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Risk Management in the New Energy Vehicle Supply Chain — Analyzing Supply Chain Risk Prevention from the Case of NIO Automobiles

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Abstract. At present, the scale of the domestic new energy vehicle industry is constantly expanding. The industrial chain has evolved from a linear structure into a complex, multi-tiered network spanning multiple regions, rendering the system more susceptible to chain transmission. This study selects NIO Inc. as the focal case, employing a case-study approach informed by supply chain theory to identify and analyze the supply chain risks confronting NEV manufacturers from two perspectives: internal operations and the external environment. It summarizes NIO's strategic responses in supplier configuration, digitalized management, and flexible supply chain design, and distills generalizable strategies applicable to the broader Chinese NEV industry. The research results indicate that single supplier dependence, inefficient collaboration in contract manufacturing, fluctuations in raw material prices, and geopolitical trade shocks are the core risks for NIO and other similar automakers. By establishing a diversified supply system, promoting data exchange between upstream and downstream entities, and building local production reserves, etc., the resilience of the supply chain can be effectively enhanced. This approach can provide practical references for new automotive players and traditional automakers that are transitioning to new energy. This study only conducted an analysis based on the single case of NIO. The lack of cross-case comparisons limits its scope and can serve as a foundation for subsequent multi-case studies.

Keywords: New energy vehicles, Supply chain risk, Nio Automobile, Information sharing

1. Introduction

Driven by China's carbon-neutrality commitments, new energy vehicles (NEVs) are displacing internal combustion engine (ICE) vehicles and gaining mainstream acceptance in the automotive industry. China's NEV market has grown substantially, and the industrial chain has been continuously divided into more specialized segments. The procurement of raw materials such as lithium and cobalt, the supply of battery cells, the manufacturing of complete vehicles, and the offline services have formed a complete and long supply chain. In the past, some car manufacturers solely focused on production capacity and sales volume, neglecting the long-term value brought by supply chain stability. Their responses were purely reactive, triggered only by raw material price

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surges, production stoppages, or component shortages. They lacked a complete system for early identification and control of risks. The supply chain of new energy vehicles differs significantly from that of traditional fuel vehicles. The power battery, as a core component, is highly dependent on overseas mineral resources. Moreover, rapid technological change, coupled with foreign trade policies and national environmental regulations, directly impacts vehicle production. The current research on risks in the new energy supply chain mostly focuses on macro analysis of the entire industry. There are relatively few in-depth analyses of individual cases of automotive enterprises. In particular, research is lacking on supply chain risks associated with the capital-intensive battery-swapping business model. This study selects NIO as the research object. NIO adopts a unique model of outsourcing production, independently developing the power battery and electric drive system, and building its own charging stations. The supply chain problems it has exposed are highly representative among the new domestic car manufacturers. This article reviews the supply chain pain points throughout the entire development process of NIO, combines the basic theories of supply chain risk identification, assessment and control, analyzes the causes of internal and external risks, summarizes the actual risk control measures implemented by NIO, and finally refines the industry-wide optimization plan. This research can enrich the case studies on supply chain risk management in the new energy manufacturing industry, and at the same time provide feasible risk management ideas for different types of domestic new energy vehicle manufacturers. It can help enterprises balance production efficiency and supply chain security, and reduce the business losses caused by unexpected risk events.

2. Basic theories related to supply chain risk management

Supply chain risk refers to various uncertain factors that occur during the operation of the industrial chain, which can disrupt the normal rhythm of procurement, production, logistics and delivery, resulting in increased costs, production stagnation, and breakdown of cooperation, among other losses [1]. Supply chain risks exhibit four key characteristics: their timing and severity are difficult to predict; they propagate cascadingly through supply chain networks; the multi-tiered structure complicates root-cause analysis; and risk mitigation measures may inadvertently introduce new operational risks. The complete supply chain risk management consists of three steps: risk identification, risk assessment, and risk control. Firstly, enterprises need to comprehensively review the entire process of procurement, production, warehousing, logistics and after-sales services, and identify all potential risks and problems. Risk assessment requires the integration of industry data and the current situation of the enterprise to analyze the probability of various risks occurring and the potential extent of losses. For instance, it involves calculating the likelihood of a major battery supplier's supply disruption, and assessing the consequences such as delivery delays, customer attrition, and the scale of economic losses that the event may cause. Finally, firms formulate prevention, emergency response, and recovery plans tailored to risk severity levels, thereby establishing a closed-loop management framework [2].

The supply chain of new energy vehicles is divided into three levels: the upstream raw materials, the midstream core components, and the downstream complete vehicles and supporting services [3]. The upstream sector mainly consists of enterprises engaged in the mining and processing of rare metal minerals such as lithium, nickel, and cobalt. These resources are highly concentrated in a few overseas countries, rendering the supply chain susceptible to disruptions stemming from geopolitical conflicts and export restrictions. The midstream sector includes the three core component manufacturers of power batteries, motors, and electronic control systems, accounting for the largest share of vehicle production costs. The downstream sector encompasses vehicle assembly plants,

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retail outlets, battery recycling, and battery-swapping services, serving end consumers [2]. Compared with traditional fuel vehicles, the new energy industry chain is longer, the core resources are more monopolized, and the technological iteration speed is faster. Besides market demand fluctuations, it also needs to face additional external risks such as new regulations on mineral imports and exports, carbon reduction policies, and battery recycling regulations. The industry exhibits heightened vulnerability, and demands for risk monitoring and contingency reserves are correspondingly more demanding. This framework will serve as the analytical framework for the subsequent risk identification of NIO.

Supply chain collaboration involves all enterprises along the industrial chain sharing order, inventory, production capacity, and logistics information under unified rules, and jointly completing risk warning and emergency allocation. Many car manufacturers and suppliers use different management systems, with inconsistent data standards and delayed information transmission. Consequently, issues such as demand forecasting deviations and component shortages exacerbate operational risks. Digital risk control is the most convenient tool for implementing information sharing. By leveraging the big data platform to connect the internal procurement, production and warehousing data of enterprises, and at the same time integrating the data interfaces of upstream and downstream enterprises, firms can automatically detect risk indicators such as inventory anomalies, supplier delays, and raw material price spikes. It shifts from passive remediation to proactive early warning, significantly reducing the economic losses caused by risks [4]. This theory provides a theoretical basis for the subsequent analysis of the information barriers in the NIO OEM model and the establishment of a digital early warning platform.

3. Analysis of the development of NIO's supply chain and core risks

3.1. The three-stage development process of NIO's supply chain and core operational risks within the enterprise

From 2014 to 2018, NIO's supply chain underwent an initial establishment phase. NIO rapidly established the vehicle supply channels and gave priority to ensuring the launch of the models. However, supplier selection was rushed, and traction battery and critical component procurement relied on sole-source arrangements. There was no complete evaluation mechanism. The goal of this stage was to quickly launch the models. This created a tension: the supplier base remained immature, embedding latent risks. From 2019 to 2021, NIO entered a restructuring and optimization phase. After experiencing issues such as delivery delays and tight battery supply, NIO began to adjust its supplier structure, increase alternative partners, and establish a basic data management system. This stage saw the cumulative exposure of early-stage supply chain deficiencies. From 2022 to the present, NIO has transitioned to an ecosystem maturity phase. A multi-battery supplier strategy has been implemented, overseas local supply chains have been established, a full-chain digital early warning platform has been built, and strategic component inventories have been reserved. A complete emergency buffer system has been established, significantly enhancing the supply chain's ability to resist risks [5].

The reliance on a single supplier poses the risk of supply disruption. In the early days, all of NIO's battery power supplies were sourced from CATL. Supplier numbers for the three-in-one electric drive system were limited, and supplier concentration for critical components was excessive. In the event of contractual disputes or supplier production disruptions, NIO lacks alternative sourcing pathways. The delivery cycle is significantly prolonged, resulting in the loss of potential customers. The collaborative efficiency of the OEM model is also relatively low. The entire vehicle

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of NIO is produced by the JAC Automobile Factory. The two enterprises belong to different entities, and their internal management systems and data formats are not unified. There is a delay in the transmission of information such as order requirements, component inventory, and quality inspection standards. Sudden demand fluctuations may trigger component overstock or shortages if NIO cannot promptly adjust production plans and communicate revisions to its contract manufacturer; delayed quality standard updates may lead to quality inconsistencies and elevated rework costs. Then it will lead to unstable vehicle quality and increase the cost of rework. At the same time, the information barriers between enterprises will cause deviations in demand forecasting, further exacerbating the problem of inventory waste or insufficient supply [6]. Furthermore, the heavy investment strategy has brought about cash flow pressure [7]. NIO continues to carry out large-scale construction of battery swap stations, invests in battery research and development, and expands its overseas stores. Scenarios such as expedited raw material procurement or excessive component inventory upstream impose substantial additional costs. Coupled with the continuous investment in new vehicle research and development and offline channels, the firm faces sustained liquidity pressure. Once the market sales fall short of expectations, difficulties in capital turnover will directly affect the payment for component purchases, further disrupting and damaging the stability of cooperation with suppliers [8]. The internal risks mentioned above are not isolated from one another; rather, there is a clear chain reaction among them. Under the contract manufacturing model, information barriers between entities can easily lead to inaccuracies in market demand forecasts, resulting in component mismatches and causing either inventory buildup or component shortages; meanwhile, NIO's continued investment in the construction of battery swap stations, R&D for its "three-electric" systems, and the expansion of overseas channels has led to heavy capital expenditure, further exacerbating the company's cash flow pressures.

3.2. Core risks related to external environment

Geopolitical and international trade disruption risks. NIO has established global sales channels. Raw materials and components need to be imported from overseas. Sino-US trade frictions, EU carbon border regulations, and tariff adjustments across key markets increase import costs and extend transit times, compressing vehicle profit margins [9]. The supply stability of overseas factories is also affected by regional conflicts and port blockades. The prices of rare raw materials fluctuate. The core mineral resources for battery power, such as lithium and cobalt, are highly concentrated in certain countries. Geopolitical conflicts, environmental mining restrictions, and rising global energy storage demand rapidly escalate mineral prices. The cost of batteries accounts for an extremely high proportion of the total vehicle cost. When battery prices surge, NEV manufacturers without long-term price hedging contracts face intensified vehicle pricing pressure; if they lock in prices and stockpile minerals in advance in large quantities, the subsequent market price decline will cause the depreciation of inventory assets, and the dual price risks are difficult to balance [8].

4. Implementation path for supply chain risk management of NIO automobiles

4.1. Establish a diversified supplier system to reduce the risk of single-point supply disruption

To address single-source battery procurement risks during its early phase, NIO expanded partnerships with battery manufacturers and established collaborations with multiple cathode, anode, and separator suppliers, thereby forming a multi-tiered supplier network [5]. The enterprise has established a dynamic supplier evaluation system. For core battery suppliers, a comprehensive

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assessment is conducted quarterly based on factors such as production capacity, quality, price, and emergency response speed. For ordinary component suppliers, a comprehensive review is completed once every six months. The order allocation ratio is adjusted according to the evaluation scores. Chronically underperforming suppliers see their order volumes progressively reduced. At the same time, alternative suppliers are continuously explored to avoid the risk of single-source supply disruption from the source. This multi-sourcing strategy represents a standard approach to risk diversification. When one factory experiences insufficient production capacity or equipment failure, the other cooperating enterprises can quickly make up for the production capacity; at the same time, they can also rely on competition to stabilize the purchase prices of raw materials, thereby alleviating the cost pressure caused by the increase in raw material prices [10]. The diversified supply model simultaneously brings about issues such as increased supplier management costs and greater difficulty in standardizing components. NIO has mitigated these trade-offs through dynamic scoring and order allocation mechanisms.

4.2. Establishment of a digitalized full-chain intelligent risk early warning system

To address the issues such as information barriers across entities and the lag and mismatch of supply and demand information in the OEM model, NIO established a cross-departmental data management team to unify the data standards in procurement, production, warehousing, and logistics processes, connect the independent business systems within the company, and build an integrated digital platform for the supply chain [4]. The platform continuously collects all real-time data such as component inventory, raw material arrival cycle, factory production capacity, and overseas logistics transportation routes. It monitors multiple risk thresholds: when core component inventory drops below safety stock levels, logistics face severe delays, or raw material prices spike, the system automatically detects anomalies and triggers automated alerts to relevant decision-makers. These digital platforms have addressed historically prevalent inter-organizational information asymmetries. NIO can simultaneously share demand forecasts and monthly production plans with all suppliers. Suppliers will then provide feedback on production capacity limits and delivery cycles. Both parties exchange information in real time, reducing demand-supply mismatches and substantially compressing risk response times. This enables a transition from reactive remediation to proactive prediction and intervention.

4.3. Double-layer elastic supply chain buffering mechanism

NIO has established strategic safety stocks. For high-priced core components such as batteries and electronic control systems, it reserves emergency reserve stocks in warehouses across various regions in China. Concurrently, NIO implements localized supply chain configurations. Major domestic production bases are strategically located to attract component suppliers nearby. At the same time, local component supply networks are established in overseas markets to reduce reliance on cross-border long-distance transportation and lower risks of supply disruptions caused by tariffs, geopolitical conflicts, and shipping delays. The dual buffering mechanism reduces supply chain vulnerability from two aspects: inventory and geographical layout. Internally, this ensures short-term production stability; externally, it buffers against global trade volatility. It also takes into account the supply chain security of both the domestic market and overseas operations.

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5. General management insights for domestic new energy vehicle manufacturers

Supplier resilience management: Many OEMs, seeking to minimize procurement costs, have historically relied exclusively on a handful of leading suppliers. This seemingly simplifies the procurement process and reduces communication costs, but in fact, it lays a major foundation for supply disruptions [5]. All new energy manufacturers need to strike a balance between production costs and supply chain resilience. They cannot simply pursue low prices and a single channel. Enterprises can categorize components based on their importance. For core components such as the three-electricity system, at least 2-3 stable suppliers should be reserved. For ordinary exterior and interior parts, alternative small-scale suppliers should be retained. At the same time, long-term cooperation agreements should be signed with suppliers, including provisions for emergency supply assurance. Through order allocation, suppliers can be incentivized to increase emergency production capacity, taking into account both production efficiency and risk-resistance capabilities.

Second, information asymmetry constitutes the primary driver of supply chain risks. Both traditional car manufacturers and new small-scale automotive startups need to establish a unified information sharing platform, standardize data across the supply chain, and integrate all data related to demand forecasting, purchase orders, transportation logistics, and finished product inventory [4]. Automakers should proactively share medium- to long-term production and sales plans with suppliers. In return, suppliers provide feedback on production capacity limits and raw material inventories. By leveraging big data models, they predict future raw material prices and fluctuations in market sales volume, and adjust their procurement plans in advance to avoid the risks of blindly stockpiling or insufficient inventory, thereby eliminating various operational risks caused by information discrepancies between the upstream and downstream [6].

6. Conclusion

The most prominent supply chain risks faced by domestic new energy vehicle manufacturers mainly lie in four areas: single supplier dependency, differences in cross-entity contract manufacturing collaboration, raw material price fluctuations, and geopolitical trade shocks. These are common industry hazards that all NEV manufacturers must address. NIO adopts a multi-supplier matrix, digital information sharing, and a dual-buffering system combining inventory and local layout, which can effectively reduce risks such as supply disruptions, price hikes, and delivery delays. Complete supply chain risk management cannot merely be reactive after a risk occurs. Enterprises need to establish a full-closed-loop management model of "risk identification, assessment, early warning, and emergency recovery", taking into account both internal operation control and external market monitoring. At the same time, they should promote information collaboration among upstream and downstream enterprises, in order to maintain the stable operation of the industrial chain over the long term. This study is limited to a single-case analysis of NIO, constraining the generalizability of findings and precluding cross-case comparisons with incumbent OEMs transitioning to electrification and other emerging NEV manufacturers. The article mainly relies on theoretical case analysis, and does not use quantitative models to calculate the economic losses caused by various risks. The data support is limited. Future research could incorporate other major automakers such as BYD, XPENG, and Li Auto as comparison cases to compare supply chain risk profiles across different business models.

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