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ТЕНДЕНЦИИ РАЗВИТИЯ МИРОВОЙ АВТОМОБИЛЬНОЙ ПРОМЫШЛЕННОСТИ В УСЛОВИЯХ ПЕРЕХОДА К ЭКОНОМИКЕ ЧИСТОЙ ЭНЕРГИИ

TRENDS IN THE DEVELOPMENT OF THE GLOBAL AUTOMOTIVE INDUSTRY IN THE CONTEXT OF THE TRANSITION TO A CLEAN ENERGY ECONOMY

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Аннотация: В условиях перехода на зеленую экономику и экономику чистой энергии, в развитии мировой автомобильной промышленности прослеживаются тенденции, связанные с необходимостью снижения негативного влияния транспорта на окружающую среду. Переход на электромобили, внедрение инновационных и экологически-чистых технологий, применение механизмов стимулирования перехода на электромобили и развитие самого рынка электромобилей, позволит снизить потребление топлива и как следствие выбросов CO_2 в атмосферу земли.

Abstract: In the context of the transition to a green economy and a clean energy economy, there are trends in the development of the global automotive industry related to the need to reduce the negative impact of transport on the environment. The transition to electric vehicles, the introduction of innovative and environmentally friendly technologies, the use of mechanisms to stimulate the transition to electric vehicles and the development of the electric vehicle market itself will reduce fuel consumption and, as a result, CO2 emissions into the earth's atmosphere.

Ключевые слова: автомобильная промышленность, экономика чистой энергии, зеленая экономика, мировые тенденции, устойчивое развитие.

Keywords: automotive industry, clean energy economy, green economy, global trends, sustainable development.

The global automotive industry is currently undergoing a period of profound transformation, characterized by diversification and increasing complexity. From a technological perspective, electrification, intelligence, and connectivity have become irreversible mainstream trends. According to data from the International Energy Agency, global electric vehicle sales exceeded 10 million units in 2022, representing a year-on-year increase of 55%, with China accounting for over 60% of the market [1]. This explosive growth has not only altered the traditional market landscape dominated by internal combustion engine vehicles but has also driven the restructuring of the entire supply chain. Major automakers are increasing their R&D investments in core areas such as battery technology and motor control systems. The rise of emerging electric vehicle companies like Tesla and BYD is rewriting the rules of industry competition.

The rapid development of autonomous driving technology is reshaping the attributes of automotive products. Tech companies such as Waymo and Baidu Apollo have pushed Level 4 autonomous driving from the laboratory to the actual road testing phase through continuous technological iteration. This technological breakthrough has not only driven product innovation but also given rise to new business models such as “Car-as-a-Service.” Traditional automakers like Volkswagen and Toyota are accelerating their technological catch-up through strategic alliances. For example, the collaboration between Volkswagen and Ford in the field of autonomous driving is a notable example [2].

In terms of global layout, regional characteristics are becoming increasingly prominent. Affected by geopolitics and trade protectionism, automakers are generally adopting a strategy of “global R&D, local production.” BMW Group's newly built electric vehicle factory in Hungary and Tesla's super factory in Berlin, Germany, both reflect this trend of “nearshoring.”

Against the backdrop of chip shortages and supply chain disruptions, establishing regionalized supply chain systems has become an industry consensus. Hyundai Motor's battery supply chain in Southeast Asia is a typical example of responding to globalization challenges.

The market structure exhibits a “the rich get richer” Matthew effect. Through mergers and acquisitions, industry concentration has continued to rise. The Stellantis Group, formed by the merger of Peugeot Citroën and Fiat Chrysler, has become the world's fourth-largest automotive group. This integration not only achieved economies of scale but also optimized global production capacity. Data shows that the market share of the world's top ten automakers rose from 63% in 2010 to 72% in 2022, marking the industry's entry into an oligopolistic competition phase.

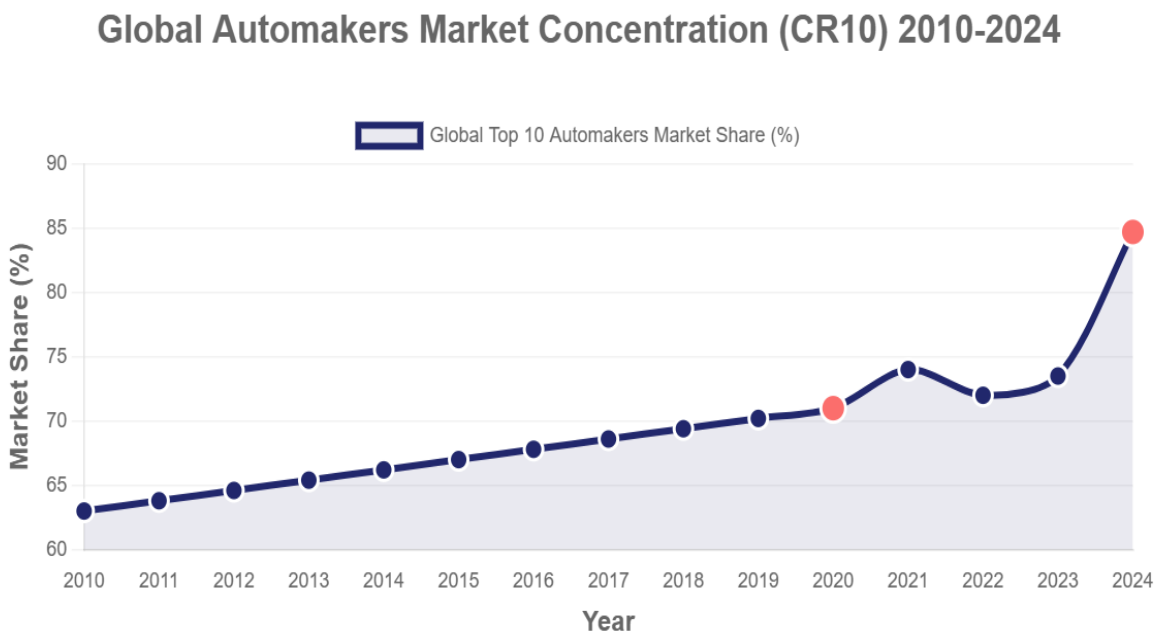

Figure 1- Changes in the CR10 share of global automakers（2010-2024）

Sustainable development has become a core issue for the industry. Volvo has announced that it will achieve full electrification by 2030, while Mercedes-Benz plans to reduce the carbon emissions of each vehicle by 50% by 2025. This transformation is not only reflected in products, but also throughout the entire value chain. The BMW Group has established a closed-loop recycling system, achieving an aluminum recycling rate of up to 90% in the production process.

Digital transformation is profoundly changing the operating model of the automotive industry. Through the application of technologies such as industrial Internet and digital twins, production efficiency and flexible manufacturing capabilities have been improved [3]. Toyota's “smart factory” project has shortened the new car development cycle by 30%, while Volkswagen's MEB electric platform has enabled multi-model production on the same line. This digitalization has not only optimized the manufacturing process, but also restructured the entire value chain from R&D to after-sales service.

In emerging markets, localization strategies have proven effective [7]. Chinese brands such as Geely and Great Wall have achieved international breakthroughs through acquisitions such as Volvo and the merger of General Motors' Indian factory. India's Mahindra has formed a strategic alliance with Ford to develop economical electric vehicles suitable for the local market. These cases demonstrate that understanding local consumer needs and establishing an adaptive supply chain are key to expanding into emerging markets.

Supply chain restructuring has become an important issue in today's world. Affected by chip shortages, car companies have adjusted their procurement strategies, shifting from just-in-time (JIT)

to just-in-case (JIC) models. Tesla has demonstrated a new supply chain mindset through its vertical integration strategy, independently developing chips and investing in lithium resources. This shift is reshaping the global automotive parts industry landscape.

Business model innovations are emerging one after another. New service models such as subscription services and on-demand transportation are transforming traditional car sales methods [8]. Mercedes-Benz has launched a “pay-per-use” service in some markets, allowing users to pay based on actual usage. This innovation not only expands revenue streams but also establishes direct connections with end users.

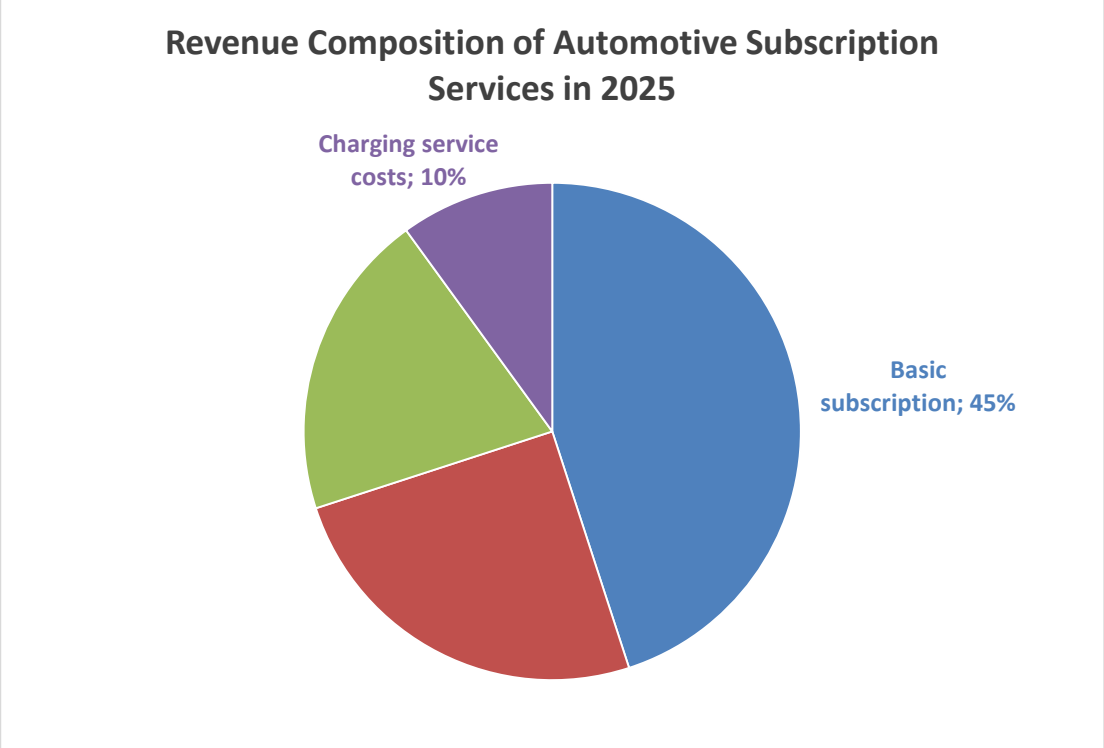

Figure 2 -Revenue composition of car subscription services in 2025

In the field of technical standards, international competition is becoming increasingly fierce. China's influence in areas such as electric vehicle charging standards and vehicle-to-vehicle communication protocols is steadily growing. Countries like the US, Europe, Japan, and South Korea are maintaining their standard advantages through technical alliances. For example, the CharIN Alliance brings together major global automakers like Volkswagen and BMW. This battle over standards is essentially a contest for future industry dominance.

The competition for talent is becoming increasingly globalized. With the strengthening of the software-defined car trend, the demand ratio between traditional mechanical engineers and software engineers has undergone a fundamental change. Tesla has recruited a large number of software talents from Silicon Valley, while Volkswagen has established a dedicated Car. Software department. This

transformation in talent structure is reshaping the organizational structure and innovation capabilities of automotive companies.

Financial innovation supports industrial upgrading. New financial tools such as green bonds and sustainability-linked loans are widely used in the automotive industry's transformation [7]. BYD raised funds through the issuance of green bonds for the research and development of new energy vehicles, while Daimler signed sustainability-linked credit agreements with several banks. This industry-finance integration model provides financial support for the industry's transformation.

The policy environment has a profound impact on industry development. Regulations such as the EU's “2035 ban on combustion engines” and China's “double credit” policy have accelerated the transition to new technologies [6]. The requirements for the localization of electric vehicles in the US Inflation Reduction Act have directly impacted the global supply chain layout. This policy-driven development model is reshaping the global automotive industry landscape.

The after-sales service market is undergoing a digital transformation. With the advent of connected vehicle technology, new service models such as remote diagnostics and predictive maintenance are becoming increasingly popular. Bosch's cloud-based diagnostic system can improve the accuracy of vehicle fault warnings to 85%. This not only enhances the user experience, but also creates new profit growth points.

In terms of industrial ecology, cross-border integration has become the new normal. The boundaries between the automotive, energy, communications, and technology industries are becoming increasingly blurred. CATL is collaborating with State Grid to build battery swap stations, while Huawei is entering the automotive supply chain through its HI intelligent automotive solutions. This ecological development is giving rise to entirely new forms of industrial organization [5].

The R&D model has undergone a fundamental change. Open innovation and collaborative R&D have become the mainstream. Toyota and BYD have jointly established an R&D company to develop pure electric vehicle models. This collaboration not only shares R&D costs but also achieves technological complementarity. Data shows that the number of industry R&D collaboration projects has increased nearly threefold over the past five years.

Brand strategies are showing signs of differentiation. Luxury brands are accelerating their transition to electric vehicles to maintain their premium pricing power, as exemplified by the success of Porsche's Taycan. Economy brands are improving cost performance through intelligent configurations, such as Hyundai Motor's digital key system. This differentiated positioning helps automakers establish a competitive advantage in niche markets.

The used car market is undergoing innovative development. Through digital platforms, transparency has been improved in areas such as vehicle history checks and valuation pricing. Carvana's automated car vending machine model in the United States and Youxin's end-to-end online

transaction system in China represent the direction of innovation in the industry. This is driving the standardization of the global used car market.

Virtualization technology is widely used in the field of testing and verification. Through digital twin technology, BMW has reduced the road testing mileage of new models by approximately 1 million kilometers. This innovation has not only shortened the R&D cycle, but also significantly reduced development costs. The development of autonomous driving simulation testing platforms has provided the necessary conditions for the commercialization of high-level autonomous driving.

Industrial policy coordination faces new challenges. Differences between countries in areas such as data security and autonomous driving regulations pose compliance risks for global operations. The EU's General Data Protection Regulation (GDPR) imposes strict requirements on connected vehicle data management, while China's Provisions on the Management of Automobile Data Security establishes the principle of local storage. These policy differences require automakers to establish more flexible global management systems [4].

In the 2nd quarter of 2025, the ZSW Center for Solar Energy and Hydrogen Research in Baden–Wuerttemberg conducted research on the number of sales of cars with electric motors, according to which the global fleet of electric vehicles has reached 56 million units to date, of which about 31 million will be useful in China.

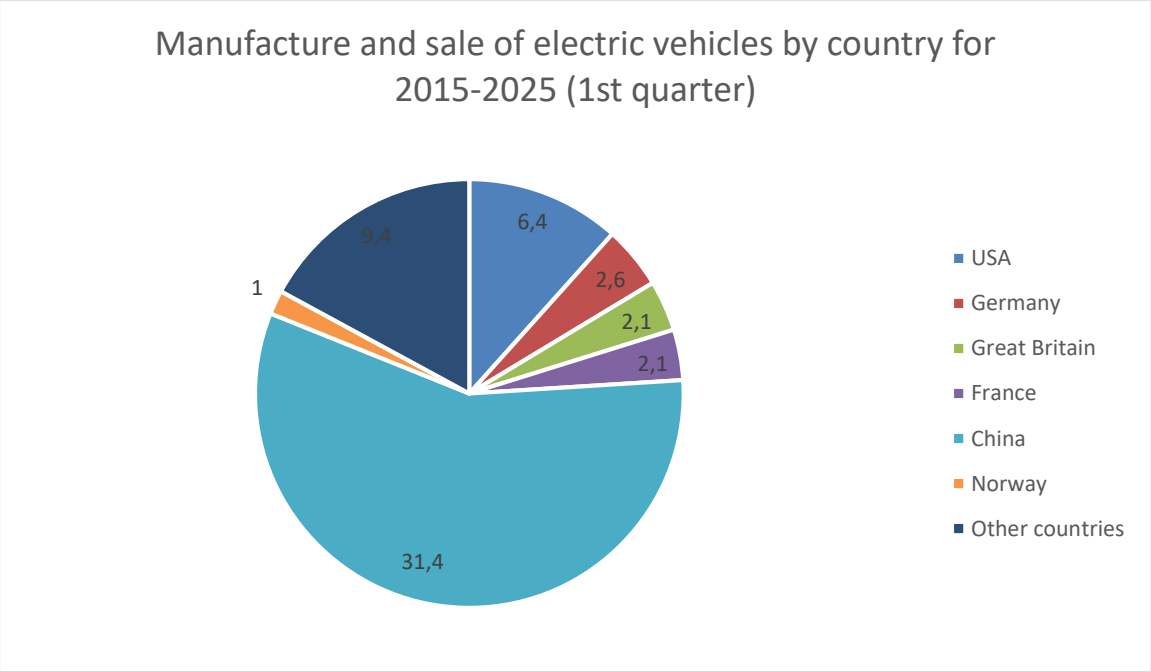

Figure 3 - Manufacture and sale of electric vehicles by country for 2015-2025 (1st quarter)

The global automotive industry is undergoing unprecedented and profound changes. The transformation of technological approaches, innovation in business models, and the restructuring of the industrial ecosystem—these changes present both challenges and opportunities. Automakers must

adopt a more open mindset to embrace these changes, leveraging strategic alliances, mergers, and acquisitions to secure critical resources and gain a competitive edge in the fiercely competitive market. Future industry competition will no longer be about isolated breakthroughs but rather a comprehensive competition across the entire industrial ecosystem.

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