

Impact on Smart Supply Chain in the Context of Industry 4.0: The Case of BYD

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Abstract. Industry 4.0 is one of the key topics put into research. Researchers have found that Industry 4.0 has a lot of theoretical research on manufacturing and supply chain management. However, there still needs to be a research gap in enterprise management and optimization of smart supply chains thanks to the fourth information revolution. Therefore, this paper uses the actual case of a BYD enterprise to analyze its enterprise's problems and use the intelligent supply chain to improve the problems. The research methodology of this paper is as follows: firstly, collect the data on BYD's R&D investment and supply chain structure, as well as the relevant thesis research on BYD's green development and cost management. Secondly, the enterprise data, supply chain structure, and so on are analyzed. Finally, it gives the corresponding suggestions and solutions in combination with intelligent supply chain management. The study shows that big data, smart data analysis, artificial intelligence, and smart supply chain framework should be used to manage BYD's capital investment, restructure the supply chain, and balance cost and sustainable development.

Keywords: Industry 4.0; Smart supply chain; BYD Company.

1. Introduction

The advent of Industry 4.0 stands as a transformative milestone in the global industrial landscape, ushering in a new era where the convergence of the integration of digital technologies and supply chain management. The integration of technologies such as big data (BD), artificial intelligence (AI), internet of things (IoT), and machine learning (ML) to create a highly interconnected and intelligent system [1].

Industry 4.0 has brought about transformative changes across various sectors, reshaping the global landscape profoundly [2-4]. Many areas of expertise are influenced by Industry 4.0, such as traditional manufacturing impacting various aspects of production, resource management, and safety. It also affects the traditional logistics and supply chain management. Moreover, industry 4.0 enables supply chain management to become more efficient, agile, and responsive [5, 6]. It empowers organizations to leverage advanced technologies and data to optimize operations, adapt to changing market conditions, and deliver enhanced customer value. Embracing Industry 4.0 can provide a competitive advantage and drive innovation in supply chain management. As information technology matures and demand rises, supply chains need to become smarter to handle performance issues effectively. Organizations begin defining their initiatives and practices to successfully transition from traditional to digital supply chains.

Nevertheless, the intersection of Industry 4.0 with smart supply chains poses complex challenges and opportunities that require meticulous investigation. Existing research has laid a foundation for understanding the overarching impacts of Industry 4.0 on supply chain management. However, there needs to be more focused investigations into the specific challenges and opportunities encountered by companies navigating this paradigm shift. This study seeks to fill this void by delving into the nuances of BYD's experience. The significance of this study lies in its potential to inform strategic decision-making for companies facing similar challenges, offering practical implications for navigating the evolving landscape of Industry 4.0-driven supply chains.

The study addresses pertinent challenges faced by the automotive industry in the context of Industry 4.0, such as balancing cost and sustainability. The trade-off between cost-effectiveness, efficiency, and sustainability is significant for companies seeking a delicate balance in their

operations. Understanding and navigating these trade-offs is crucial for long-term success in a competitive market. Plus, the focus on enhancing visibility and transparency in logistics processes is significant in a globalized marketplace. It addresses the increasing demand for traceability and accountability in supply chain operations, aligning with modern business and consumer expectations. The choice of BYD as a case study is significant, given its prominence in the automotive and green energy sectors. Insights drawn from BYD's experience can be a practical guide for companies facing similar challenges in integrating Industry 4.0 technologies into their supply chains.

This study presents a comprehensive examination of BYD's smart supply chain, employing a dual approach that combines a detailed case description with a systematic analysis of encountered challenges and the subsequent formulation of strategic recommendations. The case description delves into the background of BYD, illustrating the evolution of its smart supply chain before and after the advent of Industry 4.0. The analysis scrutinizes the impact of Industry 4.0 on the company's supply chain management, emphasizing key factors such as cost, visibility, and sustainability. The study's overarching objectives encompass understanding the implications of Industry 4.0 on smart chains, dissecting specific challenges faced by BYD while integrating Industry 4.0 technologies, and offering practical suggestions to enhance the efficiency and sustainability of BYD's smart supply chain.

2. Case Description

2.1. The Impact of Industry 4.0 on BYD's Supply Chain

Established in 1998, BYD dominated 40% of the global nickel-cadmium battery market through semi-manual, semi-mechanized methods [7] with the advent of the Industry 4.0 era. By 2002, the company expanded from battery to mobile phone production. Venturing into the automotive sector in 2003, BYD marked a significant milestone with the launch of its first new energy vehicle, the F3DM, in 2008. A major leap came in 2016 with the establishing of the "Cloud Track," reflecting BYD's substantial investment in a five-year R&D initiative. [8] Due to the global epidemic of 2019, the supply chain urgently needs digital transformation. After 2019, R&D investment rose yearly, especially in 2022, when BYD's R&D investment was approximately 1.9 times that of the prior year. However, the context of Industry 4.0 highlights a challenge: the cost burden associated with implementing a smart supply chain, signaling the need for strategic, cost-effective measures.

2.2. Supply Chain Management in BYD Company

BYD's supply chain management is characterized by a holistic approach, reflecting its evolution from a mobile phone components manufacturer to a diversified global enterprise focusing on new energy vehicles [9]. The company's supply chain encompasses various sectors, including automobiles, new energy, rail transit, and semiconductors. Historically, BYD implemented a vertical integration strategy, emphasizing self-sufficiency in production processes. In recent years, BYD has transitioned towards a more open and collaborative supply chain model. This shift is essential in Industry 4.0, where smart supply chain management is crucial. Smart supply chain management involves leveraging digital technologies like IoT, data analytics, and automation for real-time monitoring, efficiency enhancement, and decision-making optimization.

Nevertheless, this decentralized procurement management strategy has led to challenges in supplier collaboration. The dispersed upstream procurement has resulted in varied supplier quality and compromised supply chain efficiency. BYD's supply chain structure includes upstream, midstream, and downstream. The upstream supply chain consists of key material suppliers and component suppliers providing core components, which are then handed over to the midstream supply chain for both vehicle manufacturing and technology development and finally delivered to the downstream supply chain to be sold to customers by dealers. In contrast, the downstream supply chain provides after-sales and charging services to customers.

2.3. The Trade-off in BYD's Supply Chain

The increased investment in environmental protection aligns with the broader industry shift towards sustainability. However, the decline in environmental protection investment after reaching a peak in 2018 indicates a potential trade-off between sustainability goals and cost considerations. Despite the increase, the limited scale of environmental protection investment underscores the challenges BYD faces in managing the financial implications of sustainability initiatives [10-12].

Moreover, mentioning capital flow pressure due to inventory storage costs and operating expenses in first-tier cities emphasizes the real-world financial constraints BYD encounters in pursuing sustainability and cost-effectiveness. This reflects a delicate equilibrium that companies in the automotive sector, especially those undergoing Industry 4.0 transformations, must navigate.

In conclusion, BYD's case illustrates the intricate trade-off between the pursuit of sustainable practices and the need to manage costs effectively. The pressure on capital flow highlights companies' pragmatic challenges, striving to align with Industry 4.0 principles while maintaining financial viability. This nuanced balance is crucial for BYD as it navigates the evolving landscape of the automotive industry, emphasizing the necessity for strategic and sustainable financial management in the context of Industry 4.0.

3. Analysis of the Problems

3.1. R&D Investment and Return Analysis

According to the data related to BYD's R&D investment above this study, it can be intuitively found before 2019, the investment in R&D was relatively small. With the impact of Industry 4.0 and technology enhancement, the demand for R&D investment has also relatively increased, so the investment in R&D funding has increased yearly. Correspondingly, the arrival of the smart supply chain is more urgent to adapt to the rapid development of technological progress to ease the pressure from R&D. This study found that although R&D investment increased after 2019, the ratio of R&D investment relative to total operating revenue decreased, which can be surmised that the smart supply chain contributes to alleviating the pressure of operation.

The challenge of high costs associated with implementing a smart supply chain in the context of Industry 4.0 for BYD stems from several factors, reflecting the transformative nature of Industry 4.0 and the complexities of integrating advanced technologies into existing operational frameworks.

The integration of Industry 4.0 technologies, characterized by the convergence of digital, physical, and data-driven elements, demands a substantial investment in infrastructure, technology adoption, and workforce training. BYD's ambitious foray into a smart supply chain involves the deployment of advanced sensors, IoT devices, data analytics, and automation. While these innovations promise heightened efficiency, visibility, and responsiveness, the initial capital outlay and ongoing operational expenses can be substantial.

While the initial costs of implementing a smart supply chain in the context of Industry 4.0 for BYD may seem high, the long-term benefits, including enhanced operational efficiency, real-time decision-making, and improved sustainability, can outweigh these challenges. BYD's strategic vision and commitment to innovation position it well to navigate these initial hurdles and establish a smart supply chain that aligns with Industry 4.0 principles and contributes to long-term competitiveness and sustainability in the rapidly evolving business landscape. The investment in a smart supply chain is not just a cost; it's an essential step towards securing BYD's position as a leader in the automotive and green energy sectors amidst the technological transformations of the Fourth Industrial Revolution.

3.2. Closed Supply Chain System

BYD's supply chain, while comprehensive, faces challenges. The self-sufficient nature of the vertical management system creates chain inefficiencies in procurement for upstream supply. The model's success in the early stages facilitated rapid development, yet as consumer preferences evolve,

BYD must redirect its focus to core competencies. The vertically integrated model led to dispersed upstream procurement, hindering optimal supplier collaboration. The emphasis on lowering material prices as a primary criterion compromises supplier selection precision. This decentralized approach produces varied supplier quality and increases post-production inspection costs and defect rates. As BYD explores an open supply chain model, it aims to address these deficiencies, balancing cost efficiency and supplier collaboration.

To overcome supply chain deficiencies, BYD has undertaken strategic shifts. While initially successful, the company's traditional vertical integration approach has led to supplier collaboration and quality control challenges. The decentralized procurement strategy, aimed at reducing material costs, has resulted in a lack of in-depth connections with suppliers and compromised supply chain efficiency.

BYD has begun exploring an open supply chain model to address these issues. This shift involves collaborating with high-quality suppliers and focusing on the precision of supplier selection. BYD recognizes the importance of strengthening ties with suppliers to harness the benefits of scale, improving product quality, and streamlining the procurement process. The move towards an open supply chain aligns with BYD's commitment to innovation and adaptability in response to changing market dynamics.

3.3. Problems with Strategic Cost Management

Firstly, BYD needs help negotiating favorable terms with suppliers due to a decentralized procurement model. The scattered procurement approach limits negotiation power and standardization, impacting cost-efficiency and sustainability in the supply chain. Plus, the cost-centric supplier selection approach compromises precision in operations, hindering the ability to integrate sustainable practices seamlessly. Thus, emphasizing cost over other factors neglects the environmental impact of suppliers, contributing to a disconnect between operations and sustainability goals.

Secondly, Linked to the second case, more supplier connections are needed to optimize outbound logistics and collaborative efforts for sustainable transportation. With robust supplier relationships, BYD may be able to implement environmentally friendly outbound logistics, impacting the overall sustainability of the supply chain.

BYD's struggle to trade-off between cost and sustainability lies in the misalignment within Michael Porter's Value Chain. The decentralized procurement model, cost-centric supplier selection, and limited supplier connections create operational inefficiencies that hinder the seamless integration of sustainable practices. The emphasis on cost at the expense of sustainability throughout the value chain demonstrates why BYD faces challenges in achieving a successful trade-off. To address this, BYD needs to reevaluate its procurement strategy and supplier selection criteria and enhance collaboration to create a value chain where cost-efficiency and sustainability are mutually reinforcing rather than conflicting. Only through this realignment can BYD achieve the desired trade-off between cost and sustainability, creating a more resilient and competitive supply chain in the era of Industry 4.0 and sustainable development.

4. Suggestions

4.1. Smart Supervision

Smart supply chain management can be crucial in managing R&D investment and return. Related technologies can be used to deal with the high cost of the original investment, such as Data-Driven Decision-Making and Real-Time Market Feedback [13].

Smart financial analytics enable real-time monitoring and analysis of financial data within the supply chain. Integrate advanced analytics tools to assess capital flow, identify patterns, and gain insights into financial performance. Implement predictive analytics to foresee potential capital bottlenecks and proactively manage resources.

By leveraging smart financial analytics, organizations can make informed decisions, optimize cash flow, and enhance overall financial visibility.

4.2. Platform's Visibility and Efficiency

In the era of Industry 4.0, utilizing an intelligent supply chain can provide innovative solutions to address inefficiencies in upstream supply chain sourcing under traditional vertical management systems. Such as implementing Smart Procurement Platforms. To introduce intelligent procurement platforms powered by AI and machine learning algorithms, analyzing historical data, market trends, and supplier performance, providing real-time insights for strategic decision-making in procurement.

4.3. Introduction of a Smart Supply Chain Framework System

Adopting a Smart Supply Chain Framework represents a paradigm shift for BYD. Embracing technological advancements, such as IoT, AI, and data analytics, will not only mitigate the challenges of cost and sustainability but also position BYD as an industry leader committed to innovation and eco-conscious practices. This opinion is rooted in the understanding that Industry 4.0 technologies provide real-time visibility, enabling informed decision-making and fostering adaptability in a dynamic market [14].

BYD can apply optimization techniques on the logistics management platform to balance costs, efficiencies, and sustainability goals. For example, route planning algorithms can consider the costs of transport modes vs. their carbon footprint to arrive at optimal solutions. BYD should also evaluate investments required for transitioning to electric vehicles, with a long-term view of savings from lower maintenance costs and government subsidies. BYD can partner with suppliers to implement renewable energy sources to power facilities. Collectively, these measures will improve operational efficiencies while reducing environmental impact, achieving a balanced trade-off.

In conclusion, introducing a Smart Supply Chain Framework is not merely a technological upgrade for BYD but a strategic imperative for sustained success. The synergy between cost-effectiveness and sustainability is achievable through the intelligent integration of Industry 4.0 technologies.

5. Conclusion

This study analyses BYD's R&D investment, supply chain structure, operation mode, and capital cost in the context of sustainability, analyses the problems of each situation, and gives corresponding suggestions using the smart supply chain in the context of Industry 4.0. This study addresses the year-on-year increase in BYD's R&D investment, puts forward the risk of controlling capital costs, and gives the use of big data decision-making and market feedback to prevent the risk of over-investment for the low efficiency of upstream procurement that may be caused by the vertical management of the supply chain, and it is suggested to make use of the open-data procurement platform in the smart supply chain, to make the transaction transparent and visible; for the issue of sustainability and capital costs, this study adopts the value chain framework analysis to summarise the problems in each case and gives corresponding suggestions using the smart supply chain in the context of Industry 4.0. For the issue of sustainable development and capital cost, this study adopts the value chain framework analysis to conclude that BYD's enterprise has misaligned its value chain, which can be weighed by using the Internet of Things (IoT) in the smart supply chain, data analysis, and so on. This study contributes to the smart supply chain in the context of Industry 4.0 for BYD's cost control and green and economic trade-off development, which is currently limited to the company but should be analyzed in general for the national and global community in the future.

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