Enterprise Supplier Management and Sustainable Development: A Case Study of Tesla Supplier Management

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Abstract. In line with global green initiatives and the growth of Environmental, Social, and Governance (ESG) corporate sustainability standards, how supply chain management can better meet corporate sustainability goals has become a key issue today. This article examines the Tesla supplier management case study further to explain how Tesla advances its sustainability objectives through green initiatives and digital collaboration. Tesla incorporates green, circular, and low-carbon principles into the entire lifecycle management of its new energy vehicles, creating a responsible green supply chain. Concerning environmental initiatives, Tesla emphasizes the use of eco-friendly and recycled materials and is dedicated to battery recycling and reuse, to recycle over 90% of battery manufacturing waste by 2023. The Shanghai Gigafactory's industrial waste recycling rate is an impressive 93%. Tesla also utilizes digital technology to enhance supply chain management, developing a proprietary production and manufacturing control system that enables real-time collection and monitoring of quality information throughout the entire business chain. By utilizing an artificial intelligence platform to optimize process parameters and forecast quality risks, Tesla significantly enhances the efficiency and accuracy of its manufacturing process. Through the deep integration of green initiatives and digitalization, Tesla not only achieves efficient supply chain collaboration and low-carbon operations but also sets an example for global companies to reach sustainable development goals through supply chain innovation.

Keywords: Supplier management, sustainable development, Tesla, greening, digitalization.

1. Introduction

With the advancement of Environment, Society, Governance (ESG) corporate sustainability disclosure standards, companies must not only comply with the nation's stringent environmental protection regulations but also meet consumers' growing demand for green products. For industrial manufacturing businesses, managing the supply chain for green sustainable development and enhancing the green, low-carbon, circular economic system have significant long-term effects [1].

The report “Scope 3 Upstream: Big Challenges, Simple Remedies," jointly published by Boston Consulting Group and the Carbon Disclosure Project, states that Scope 3 (indirect) emissions from the supply chain are 26 times higher than Scope 1 and 2 emissions. Transactions between companies and suppliers are the primary source of Scope 3 carbon emissions. Therefore, managing suppliers is essential not only for reducing Scope 3 emissions but also for speeding up progress toward the Sustainable Development Goals. As the corporate supplier management model continues to develop, traditional methods can meet basic needs but are labor-intensive and heavily influenced by subjective judgment. Consequently, digital technologies such as the Internet of Things and big data are necessary to address companies' evolving supplier requirements.

This article also examines the role of greening and digital collaboration in supplier management and achieving corporate sustainability goals through a case study of Tesla's supplier management. While digital technologies, such as the Internet of Things and blockchain, have demonstrated their

potential to enhance supply chain transparency, complete digital transformation is rarely fully achieved. In this context, this article highlights the combined effects of greening and digitalization in supplier management and their impact on competitiveness. Taking Tesla's supply chain as an example, this article examines how the company has built a low-carbon supply chain ecosystem by integrating green standards and digital collaboration, offering valuable insights into supplier management strategies for other companies.

Tesla's supply chain management focuses on vertical integration [2]. Its global network of Gigafactories (such as Shanghai, Berlin, and Austin) allows it to maintain closed-loop control from battery production to vehicle assembly, which reduces costs and boosts efficiency. The Shanghai factory has a localization rate of over 95% for parts sourced from more than 400 Chinese Tier 1 suppliers, with over 60 already part of Tesla's global supply chain, supplying areas like batteries, chips, and autonomous driving systems. Tesla utilizes an AI-driven platform to manage its global suppliers, enabling real-time data sharing, which lowers component costs by 15% and shortens delivery times. Its "zero inventory" approach (such as the "warehouse on wheels" at the Shanghai factory) cuts logistics cycles from seven days to just four hours, greatly enhancing capital turnover. Nonetheless, the supply chain still faces challenges, including geopolitical risks such as tariffs and dependence on raw materials like lithium and cobalt.

2. Tesla's Green Management

Tesla has made significant investments in green supply chain management, setting an example for other companies to follow. The company utilizes large amounts of renewable energy, such as electricity, in vehicle manufacturing to reduce its reliance on non-renewable resources like lithium and cobalt. It also implements a comprehensive green management model, covering the entire process from procurement to complete lifecycle management [3]. Additionally, the company is promoting digitalization to enhance supply chain transparency and efficiency.

Tesla's green supply chain management focuses on reducing carbon emissions throughout its lifecycle, responding to global carbon neutrality goals and addressing the high carbon emissions associated with the production of materials for new energy vehicles (Bird’s Eye View account for 35.9% of carbon emissions). In practice, Tesla implements a closed-loop management system from design, procurement, production, and recycling. Recycled materials are prioritized in design, while hazardous substances are strictly controlled. Production reduces energy consumption and waste through rooftop photovoltaics at the Shanghai factory, recycled water reuse (industrial water can be recycled for fish farming), innovative processes (such as integrated die-casting to reduce the number of parts), and waste solvent recovery technology (reducing waste by 75%). Supply chain collaboration requires suppliers to use green electricity and disclose their carbon data, driving reductions in upstream emissions.

The Shanghai factory has been certified as a "National Green Factory," achieving a 93% waste recycling rate. The carbon footprint of its vehicles is lower than the industry average (Model Y is 10.28% lower). By 2022, 300 tons of lithium materials will be recycled, and 100% of batteries will be recycled, achieving synergistic efficiency in resource recycling and carbon reduction. Lithium Iron Phosphate (LFP) battery scale-up: Contemporary Amperex Technology Co. Limited (CATL) supplies LFP batteries to Tesla's Shanghai factory, driving down costs for the Standard Range Model 3/Y, and expanding to the US Megapack energy storage product. The Shanghai factory's carbon emissions decreased by 15%, and the LFP carbon footprint is 18% lower than that of ternary batteries. The Megapack energy storage system utilizes retired batteries, reducing ore mining by 6.1 tons per ton of battery. Other applications of green materials: Cooperating with CATL to develop 4C fast-charging batteries and M3P new materials. Silicon Carbide (SiC) Application of Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) modules: Chip supplier STMicroelectronics provides the Tesla Model 3 with a SiC MOSFET (complete silicon carbide power module), which can reduce conduction loss and switching loss, improve the performance of electric vehicles, reduce

production costs, and improve energy efficiency. The application of MOSFET modules increases the energy efficiency of electric cars by 5% and reduces annual emissions of each vehicle by approximately 0.5 tons.

To support Tesla's ongoing efforts to reduce carbon emissions, CATL continues to develop a green supply chain. By 2024, the share of zero-carbon electricity in CATL 's core operations is expected to reach 74.51%, and nine “zero-carbon” factories are predicted to be operational. The greenhouse gas emission intensity per unit of product has dropped by 20.97% year-over-year. CATL's increased use of green energy and lower emissions help meet Tesla's requirement for Chinese battery suppliers to use at least 50% renewable energy by 2025.

After the enactment of the Inflation Reduction Act, Tesla and CATL launched a new collaboration. Tesla built a new facility near its Nevada Gigafactory, installed CATL's battery production equipment, and started producing LFP batteries under CATL's guidance. This partnership shifted green cost pressures onto suppliers, encouraging them to adopt more sustainable practices. It also improved factory locations, reduced transportation time, and further lowered emissions, advancing the goal of a green supply chain.

At Tesla's Investor Day in March 2023, the company announced plans to reduce silicon carbide use by 75% in future vehicle production. Later, STMicroelectronics stated in its 2023 Sustainability Report that it aims for carbon neutrality across all direct and indirect Scope 1 and Scope 2 emissions by 2027 using 100% renewable energy. This effort will lower both carbon emissions and silicon carbide use, further aligning with Tesla's sustainability goals.

3. Tesla's Digital Management

In recent years, with the development of big data and the Internet of Things, Tesla has also kept pace with the times and established digital management systems for suppliers, cooperating with suppliers such as CATL. Tesla uses advanced data analysis and artificial intelligence technology to plan and optimize the supply chain. The self-developed production and manufacturing control system in the super factory integrates data information from all aspects of production [3, 4]. It enhances the application of production and user digital management systems, providing intelligent digital services to users and products, and establishes a digital management system for Tesla's supply chain, thereby promoting the company's digital innovation and development.

In factory production, Tesla can optimize its supply chain process in cooperation with CATL by leveraging CATL's digital technology, ensuring the most efficient use of raw materials. At the same time, the improvement of the company's internal automation level not only reduces labor costs but also significantly reduces the scrap rate in automated production. Reducing costs and increasing efficiency through the digital transformation of the supply chain, as well as improving manufacturing yield, will also help battery companies lower their manufacturing costs and enhance delivery capabilities on a large scale. For example, CATL's Ningde factory is the world's first battery factory to receive the title of "Lighthouse Factory." The factory's lithium battery equipment utilizes technologies such as artificial intelligence, advanced analytics, and edge cloud computing to achieve a defect rate of only one billionth of a battery pack per set within 1.7 seconds over three years, while increasing labor productivity by 75%. Digital transformation has become a key path for battery companies to reduce costs and improve product delivery.

In addition, Tesla has actively adapted to the development of the digital economy and, leveraging its strong digital development capabilities, launched the Auto Bidder smart energy management platform in 2017. The functions of Auto bidder "system + platform + algorithm library" meet the needs of digital economic production materials, productivity and production relations of the supply chain, and realize the "car + pile" The closed loop of the new energy industry ecosystem of "+light + storage + load + intelligence" has become the core and hub of Tesla's layout of distributed energy. Its digital and intelligent future will help Tesla exert the synergistic effect of the green ecosystem, improving its value symbiosis and value-added capabilities. Under the development of Tesla's digital

industrial chain, it has also made significant contributions to achieving the "dual carbon" goals. In the future, with the continued development and application of digital technology, digital transformation will become a crucial means for more companies to achieve high-quality development and contribute to the "dual carbon" goals [4, 5].

4. Problems and Suggestions

4.1. Issues and Challenges

4.1.1 Environmental oversight of Tesla's tier 3 and higher suppliers is challenging

Although Tesla requires its partners to follow environmental regulations in its Supplier Code of Conduct, questions have been raised about how effectively it supervises and enforces corrective actions. Reports show that several suspected Tesla suppliers have a history of environmental violations, including excessive wastewater discharge, unregulated dust emissions, and illegal dumping of hazardous waste. Tesla generally does not directly work with third-tier suppliers, so environmental data such as carbon emissions and waste disposal must be transmitted through multiple levels. This process is slow and susceptible to manipulation. Battery materials, such as cobalt and lithium, mostly come from high-risk regions, including the Democratic Republic of the Congo and Indonesia. Local small and medium-sized suppliers are not yet digitalized; blockchain traceability is not yet implemented, and manual records lack reliability. Third-tier suppliers are technologically behind. While first-tier suppliers use MES systems to monitor energy consumption, third-tier suppliers mostly rely on paperwork orders, preventing real-time data integration with Tesla’s platform. Producing graphite negative electrodes requires carbonization, and most third-tier suppliers still use coal-fired power, with less than 20% of their energy coming from green electricity, far from Tesla’s goal to reach 100% by 2030. The adherence to environmental standards among suppliers varies, with Chinese suppliers required to meet ISO 14001, but some factories in India, Southeast Asia, and other regions still operate outdated equipment, with a desulfurization rate below 60%, which is lower than the industry standard of over 90%.

4.1.2 Geopolitics and raw material dependence

Tesla's supply chain is highly dependent on key raw materials from specific regions, including lithium, cobalt, nickel, and rare earth magnets, which are sourced primarily from China. The mining and supply of these materials are often associated with geopolitical risks, price volatility, and ethical and environmental issues. For example, China's suspension of rare earth magnet exports directly impacted Tesla's production plans for its Optimus Prime robot, highlighting the vulnerability of its supply chain to political risks. Furthermore, the EU's carbon tariff policy could increase costs for Tesla, given its reliance on Chinese materials in its supply chain.

4.1.3 Cost control and technical bottlenecks

Tesla has increased control and sustainability through vertical integration (e.g., Gigafactories and in-house battery development) and closed-loop recycling (e.g., recycling of battery materials). However, vertical integration can amplify the risk of internal production bottlenecks. The large-scale adoption of recycling technologies, such as battery recycling, still requires overcoming technical and economic barriers. Furthermore, newly built overseas factories (e.g., in Mexico and Berlin) face challenges such as increased costs associated with localized production, insufficient supply chain support, and policy uncertainty.

4.2. Improvement Directions

Tesla can offer low-interest loans to small and medium-sized suppliers at or above the third tier to fund the installation of IoT energy consumption monitoring equipment linked to Tesla and its first- and second-tier suppliers. Suppliers are also required to join the blockchain platform and access the carbon footprint data chain. Tesla is collaborating with CATL to develop a closed-loop "solid-state

battery recycling" process, eliminating smelting steps for third-tier suppliers and reducing carbon emissions at the source. Tesla is also establishing a shared responsibility mechanism with its first-tier suppliers: first-tier suppliers pay an environmental protection deposit to Tesla, and any violations by second- and third-tier suppliers will result in the mandatory deduction of this deposit.

Global supply chain ecological management is shifting from "passive compliance" to "active empowerment", but the transparency of carbon data across multiple levels of suppliers remains a major bottleneck. In the future, companies need to establish a global unified recycling standard to facilitate unified supplier green ratings, develop lower-cost digital traceability technology throughout the entire supply chain to enable carbon footprint tracing, and provide green supply chain loans to help suppliers at all levels achieve green transformation as soon as possible.

5. Conclusion

This article, through a case study of Tesla's supplier management, reveals the critical role of green and digital collaboration in supply chain management. Research shows that Tesla has significantly reduced supply chain carbon emissions and improved operational efficiency through the use of strict green standards, digital technologies (such as carbon footprint tracking and AI-enabled capabilities), and in-depth collaboration with suppliers. This practice not only supports Tesla's sustainable development goals but also offers valuable management insights for other companies.

Companies should strengthen green standards, incorporate sustainability requirements into supplier evaluation systems, and set clear emission reduction targets. They should promote digital collaboration, build a unified data platform, achieve transparent supply chain management, and leverage technological tools to optimize production processes. They should strike a balance between innovation and cost, helping suppliers overcome initial cost barriers to transformation through financial support or technology sharing. In the future, with technological advancements and improved policies, the integration of green and digital transformation will deepen. Companies need to continuously focus on the application of emerging technologies (such as blockchain and digital twins) while addressing the complex challenges brought about by the globalization of supply chains to achieve more efficient, sustainable development goals.

6. Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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