Proceedings of the 8th International Conference on Economic Management and Green Development
DOI: 10.54254/2754-1169/111/2024.17760

Status and Development Strategies of Electric Vehicle Supply Chain and Charging Stations in China and the U.S.

Qiuyan Zhou[1,a,*]

[1]*The University of Hong Kong, Pokfulam, Hong Kong, China*
a. zhouqiuyan1224@126.com
**corresponding author*

Abstract: The market for electric vehicles (EVs) is rising rapidly in China and the United States. This study systematically explores key aspects of the EV supply chain and the impacts related to charging stations through a literature review and case study analysis. Contemporary Amperex Technology Co., Limited (CATL) is used as a case study to analyze its success factors in the battery supply chain. It is found that innovative technology and a globalized layout are the main factors driving the development of the supply chain. Through data analysis, EV sales and the number of charging stations in China and the United States are compared, revealing their correlation. Constructive suggestions to promote the EV and charging station industries are put forward to foster the healthy development of the EV supply chain.

Keywords: Electric Vehicle Supply Chain, Charging Stations, Battery Supply Chain.

1. Introduction

1.1. Background of the Study

Facing the current global energy structure transformation and green transportation development, Battery Electric Vehicles (BEVs) have been developing rapidly in recent years, especially in China and the United States. In the face of increasingly serious environmental pollution, the environmentally friendly and high-efficiency features of electric vehicles have become the focus of attention for governments and enterprises. According to the International Energy Agency (IEA), global sales of electric vehicles have shown explosive growth in the past few years, especially in major markets such as China and the United States [1]. This situation is driven not only by the increasing environmental awareness of consumers but also by the continuous technological innovation of car companies and government support [2].

The development and popularization of electric vehicles are inseparable from the supply chain support of related industries. The EV supply chain covers multiple links from raw material procurement to battery manufacturing to vehicle production and sales [3]. Each link in the EV supply chain is crucial. In particular, the updating and upgrading of battery technology and cost reduction provide a solid foundation for the wide application of electric vehicles [4].

Meanwhile, charging stations, as key supporting infrastructure for electric vehicles, play a crucial role in whether electric vehicles can be widely used. The number and layout of charging stations directly affect consumers' willingness to purchase vehicles and their psychology, such as mileage

DOI: 10.54254/2754-1169/111/2024.17760

anxiety. Therefore, it is of great practical significance and academic value to study the supply chain of electric vehicles and their charging stations.

1.2. Purpose and Significance of the Study

The main objective of this study is to systematically analyze various aspects of the EV supply chain in China and the U.S. and the impact of charging station construction on the development of the EV market. This is achieved through a literature review, a case study of CATL, and a comparison of the development of electric vehicles in China and the U.S. We aim to: identify the key links and major challenges in the EV supply chain, analyze the current state of charging stations and their role in the EV market, and make constructive suggestions to promote the high-speed, healthy, and sustainable development of the EV and charging station industry.

2. Literature Review

In recent years, the global development of new energy vehicles has been rapid, with many countries strongly supporting the technological innovation and promotion of electric vehicles. China and the United States, as major players in the automobile market, especially in the electric vehicle market, have an important influence in EV-related fields. Thus, it is necessary to study the impact of electric vehicles and charging stations in China and the United States.

2.1. China's New Energy Vehicle Market

The growth of China's new energy vehicle market is due to the rapid development and technological updates of China's own automobile brands, as well as the support of the Chinese government. According to data released by the China Association of Automobile Manufacturers [5], China's new energy vehicle sales reached 9.495 million units in 2023 [6]. The Chinese government encourages consumers to buy new energy vehicles through policy measures such as subsidies and tax incentives and encourages enterprises to increase R&D investment to improve the technical level and market competitiveness of new energy vehicles.

Relevant studies have shown that China has made significant progress in the technological innovation of new energy vehicles. The rapid development of lithium-ion battery technology has significantly reduced battery costs and improved the market competitiveness of electric vehicles [7]. Enterprises such as CATL and BYD occupy an important position in the global battery market, continuously reducing production costs through technological innovation and scale effects, and improving the performance of new energy vehicles through technological improvement[8][9].

2.2. U.S. New Energy Vehicle Market

The U.S. is one of the world's major markets for new energy vehicles. According to data released by the U.S. Department of Energy (DOE), U.S. sales of new energy vehicles reached 1.6 million units in 2023[10]. Tesla, a representative of electric vehicles in the United States, occupies a leading position in the American market [11].

The U.S. government has also implemented supportive policies for the new energy industry and market, such as tax incentives and infrastructure construction [2]. However, the overall growth rate of the U.S. new energy vehicle market is relatively slow due to inconsistent state policies and differences in consumer acceptance [3].

DOI: 10.54254/2754-1169/111/2024.17760

2.3. Construction and Use of Charging Stations

Charging infrastructure is one of the important factors for the development of electric vehicles, with the number and layout of charging stations playing a significant role in promoting the development of electric vehicles. The development of charging stations in China and the United States differs.

2.3.1. Charging Stations in China

According to data released by the China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA), by the end of 2023, about 2 million public charging stations had been built in China, with a ratio of 1:3 between fast-charging stations and slow-charging piles [12]. These charging stations are mainly located in large cities and coastal areas such as Beijing, Shanghai, Shenzhen, and Guangzhou.

Currently, the utilization and efficiency of charging stations in China are relatively low. The average daily usage of public charging stations in China is 1.2 times, and the average charging duration of fast-charging stations and slow-charging stations is 30 minutes and 6 hours, respectively [12]. The distribution of charging stations is not balanced, leading to low utilization rates in some areas.

2.3.2. Charging Stations in the U.S.

Charging infrastructure is more widely developed in the United States. According to ChargePoint, by the end of 2023, there were about 1.2 million public charging stations in the U.S., with a ratio of 1:4 between fast-charging stations and slow-charging stations [13]. Charging stations are mainly located in densely populated and economically developed states such as California, New York, and Texas. The average daily use of public charging stations in the U.S. is 1.5 times, and the average length of charge for fast and slow chargers is 45 minutes and 8 hours, respectively. California has the highest utilization of charging stations, while some Midwestern and Southern states have lower utilization [13].

2.4. Supply Chain and Technology Overview of Electric Vehicle Batteries

Batteries are the core components of electric vehicles, and their technological advancement and cost reduction play an important role in driving the development of the new energy vehicle market. A study by Nykvist and Nilsson suggests that the rapid decline in battery costs is a key factor driving the expansion of the electric vehicle market [4]. A study by Fell points out that the advancement of lithium-ion battery technology has significantly improved the market competitiveness of electric vehicles [7].

2.5. Power Systems

The popularity of electric vehicles is placing new demands on the power system. Research by Nehrir shows that the future development of electric vehicles needs to rely on adequate power supply and smart grid support [14].

3. Case Study

Through a case study of CATL, a major supplier of electric vehicles, in the battery supply chain, we objectively analyze the supply chain management of batteries, an important part of the supply chain of new energy vehicles, to identify the success factors of supply chain management in the field of electric vehicles.

DOI: 10.54254/2754-1169/111/2024.17760

3.1. Supply Chain Management

3.1.1. Procurement of Raw Materials

The production of electric vehicle batteries is highly dependent on raw materials with very specific chemical elements. According to Moores [15], the global cobalt supply chain is highly vulnerable to geopolitical factors and fluctuations in market demand, which can lead to an unstable supply. CATL has adopted a diversified supply strategy for raw material procurement to better cope with the volatile market supply situation and has taken the following measures to ensure the normal operation of the raw material supply chain.

- Multi-region/country sourcing: By finding cooperative supply chains in different countries around the world to circumvent the problem of supply chain breakage due to a single sourcing source, CATL has entered into cooperative relationships with regions such as Australia, Africa, and South America to ensure a stable supply of lithium, cobalt, nickel, and other raw materials for battery manufacturing.

- Overseas Mineral Layout: CATL has invested in the lithium industry in different regions such as North America and Australia through subscription of shares. It is also involved in lithium extraction projects in overseas salt lakes and has taken the lead in jointly mining lithium resources with other enterprises in Bolivia. In addition to lithium resources, CATL also has overseas layouts in nickel, cobalt, and other key mineral resources for lithium batteries. Indonesia has abundant nickel resources, and CATL has focused its nickel mine development projects on Indonesia and other places. For cobalt, CATL has chosen to strategically cooperate with Luoyang Molybdenum. Meanwhile, CATL also focuses on domestic mineral layouts, laying out the prospecting rights of Guizhou Province Daping phosphate mine as well as Jiangxi Yichun ceramic clay (containing lithium).

- Sustainable development: CATL has been promoting the path of carbon neutrality for lithium batteries. The optimization of carbon emissions from battery cells is achieved through measures such as improving manufacturing yields, increasing the proportion of recycled materials used, and using green energy.

3.1.2. Manufacturing

According to Nehrir's study [14], production management and manufacturing technology are important influences on the production efficiency and cost of electric vehicles. CATL is committed to building a flexible, efficient, low-cost, high-quality, self-upgrading "smart factory." Through the concept of automation, digitization, and intelligence, the use of 5G, artificial intelligence, machine learning, predictive algorithms, and other new technologies helps make production efficient and convenient.

3.2. Analysis of Success Factors

3.2.1. Technological Innovation

CATL has now launched cutting-edge technologies with high specific energy technology, long life technology, and ultra-fast charging technology continuously upgraded and iterated. Meanwhile, it has also continuously strengthened its innovation concept and created material innovation platforms, product innovation platforms, and intelligent innovation platforms. Through these technological innovations, CATL has continuously improved the market competitiveness of its own electric vehicles.

DOI: 10.54254/2754-1169/111/2024.17760

3.2.2. Strategic Layout for Globalization

CATL has developed different strategic layouts to better utilize battery resources in electric vehicles by taking into account the different conditions of mineral resources in different regions, as well as government policies and requirements in different regions. This ensures the stability of raw material supply and reduces supply chain risks.

3.2.3. Upstream and Downstream Relationships in the Supply Chain

Through the globalization layout, CATL and raw material suppliers have realized the supply guarantee of having raw material end in the supply chain. Meanwhile, CATL has established partnerships with almost all the mainstream car enterprises in the world, and established close business dealings with the downstream of the supply chain. Currently, CATL has become an excellent supplier partner of SAIC Volkswagen. Under the current situation of fierce competition in electric vehicles, reaching a friendly relationship with major car manufacturers has significant implications and impacts on the supply chain of electric vehicles.

4. Results and Analysis

4.1. Data Collection

Based on published data from the China Association of Automobile Manufacturers [16], the China Electric Vehicle Charging Infrastructure Promotion Alliance [17], the U.S. Department of Energy [10], ChargePoint [18], and the International Energy Agency [19], information on EV sales in China and the U.S., as well as charging stations, for the years 2015-2023 was collected.

Table 1: China EV and USA EV sales data from 2015 to 2023

Year	China EV Sales (units)	Sales (units)
2015	331092	115000
2016	507000	159000
2017	777000	200000
2018	1256000	361000
2019	1206000	320000
2020	1303000	328000
2021	3521000	607000
2022	6887000	807000
2023	9495000	1600000

Table 2: China Public Charging Stations and USA Public Charging Stations data from 2015 to 2023

Year	China Public Charging Stations (units)	USA Public Charging Stations (units)
2015	49900	16000
2016	150000	31000
2017	214000	40000
2018	330000	55000
2019	516000	69000
2020	807000	80000
2021	1061000	100000

DOI: 10.54254/2754-1169/111/2024.17760

Table 2: (continued).

2022	1480000	110000
2023	2000000	1200000

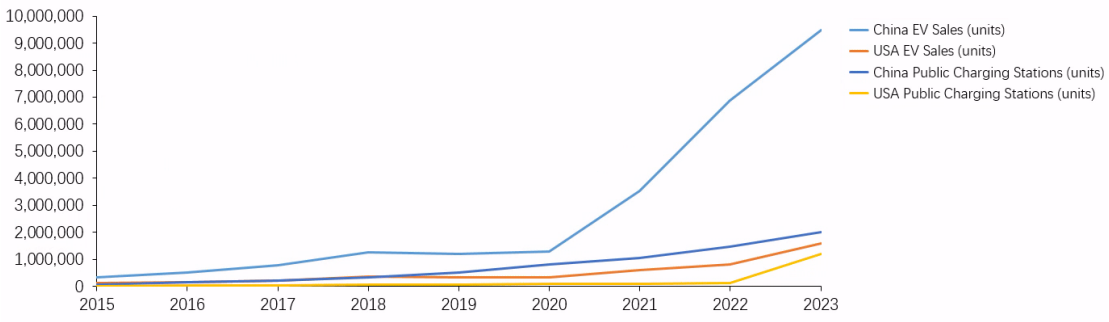

Figure 1: Line chart of EV sales and charging numbers in the U.S. and China

4.2. Data Analysis

Based on the data in Table 1, Table 2 and Figure 1, a line graph with the year as the unit of the X-axis was plotted, in which the vertical coordinate represents the number of electric vehicles sold in China/US and the number of public charging stations in China/US. The reason for putting the number of electric vehicles sold and the number of public charging stations into one line graph is to not only find the trend from 2015-2023 but also to observe the relationship between the number of electric vehicles sold and the number of public charging stations.

Through the chart, it can be seen that both China and the United States' electric vehicle sales are increasing year by year, indicating the continuous high development of electric vehicles. From 2021 to 2023, China's electric vehicle sales growth rate increased, with an average annual growth rate of more than 50%. The U.S. electric vehicle sales growth rate also increased starting in 2021, reaching a record high in 2023. At the same time, it can be found that in both China and the United States, the year-by-year trend of electric vehicle sales and the number of public charging stations is consistent, showing a correlation.

4.3. Data Conclusions

Through comparison, it can be found that China's development of electric vehicles is much faster than that of the United States. This is closely related to the development of China's domestic brands, such as BYD, Ideal, Azure, and Inquisition, which have attracted a large number of consumers through technological innovation. The Chinese government's strong support for the electric vehicle industry, both in terms of energy and technology as well as the market, has also helped China's auto sales. The increase in sales of electric vehicles indirectly proves that the supply chain of electric vehicles is currently relatively good. Through technology and other optimizations, the cost of raw materials in the supply chain, as well as the cost of transportation, can be reduced, improving the resilience of the supply chain.

The gap between the number of charging stations in China and the United States is smaller than the sales volume of electric vehicles in both countries. It can be concluded that China's charging stations may continue to grow in the future to meet the matching demand for electric vehicles in China. The public charging stations in the U.S. match the sales of electric vehicles, meaning that the U.S. charging station resources are sufficient to provide adequate resources for local electric vehicle

DOI: 10.54254/2754-1169/111/2024.17760

charging services. Therefore, in the future, China needs to pay more attention to the supply chain of charging stations to ensure that it can meet future demand.

5. Conclusion

5.1. Electric Vehicle Supply Chain

Through the review of the electric vehicle supply chain in China and the United States, the statistical analysis of relevant data, and the analysis of the case of CATL, we can draw the following conclusions:

- Innovation in technology: Technology is an absolute driving force for the development of the supply chain of electric vehicles. Whether it's the innovation of battery technology from CATL or the continuous technological revolution of Chinese new energy vehicle brands such as BYD, Ideal, and Inquisition in the field of electric vehicles, all of them can make the supply chain of electric vehicles more efficient and stable, improving the prosperity of the whole process of the supply chain.

- Globalization strategy layout: By considering the manufacturing materials and transportation factors required for electric vehicles according to different fields and resources around the world, the stability of the supply chain can be ensured through multiple routes and multiple source suppliers to reduce the shortage or interruption of raw materials brought about by a single supplier.

- Creating friendly relationships upstream and downstream of the supply chain: For the supply chain of electric vehicles, due to the increasingly fierce competition of electric vehicles nowadays, the first-tier suppliers need to establish friendly relationships with downstream customers. This can be done through the establishment of strategic partners to maintain the stability of the downstream of the supply chain. Meanwhile, in the face of resource constraints and obvious price fluctuations of some of the required raw materials, it is essential to establish friendly business relationships with upstream suppliers.

5.2. Charging Station Supply Chain Development

At present, the global charging station market is still showing a rapid growth trend, especially in China and other regions with a large growth rate of electric vehicles. Therefore, the establishment of a sound charging station supply chain is the basis for guaranteeing the future development of charging stations.

In the face of the growth of electric vehicle sales, charging station suppliers should have a long-term awareness and advance the charging station supply chain layout. Especially in China, charging station suppliers should strengthen the construction of the supply chain to keep pace with China's electric vehicle sales.

This research focuses on the analysis of the electric vehicle-related supply chain through the sales of electric vehicles and the development of charging stations in China and the United States, as well as the analysis of the successful case of CATL. It concludes with factors that can be improved in the supply chain of electric vehicles and puts forward suggestions for the future development of the supply chain in the field of electric vehicles.

Since this research only discusses the relevant situations in China and the United States, but the global EV situation is complex and changing, future studies need to examine the EV supply chain situation in more regional countries to better establish a study on the overall development of the EV supply chain.

References

[1] *IEA. (2023). "Global EV Outlook 2023." International Energy Agency.*

[2] *Zhou, X., et al. (2023). "Government Policies and Market Trends in the Electric Vehicle Industry." Journal of Cleaner Production.*

[3] Chen, J. (2022). "The Supply Chain of Electric Vehicles: Challenges and Opportunities." Journal of Supply Chain Management.
[4] Nykvist, B., & Nilsson, M. (2015). "Rapidly Falling Costs of Battery Packs for Electric Vehicles." Nature Climate Change.
[5] China Association of Automobile Manufacturers. (2023). "New Energy Vehicle Sales Data Report 2023."
[6] China Electric Vehicle Charging Infrastructure Promotion Alliance. (2023).
[7] Fell, H.-J., et al. (2020). "Impact of Battery Technology on Electric Vehicles Market Competitiveness." Journal of Energy Storage.
[8] CATL. (2023). Corporate Annual Report.
[9] BYD. (2023). Corporate Annual Report.
[10] DOE. (2023). US Department of Energy Annual Report.
[11] Tesla, Inc. Tesla Annual Report 2023. 2023. Available from: https://ir.tesla.com/_flysystem/s3/sec/0001628280240023 90/tsla-20231231-gen.pdf.
[12] EVCIPA. (2023). "China Charging Infrastructure Report 2023."
[13] ChargePoint. (2023). "U.S. Public Charging Post Statistics for 2023."
[14] Nehrir, M. H., et al. (2018). "Electric Vehicle Integration into Power Systems." IEEE Transactions on Smart Grid.
[15] Moores, S. (2020). "The Global Cobalt Supply Chain and Its Vulnerabilities." Journal of Materials Supply.
[16] CAAM. (2023). CAAM Yearbook.
[17] EVCIPA. (2023). Annual Report of the China Electric Vehicle Charging Infrastructure Promotion Alliance.
[18] ChargePoint. (2023). ChargePoint Network Statistics.
[19] IEA. (2023). Global EV Outlook 2023. Retrieved from [IEA website](https://www.iea.org/reports/global-ev-outlook-2023).