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An Analysis of Tesla's Supply Chain Management Model

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Abstract. As the global new energy vehicle (NEV) industry enters a phase of stock competition and high-quality development, supply chain management capabilities, cost optimization levels, and resilience to supply chain risks have become key sources of competitive differentiation among automakers, fundamentally changing the traditional automotive industry's emphasis on scale-based competition. Tesla, as a benchmark enterprise in the global NEV industry, has established a new supply chain management system that is underpinned by digitalization, features vertical integration as its core barrier, and integrates global layout with localized adaptation and coordination. The model also incorporates multiple supply sources and production locations to diversify supply chain risks. This paper takes Tesla's supply chain management model as the research object, systematically analyzing its core supply chain characteristics from three major frameworks: upstream supplier layout, midstream independent manufacturing of core technologies, and downstream direct-to-consumer (D2C) services. Additionally, it examines the practical challenges faced by Tesla's supply chain in the context of current global geopolitical conflicts, overseas policy barriers, and fluctuations in mineral resources. The study finds that the core advantages of Tesla's supply chain model lie in eliminating information silos across the entire chain through digital technology, gaining control over costs and technology through independent research and production in core areas, and achieving cost reduction, efficiency improvement, and risk diversification through a globally dispersed layout and deep localization adaptation. However, the model also has limitations, including limited resilience to supply disruptions resulting from a streamlined supplier base and substantial exposure to foreign-market policy changes.

Keywords: Tesla, New Energy Vehicles, Supply Chain Management, Vertical Integration, Digital Supply Chain

1. Introduction

In recent years, the new energy vehicle industry has entered a stage of rapid expansion. In 2023, more than 14 million new energy vehicles were registered worldwide, an increase of 3.5 million compared to 2022, representing a year-on-year growth of 35%. The performance of the Chinese market was particularly outstanding — in 2023, the production and sales of new energy vehicles reached 95.87 million units and 94.95 million units respectively, with year-on-year growth rates of 35.8% and 37.9% respectively. It ranked first globally for nine consecutive years [1]. Against this

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backdrop, supply chain efficiency has become one of the most crucial competitive factors for automakers. In practice, automakers with stronger cost-control capabilities are better positioned to compete in the market. Tesla is a leading enterprise in the global field of new energy vehicles. Unlike traditional car manufacturers that rely on outsourcing of large-scale components, Tesla has pursued a distinct supply chain strategy characterized by deep digital integration, extensive vertical integration, and the simultaneous pursuit of global expansion and localized operations. After Tesla entered China, it produced a significant "catfish effect" — stimulating more innovation and competition in technology, price, and marketing, and driving the technological improvement, scale expansion, and cost reduction of China's new energy vehicle industry chain. For example, Tesla's Shanghai Gigafactory delivered approximately 710,000 vehicles in 2022, accounting for 54.2% of the company's global deliveries, while its local supply ratio increased from 86% at the end of 2020 to more than 95% in 2023 [2]. It can be said that Tesla's development experience has important reference value for domestic new energy vehicle enterprises in optimizing their supply chain systems and enhancing the resilience of the industry chain. The core theme of this research is the innovative logic, practical path, and industry reference value of Tesla's supply chain model in the context of the rapid expansion of the global new energy vehicle industry.

The study addresses the following research questions: What is the underlying logic of Tesla's supply chain strategy, which differs from the "mass outsourcing" model of traditional automakers?

After Tesla entered China, the "catfish effect" it brought about manifested in three aspects: technological iteration, price system, and localization of the industrial chain. What quantifiable practical impacts did this have on China's new energy vehicle industry? Which aspects of Tesla's model can provide useful lessons for Chinese automakers seeking to address weaknesses in their supply chains and strengthen industrial-chain resilience?

2. The core architecture characteristics of Tesla's supply chain

The supply chain of Tesla can be divided into three levels: the upstream, the midstream, and the downstream.

2.1. Upstream: global network of high-quality suppliers

The upstream of Tesla mainly builds a supplier system centered around three core components: battery power, electric drive, and electronic control.

Battery sector: Tesla has deeply established partnerships with leading battery companies such as CATL and Panasonic. CATL is responsible for supplying battery packs for domestic Tesla vehicles, while Panasonic has been jointly developing battery technology with Tesla. To further secure its supply of critical materials, Tesla has also expanded its involvement upstream into mineral resources, including lithium in Australia and nickel in Indonesia, while signing long-term agreements with Huayou Cobalt and Zhongwei New Materials for the supply of raw materials used in battery cathode precursors.

In the motor field: The main suppliers include enterprises such as Zhongke Sanhuan (neodymium iron boron magnets), Hengdian Dongzhi (motor magnetic beads), and Xusheng Co., Ltd. (transmission housing). These are all Chinese enterprises.

Electronics control field: The cooperating parties include STMicroelectronics, Texas Instruments, etc.

According to incomplete statistics, there are over 180 Chinese suppliers that have direct supply relationships with Tesla, among which more than 40 are A-share listed companies [3]. This suggests

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that Tesla's China operations have achieved a high degree of local sourcing for most vehicle components, with the brand itself remaining American. This combination model of global core resource layout and local component supply not only ensures the security of core raw material supply but also reduces component procurement and logistics costs. However, the high concentration of suppliers and the reliance on a few enterprises for core battery materials pose certain risks of supply concentration.

2.2. Midstream: independent manufacturing of core technologies

Traditional automakers usually outsource the production of components and only do assembly themselves. Tesla, however, broke this logic — it independently develops and manufactures core components.

Tesla has complete control over the manufacturing rights of core parts such as motors, electronic control units, battery Packs and modules, and integrated casting chassis. The most typical example is the 4680 battery. In early 2022, Tesla's pilot production facility in Fremont, California, produced its one-millionth 4680 battery cell, demonstrating the company's progress in developing in-house capabilities across battery materials, cell design, and manufacturing processes [4]. The advantages of independent production are obvious: it reduces the risk of "supply disruption" and enhances the dominance over costs and technologies. Another representative innovation is the integrated die-casting technology. Traditional automotive manufacturing relies on the welding and assembly of hundreds of stamping parts, while Tesla uses a 6,000-ton super die-casting machine to integrate the rear floor panel of Model Y from the original 70 separate parts into a single component. This innovation reduces manufacturing costs by 40% and shortens production time from 1 to 2 hours to 3 minutes [5]. Through independent research and production of core links, Tesla has moved beyond a predominantly assembly-based manufacturing model, while gaining greater control over supply chain costs and strengthening its technological capabilities.

2.3. Downstream: D2C Direct-to-Consumer model

Tesla adopted a completely different D2C (Direct-to-Consumer) direct sales model at the sales end, which is quite different from the traditional 4S stores. Consumers can learn about the models through the official website, make their own selections, pay the deposit, and the factory will produce according to the orders, finally delivering the products directly to the customers. This model bypasses dealers and offers three main benefits: it eliminates dealer markups and commissions, reducing transaction costs; it allows Tesla to directly capture customer needs and feedback, accelerating product iteration; and it enables build-to-order production, minimizing inventory risks. Tesla also moved its after-sales services, and 80% of the after-sales problems can be solved online, combined with the OTA remote upgrade technology, further improving service efficiency. However, the direct sales model has high initial investment costs and limited coverage of offline service outlets.

3. Tesla's core practices in supply chain management

3.1. Digital technology drives cross-linkage throughout the supply chain

Tesla has implemented technologies such as AI, IoT, big data analysis, and digital twins in its supply chain, achieving collaboration in four dimensions.

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Supply-side collaboration: Tesla has developed its own Warp material system, which integrates sales orders, factory production capacity, and supplier inventory data in real time. After a customer places an order, the system automatically calculates the required components and promptly notifies the suppliers. Traditional automakers typically take about 7 days from placing an order to arranging production, while Tesla only takes 2 hours. Digital twin technology is also used to simulate logistics routes and identify and solve logistics bottlenecks in advance.

Production-side collaboration: Tesla has developed its own MOS intelligent manufacturing system, which uses 5G networks to achieve capacity coordination and full-process data traceability across its six global factories. The Shanghai Super Factory is a typical example — when it was built in early 2019, the weekly production capacity was approximately 3,000 vehicles, and by 2023, it had increased to approximately 20,000 vehicles [6].

Logistics-side collaboration: The Shanghai Gigafactory employs a "zero-inventory" loop layout, with components delivered directly to the production line and minimal stockpiling. Through precise material distribution, the inventory turnover rate has increased by 25% to 30% compared to traditional automakers.

Service-side collaboration: As of January 2024, Tesla has over 55,000 Superchargers worldwide. OTA technology enables car owners to complete software upgrades and remote fault diagnosis without having to visit the store, significantly reducing the cost of after-sales services. This ecosystem enables real-time data exchange and autonomous decision-making throughout the supply chain.

3.2. Strengthening supply chain initiative through vertical integration

Another significant feature of Tesla's supply chain management is its deep vertical integration. On the one hand, Tesla extends its involvement upstream from the consumer-facing end of the value chain to critical mineral resources, while also developing its own 4680 battery production capacity and establishing operations in Australian lithium mines and Indonesian nickel mines, thereby increasing its control over key stages of the battery manufacturing process. On the other hand, through technological innovation and independent research and development, Tesla has reduced the number of cooperating suppliers to approximately 130, with fewer than 70 being core suppliers. This streamlined supplier structure can improve coordination and responsiveness across the supply chain. Vertical integration has completely shattered the fragmented supply chain pattern of the new energy vehicle industry, achieving full chain controllability and manageability [7].

3.3. Global layout and localization adaptation

Unlike the single-market-focused and supply-chain centralized model adopted by most automakers, Tesla has established production bases in multiple regions around the world, forming a cross-regional production capacity matrix to mitigate risks from geopolitical factors, trade barriers, and fluctuations in supply and demand in a single market.

At the global layout level, Tesla has completed the capacity layout in three core regions: North America, Europe, and Asia. Each factory has a clear supply chain division and market positioning. Tesla has six factories globally, located in North America, Europe, and Asia. Each factory is deeply integrated into its local supply chain. The Shanghai Gigafactory is the most successful example. In 2022, the Shanghai factory delivered 710,000 vehicles, accounting for 54.2% of Tesla's global deliveries. The localization rate has increased from 86% at the end of 2020 to over 95% in 2023, with about 360 local first-tier suppliers signed. The Shanghai factory is not only the main production

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base in China but also serves as a global export center. At the same time, Tesla continues to expand its presence in emerging markets. The Mexico factory has been planned and is set to be established, with an estimated investment of over 5 billion US dollars. The planned production capacity is 1 million vehicles per year [8]. Tesla also benefits from Mexico's geographic advantages, as the country can serve both the North American and South American markets. In addition, Mexico has trade agreements with the United States that allow Tesla to benefit from preferential treatment under relevant US trade policies. The Indian market is also under discussion. India is already the world's third-largest automotive market, but currently, the proportion of electric vehicles is less than 1%, with huge growth potential. Overall, the global layout combined with the localization adaptation model enables Tesla to have both global risk control capabilities and local profit efficiency, forming a supply chain advantage distinct from traditional automakers.

4. Supply chain challenges faced by Tesla and their mitigation strategies

4.1. Current main challenges

External Policy Restrictions: Although the US' "Inflation Reduction Act" retains the tax incentives for battery storage, it imposes restrictions on raw materials from "targeted foreign entities". Due to the high concentration of global critical mineral refining capacity in China, the compliance costs for Tesla's supply chain have significantly increased. This challenge has affected the US clean energy industry chain — the scale of joint bidding for photovoltaic-storage projects in some states has declined by 15%, and many start-ups have postponed their solid-state battery R&D plans due to tighter financing conditions.

Geopolitical Factors Disturbance: Global chip shortages, uneven distribution of mineral resources, and trade frictions have continuously impacted the stability of cross-regional supply chains. The core lithium, nickel, and cobalt minerals for batteries are concentrated in a few countries, and fluctuations in resource prices and adjustments in export policies directly affect Tesla's upstream material procurement costs and supply stability; the reliance on overseas leading manufacturers for automotive-grade chips leads to global chip supply-demand mismatches, which can easily restrict production capacity at the production end.

4.2. Tesla's response path

Short-term direction: Tesla has established a battery-material recycling facility in Texas, which recovers and reuses materials from spent batteries to reduce its reliance on imported critical minerals. At the same time, it continuously iterates its digital system to optimize supply chain efficiency. Medium- and long-term direction: Tesla is exploring new business areas — the virtual power plant project has been connected to the California power grid, enhancing grid stability by integrating distributed energy resources; hydrogen fuel cell heavy-duty trucks are also under development, with test data showing a range of up to 800 kilometers. These explorations help build a multi-track collaborative supply chain risk-resistance system, reducing reliance on a single business.

5. Conclusion

Overall, the core logic of Tesla's supply chain management model can be summarized as the following four points:

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First, digitalization is the underlying support. From the Warp material system to the MOS manufacturing operating system, from digital twins to OTA upgrades, Tesla integrates digital technology into every link of the supply chain, achieving efficient operation throughout the entire chain from order to delivery.

Second, key links are autonomously controlled. Tesla adheres to self-research and self-production of core components, especially the 4680 battery and integrated die-casting technology. This not only reduces reliance on suppliers but also gives Tesla cost and technological advantages.

Third, globalization and localization are carried out simultaneously. Tesla has established production bases globally, with each factory closely integrated with its local supply chain. The Shanghai Gigafactory, with a localization rate of over 95%, provides strong evidence of this approach.

Fourth, Tesla continues to explore new growth drivers. In the face of policy restrictions and geopolitical risks, Tesla builds a diversified layout through new businesses such as battery recycling, virtual power plants, and hydrogen-powered trucks, enhancing the overall risk-resistance capability.

Tesla's supply chain management model is not perfect, but its innovative practices in digital collaboration, vertical integration, and local adaptation have provided important reference samples for the global new energy vehicle industry. Accordingly, domestic automakers can prioritize supply chain digitalization, moderate vertical integration, and a balance between scale and refined management. This article focuses on Tesla's supply chain model and does not conduct quantitative comparisons among multiple automakers. In the future, it can combine more automaker data to quantitatively analyze the impact of supply chain management on profitability and production capacity, and improve the universality of the research.

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