producer and consumer of lithium battery materials. Under these circumstances, major lithium producers like Albemarle perceive their market position and interests as being challenged. However, between 2022 and 2023, despite no significant increase in global demand for lithium resources, prices continued to rise due to substantial capital inflows into upstream production driven by profit motives. This led to disruptions in production and supply chains for many new energy vehicle manufacturers and an increase in model prices. Looking ahead to 2025, uncertainties in international political and economic situations are intensifying. The imposition of additional tariffs on multiple countries' goods by the United States significantly reduces the stability of international trade environments, with globalization increasingly giving way to regionalized industrial chain structures. Given its resource advantages and cost efficiencies, China remains a critical source for most U.S. new energy vehicle enterprises seeking imported batteries and components. To reduce dependence on China, the U.S. has enacted policies such as IRA (Inflation Reduction Act) and called upon Western nations to establish domestic lithium supply chains to mitigate reliance on Chinese resources while countering competition from Chinese enterprises in this sector.

In light of the aforementioned measures and risks, this paper focuses on investigating how China and the United States can expedite and refine the restructuring of their respective supply chains in the production of new energy vehicle batteries, in the context of a global economic downturn. The aim is to stabilize, and potentially expand, their market positions on the international stage amidst the ongoing trade competition. The article addresses this issue by analyzing from these four perspectives. The factors driving supply chain adjustments, the competitiveness analysis of leading enterprises, industry supply chain risks, and the causes of these risks. Ultimately, it forecasts the future prospects of the industry in both China and the United States, positing the implementation of a "dual-track system" between the two nations. This approach aims to contribute to fostering a favorable business environment, constructing an inclusive and mutually beneficial globalization, and stabilizing the international political and economic order through the efforts of major global powers.

2 Factors Driving Supply Chain Adjustments

2.1 Politics and Geopolitics

The industry is considered to be the centerpiece of NEVs; therefore, the growth of the industry has a direct impact on the growth of the NEV industry. Consequently, it is held in high esteem by the governments of the United States and China.

Policies in the USA. In terms of domestic legislation, take the “Detaching from Foreign Hostile Battery Dependence Act” an example [1]. On June 7, 2024, the U.S. "Special Committee on U.S.-China Strategic Competition" enacted this bill, which mandates a prohibition on the Department of Homeland Security from procuring batteries from six Chinese companies—CATL, BYD, Envision Energy, EVE Energy, Guoxuan High-Tech, and Lithium Energy Storage. This act employs a "hard decoupling" sanction strategy against Chinese enterprises while endeavoring to promote the decoupling of supply chains with geopolitical rivals of the United States.

On the geopolitical front, on 12 October 2021, during the 15th Conference of the Parties to the United Nations Convention on Biological Diversity (CBD), the United States The "Sustainable Critical Minerals Coalition" was formally established by Canada, Australia, and seven other countries. This coalition has established higher environmental and labour standards for the production and purchase of critical mineral materials. It also has plans to implement the same standards in the future for lithium, nickel, copper, and cobalt. The Alliance has set higher environmental and labour standards for the production and purchase of key mineral materials. It also has plans to do the same for lithium, nickel, copper, and cobalt in the future. The objective of this initiative is not to ensure the sustainable development of lithium resources, but rather to construct a "blue barrier" that impedes the development of lithium resources in developing countries, such as China. Secondly, the United States also promotes the globalization of its economic interests through free trade agreements and regional economic cooperation

organizations. For instance, the U.S.-led Trans-Pacific Partnership (TPP) a trade agreement initiated by the United States, seeks to reshape the economic structure of the Asia-Pacific region, thereby augmenting U.S. economic influence in the region. Concurrently, U.S. geopolitical partners have initiated a series of actions against China. In accordance with the provisions stipulated within the Investment Canada Act, the Canadian government has issued directives to three Chinese entities, compelling the divestiture of their interests in Canadian "junior mining enterprises". This mandate encompasses a Canadian-operated lithium project situated in Chile. In July 2023, the European Union also announced that it and Chile were in the process of drafting a lithium memorandum of understanding. In addition, Australia has restricted Chinese companies from investing in or increasing their stakes in Australian lithium miners, citing concerns pertaining to national security. Furthermore, Australia is seeking to increase its domestic lithium pyroxene refining capacity, with a view to reducing its reliance on China.

Policies in China. China, in its capacity as a unified market of considerable size and influence on a global scale, wields significant procurement leverage within the global lithium supply chain. This position affords it a substantial degree of influence over the global distribution of lithium, a factor that Western nations find challenging to counteract. However, it is important to recognize the role of international dynamics in this context. It is evident that China's lithium industry must enhance technological innovation, optimize industrial layout, and strengthen international collaboration to elevate lithium product quality and added value. This will, in turn, bolster market competitiveness. This involves achieving synergistic development across the lithium industrial chain, improving resource utilization efficiency, and mitigating market risks. Furthermore, enhancing the recycling of lithium resources is imperative to boost efficiency and reduce reliance on primary lithium ores. In 2012, the State Council promulgated the "Energy Saving and New Energy Vehicle Industry Development Plan (2012-2020)". Since then, China has maintained a strategic focus on pure electric drive, coupled with the advancement of the new energy vehicle industry, has yielded substantial progress, becoming a major driving force in the transformation of the global automobile industry. Despite considerable progress in China's power battery industry over the years, there are still significant challenges in achieving the desired performance, quality and cost of power battery products for use in new energy vehicles. These challenges are particularly pronounced in relation to key raw materials, system integration technology, manufacturing equipment and technology, and other related areas. The industry still has a considerable way to go to reach the same level as other leading international power battery manufacturers. Consequently, on 20 February 2017, China promulgated the "Action Plan for Promoting the Development of the Automotive Power Battery Industry" with the aim of accelerating the objective is to enhance China's capabilities in the automotive battery industry and to encourage the sustainable growth of its new energy vehicle industry, thereby ensuring a robust and environmentally friendly development trajectory.

In recent years, on October 20, 2020, the People's Republic of China unveiled the "Development Plan for New Energy Vehicle Industry (2021-2035), " a document which

meticulously delineates the nation's ambitious objectives concerning the large-scale deployment of new energy vehicles [2]. This policy, in addition to the specifics mentioned in the table, has been demonstrated to promote the establishment of a standardized modular system for power batteries and to accelerate breakthroughs in key manufacturing equipment to improve process levels and production efficiency.

2.2 Different Technological Approaches

Solid-State Batteries in USA. Instead of prioritizing the domains of lithium mineral reserves and engaging in a "price war" with China, the United States is demonstrating a marked predilection for accelerating technological iteration with a view to contending for the vanguard of next-generation battery technology (e.g. solid-state batteries). Recently, the United States announced its intention to develop a revolutionary solid-state battery, which it believes will transform the current state of battery technology. A transnational technological alliance comprising the European automotive powerhouse Stellantis and the American solid-state battery innovator Factorial Energy has announced the successful vehicle-grade validation of their jointly developed FEST solid-state battery [3]. This breakthrough has the potential to set new industry benchmarks and accelerate the commercial production timeline of solid-state batteries to within two years. In accordance with the established timeline, the demonstration fleets of the Dodge Charger Daytona, equipped with this technology, are scheduled to undergo road testing in 2026. This transition signifies a pivotal shift from laboratory research to commercial application in the solid-state battery sector.

Lithium-ion Batteries in China. China, having undergone a period of development in the lithium battery sector that has spanned several years, has accumulated a number of advanced technologies, efficient production capabilities, and a well-established supply chain system. Presently, China stands as the foremost global producer of batteries, with a share exceeding 70% of global lithium-ion battery manufacturing. According to data from the research institution SNE Research, it is projected that the total global battery shipments (including both power and energy storage) will reach nearly 1.3 billion kilowatt-hours, equivalent to 1299 gigawatt-hours, by 2024. It is noteworthy that six of the ten companies with the highest shipment volumes are Chinese enterprises. Concurrently, Chinese battery manufacturers are expediting their global expansion, achieving notable recent milestones in emerging markets such as Southeast Asia. On 13 March, the Thai National Committee for Enhancing Industrial Competitiveness approved a resolution that permitted a subsidiary of China's foremost lithium battery company, Sunwoda, to invest 50 billion Thai baht (approximately 10.7 billion yuan) in the production of power batteries and energy storage system batteries in Thailand.

3 Industry Supply Chain Risks

3.1 Lithium Resources

From 2022 to 2023, there was a marked increase in the price of lithium resources, and the lithium battery industry experienced a significant decline in activities related to lithium mining, smelting, and the production and processing of lithium battery materials. The fundamental cause of this phenomenon can be attributed to the cyclical mismatch between resource development and capacity expansion, as well as the price inversion caused by the lag in the transmission of the industrial chain. Specifically, during the period of rising lithium prices, a substantial amount of capital was invested in the upstream sector of the lithium industry, and there was a notable enthusiasm for capacity expansion across the entire industry. However, a considerable discrepancy emerged between the resource development cycle and the smelting capacity expansion cycle. The discrepancy in the rhythm of the two has resulted in a significant surge in lithium carbonate production capacity over a brief period, coinciding with an increase in industry output. This has precipitated a rise in the supply price of lithium ore resources, leading to an excess of lithium carbonate. The phenomenon of overcapacity has precipitated a decline in lithium prices, with certain lithium mines commencing the cessation of production or even undergoing transfer [4].

3.2 Homogeneous Competition

In China, there is an expanding presence of Chinese companies in the field of pure electric vehicle batteries, coinciding with the growth of the market for pure electric vehicles and the increasing export of batteries and electric vehicles to European markets. In terms of new energy, Poland has already developed a relatively well-developed electric vehicle industry chain. On 24 June 2024, the Ministry of Foreign Affairs (MFA) published a notice on its website informing the public that the People's Republic of China and the Republic of Poland had adopted an action plan for the purpose of strengthening the Comprehensive Strategic Partnership is hereby presented for the years 2024 to 2027 [5]. In 2025, the two sides commenced collaborative efforts to develop a comprehensive strategic partnership with Poland. It is evident that both parties are in agreement with the China Council for the Promotion of International Trade, the Polish Investment and Trade Agency, and other trade and investment promotion organizations in the two countries. The objective of this agreement is to enhance cooperation between the two nations. Furthermore, both parties advocate for bilateral investment cooperation in the domains of electric vehicles, green development, logistics, and other sectors. This agreement seeks to optimize the investment environment and facilitate the entry of enterprises from the two countries into each other's markets. The ultimate aim of this agreement is to provide equal opportunities and a fair competitive business environment for enterprises. Recent reports in foreign media outlets have indicated that South Korean battery manufacturers have been expanding their investment portfolio in the European market. On 25 March, the leading enterprise LG Energy Solutions (LGES) and the Polish National Power Group (PEG) entered into a contract for the

supply of energy storage batteries. The project's lithium iron phosphate ($LiFePO_4$) energy storage batteries are to be manufactured at LG Energy Solution's battery plant in Wroclaw, Poland. This will be the first time that the plant has produced and supplied energy storage batteries.

As a new energy force closely following Chinese companies, South Korean companies are undoubtedly the biggest competitors in the globalization of China's new energy vehicles. Despite China's dominant position in the global power battery market, with prominent Korean enterprises such as LG New Energy and Samsung experiencing a surge in market share, Chinese companies are also facing a decline in their share of the power battery market. It is imperative to acknowledge the heightened propensity of the United States, Europe, Japan and South Korea to establish a community of interest. In the prevailing geopolitical climate, there is an imperative for heightened vigilance with regard to the emergent energy companies, notably those represented by Korean enterprises, in order to consolidate other forces and establish a coalition to exert influence.

3.3 Risk of Battery Passport

First battery passport is an innovative initiative launched by GBA to improve the management of the entire battery lifecycle. The "Battery Passport" can be regarded as a digital representation of the physical battery, with the capacity to facilitate seamless digital oversight of the complete power battery supply chain [6]. Nonetheless, the presence of virtuality indicators or the decision to refrain from disclosing such information may potentially introduce a certain degree of risk for corporate entities. For instance, the cycle life in the core parameters of performance, the number of sensitive metals such as nickel and cobalt in the main elements of the battery, as well as the ability to meet the ESG indicators have all become key risks for enterprises to consider. The power battery recycling mechanism involved in the ESG standard requires the sustainability and circularity of the EVB, which requires that new energy automobile battery enterprises determine and decide on the appropriate closed-loop pathway of the value chain, the use of secondary materials or the supplier selection [7].

4 Approaches to Risk Management

4.1 Strategies for Addressing Risks in the Industrial Supply Chain

China: Accelerating Diversification of Supply Chains. Presently, China has constructed the most comprehensive power battery industry chain globally. The nation's power battery industry has accomplished significant achievements, primarily by adhering to two technological pathways in parallel: the development of lithium iron phosphate batteries and ternary batteries. In addition to the imperative of adhering to the diversification of technical routes, it is also crucial to ensure the full development of industrial advantages [8]. Furthermore, active participation in globalization is paramount. The ongoing development of high-energy liquid batteries and solid-state batter-

ies in China presents a significant opportunity for the advancement of the nation's battery industry. Moreover, upstream battery raw material enterprises, battery companies and automobile manufacturers are collaborating to enhance the supply of lithium, cobalt, nickel, phosphorus and other key resources. This is achieved through capital and industrial cooperation, with the objective of ensuring vertical integration and thereby mitigating supply chain risks [9].

The United States: Mitigates Manufacturing Decentralization through Technological Innovation. The financial burden of labor in the United States is significantly higher than in developing countries [10]. Furthermore, the industry chain, both upstream and downstream, is found to be inadequate. This structural contradiction has the potential to render the United States at a disadvantage in terms of cost competitiveness in the low-end manufacturing sector. Concurrently, high-end industries may be vulnerable to the dissolution of technological monopolies. However, it is important to note that tariff policy is not only incapable of reversing this trend but will instead serve to exacerbate the existing supply chain distortions and inflationary pressures. Nevertheless, in order to circumvent the risk of hollowing out the manufacturing industry, it is imperative that technological innovation is embraced. A prime example of this can be seen in the collaborative efforts of battery companies and car manufacturers in conducting research and development of solid-state batteries and LiFePO4 batteries, to ensure a leading position in the impending technological revolution [11].

4.2 Downward Sustainability and Circularity of ESG Criteria in Battery Passport

The inception of the notion of ESG can be traced back to 2004 when it was initially introduced by the United Nations Environment Program. The acronym's constituent elements are intended to represent the three fundamental concepts of environmental, social and governance issues, and the concept is a comprehensive framework for measuring corporate sustainability and social responsibility performance. In order to develop a sustainable and viable battery industry, it is essential that battery recycling is made commercially viable. This corresponds to the concept of waste management in the context of ESG. The issue of recycling batteries is not unique to China; rather, it is a challenge faced by all nations worldwide. In response, various countries have devised distinct recycling programs for used batteries. For instance, the United States government implements regulatory frameworks for the management of hazardous waste, including lithium batteries, under the auspices of the Resource Conservation and Recovery Act (RCRA). The legislation stipulates that companies engaged in the recycling of lithium batteries are obligated to possess the requisite licenses to undertake the processes of dismantling, transporting, and disposing of used batteries in strict accordance with the hazardous waste treatment process. On 21 February 2025, the Action Plan for Improving the Power Battery Recycling System for New Energy Vehicles was considered and adopted by China's executive meeting of the State Council. The meeting requested that recycling should be regulated by means of the rule of law, that relevant administrative

regulations should be formulated and improved, and that supervision and management should be strengthened. In order to accelerate the development and revision of power battery green design, product carbon footprint accounting and other relevant standards, it is essential to take the lead in driving the standardization of recycling.

5 Conclusion

The EV battery industry stands at a critical juncture shaped by geopolitical rivalry, resource competition, and technological divergence. China's dominance in lithium-ion battery production and cost efficiency contrasts with U.S. efforts to pioneer solid-state technology and reduce dependency on Chinese supply chains. However, both nations face inherent risks, China grapples with overcapacity and international competition, while the U.S. struggles with high manufacturing costs and fragmented supply chains. The emergence of a "dual-track system" underscores bifurcated market dynamics-China's low-end sector and Western high-end innovation. To navigate these challenges, China must prioritize supply chain diversification, recycling systems, and global expansion, while the U.S. should leverage technological alliances and policy incentives. Sustainable growth hinges on balancing competition with collaboration, particularly in addressing ESG standards and circular economic practices. Policymakers and enterprises must adopt inclusive strategies to mitigate supply chain disruptions and foster a resilient, globally integrated industry. Ultimately, the transition to new energy vehicles demands harmonizing economic objectives with environmental and social responsibilities, ensuring long-term viability in an era of redefined globalization.

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