Digitalization And Enterprise Performance in The New Energy Vehicle Industry

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Abstract. The rapid growth of the new energy vehicle (NEV) industry has been accompanied by an accelerated wave of digital transformation, which holds significant implications for enterprise performance and sustainable mobility. This synergy fundamentally reshapes competitive dynamics and operational models. This paper investigates the relationship between digitalization and the performance of NEV enterprises, with a particular focus on both the opportunities and challenges it presents. Case studies of leading global and Chinese manufacturers demonstrate digitalization's role in enhancing operational efficiency and customer experience; however, significant challenges are also revealed, including data security risks and the high cost burden on SMEs. To address these issues, the paper proposes a range of strategies, proposes strategic interventions focused on cybersecurity, cost-sharing mechanisms, interoperability standards, and talent cultivation. The research highlights not only the commercial benefits of digital transformation but also its social value in advancing sustainability and innovation in transportation. Ultimately, the findings underscore the necessity of a balanced approach that combines technological adoption with comprehensive risk management, paving the way for resilient and inclusive digital ecosystems in the NEV industry.

Keywords: New Energy Vehicles; Digital Transformation; Enterprise Performance; Sustainable Transportation; Supply Chain Management.

1. Introduction

1.1. Research Background

Driven by the dual forces of carbon neutrality and the transformation of the energy structure, the global new energy vehicle (NEV) industry has entered a stage of rapid development. According to data from the International Energy Agency (IEA), global sales of new energy vehicles reached 14 million in 2023, accounting for 18% of the total global vehicle sales, with a year-on-year growth of 35%, highlighting the crucial role of this industry in achieving sustainable transportation [1]. Meanwhile, digitalization has become the core driving force for industrial upgrading: China's "14th Five-Year Plan for the Development of the Automotive Industry" clearly states that it will promote the deep integration of new energy vehicles with digital technologies such as big data, artificial intelligence, and industrial Internet [2].

From a business perspective, digitalization helps new energy vehicle enterprises reduce production costs, shorten product development cycles, and enhance market response speed, which is a core advantage in the fierce market competition. From a social perspective, the coordinated development of new energy vehicles and digitalization has accelerated the replacement process of traditional fuel vehicles, reduced greenhouse gas emissions, and provided support for global climate goals [1,2]. Given these commercial and societal imperatives, exploring the impact of digitalization on the performance of new energy vehicle enterprises and the implementation challenges is of both commercial value and social significance.

1.2. Literature Review

Existing research has focused on the intersection of digitalization and the automotive industry, providing a fundamental reference for this article. Collectively, these studies establish a strong, albeit fragmented, correlation between digitalization and improved efficiency or performance in the

automotive sector. Wang Li and Li Hua analyzed the data of 50 Chinese new energy vehicle manufacturers and found that the core component of digitalization - intelligent manufacturing - can shorten the production cycle by 15% to 20% and reduce the defect rate by 25%, directly improving operational efficiency [3]. Zhang Qi et al. further pointed out that big data-driven R&D (such as simulating battery performance through digital twins) has shortened the product iteration cycle of new energy vehicles by 30% compared with traditional methods [4].

Globally, Smith and Jones' study of 80 automotive enterprises confirmed a positive correlation between digitalization and financial performance, but the research focused mainly on traditional fuel vehicle manufacturers, with limited analysis of new energy vehicles, thus highlighting a critical gap in understanding the digitalization dynamics unique to NEVs [5]. Brown et al. focused on the digitalization of the supply chain and found that real-time data sharing among suppliers could reduce the inventory costs of new energy vehicle enterprises by 18% to 22% [6]. Li Shuang and Wang Zhe added that Internet of Vehicles services (such as remote vehicle monitoring and personalized navigation) can increase the customer retention rate of new energy vehicle brands by 40% [7].

1.3. Research Gaps

However, although existing research has verified the value of digitalization, there are still three limitations: First, most studies focus on a single link of digitalization (such as intelligent manufacturing or supply chain), without systematically analyzing its multi-dimensional impact on the performance (financial, operational, and market performance) of new energy vehicle enterprises. Secondly, existing literature pays relatively little attention to the uniqueness of new energy vehicles (such as the digitalization of battery management systems and the integration of charging network data), and these characteristics are significantly different from those of traditional vehicles [3,5,6]. Thirdly, there is a scarcity of research addressing the practical implementation barriers—such as technical compatibility and data security risks—faced specifically by NEV enterprises, resulting in a lack of actionable insights for practitioners.

1.4. Research Framework

To fill the above gap, this study follows the following logic: Firstly, in combination with the global development trend of new energy vehicles and digital policies, the significance of the research is clarified; Secondly, critically review the relevant literature, synthesizing existing findings and identifying their limitations. Secondly, describe the current digitalization status of the new energy vehicle industry and illustrate practical applications with cases. Finally, systematically analyze the positive impact of digitalization on the performance of new energy vehicle enterprises, identify key issues in implementation, and lay the foundation for subsequent optimization strategies.

2. Case Description

2.1. Overview of Digitalization of the Global New Energy Vehicle Industry

Globally, leading new energy vehicle (NEV) manufacturers are at the forefront of digital adoption, establishing de facto industry benchmarks. The Tesla Texas Gigafactory in the United States adopts Industry 4.0 technology, equipped with over 1,200 industrial robots and real-time data analysis systems. The production automation rate of Model Y vehicles reaches 95%, and the production cycle for each vehicle is only 7 hours, which is much lower than the industry average of 10 to 12 hours [8]. The Volkswagen ID series factory in Germany has reduced the trial production cost by 30% and enhanced production flexibility through digital twin simulation of the entire production process [5].

2.2. Current Digitalization Status of China's New Energy Vehicle Industry

As the world's largest NEV market and a critical arena for global competition, China's digitalization trajectory offers invaluable insights into both the potential and the pitfalls of industry-wide transformation.

As the world's largest market for new energy vehicles, China has a relatively high digital penetration rate but uneven development. According to data from the China Association of Automobile Manufacturers (CAAM), the digital penetration rate of China's new energy vehicle industry reached 65% in 2023 (a composite metric encompassing production, R&D, and management processes), higher than the global average of 52% [2]. Among them, the production (penetration rate 70%) and R&D (penetration rate 55%) sectors are the most mature: For instance, BYD's "Smart Factory" in Shenzhen integrates artificial intelligence and Internet of Things technologies to achieve end-to-end digitalization from order to delivery, reducing the delivery cycle by 20% [9].

However, small and medium-sized new energy vehicle enterprises are significantly lagging. Their digitalization rate is only 30%, which is starkly contrasting with the near-total digital integration of industry leaders like Tesla. They also have limited investment in core technologies such as artificial intelligence and digital twins [9]. The digitalization of downstream fields (such as charging networks) is also insufficient - only 40% of public charging piles in China are connected to digital management platforms, resulting in a low utilization rate [2]. This bifurcation within China's NEV sector—between highly digitalized giants and struggling SMEs—presents a compelling case study for analyzing the determinants of digital success and the barriers to its widespread adoption, which are the core foci of this paper.

3. Problem Analysis

3.1. Positive Impact of Digitalization on the Performance of New Energy Vehicle Enterprises

3.1.1 Enhance production and operational efficiency

Digital optimization of core operational processes directly reduces costs and increases efficiency. For large enterprises like Tesla, the intelligent manufacturing system enables the automation of welding, painting, and final assembly, reducing human errors and labor costs. Tesla's 2023 annual report shows that its digital production line has reduced the labor cost per vehicle by $1,200 compared to 2021 [8]. At the supply chain level, real-time data sharing between new energy vehicle manufacturers and battery suppliers enables just-in-time production. Brown et al. (2022) found that this measure can reduce the inventory holding cost of enterprises by 18% to 22% [6]. Byd also confirmed that after implementing digital supply chain management, its inventory turnover rate increased by 25% [9].

3.1.2 Optimize customer experience and enhance market competitiveness

Digitalization helps new energy vehicle enterprises meet customers' personalized demands and improve retention rates. The vehicle networking service relying on 5G and the Internet of Things can provide users with real-time functions such as remote temperature control, predictive maintenance reminders, and over-the-air (OTA) software upgrades. Li Shuang and Wang Zhe (2023) conducted a survey of 10,000 new energy vehicle owners and found that brands with mature connected vehicle services (such as NIO) have a customer retention rate of 80%, which is 40% higher than that of brands without such services [7]. Nio's 2023 report indicates that its digital platform (NIO App) supports users in customizing body colors, interiors, and software packages. In 2023, customized models accounted for 35% of total sales [10]. This personalization not only enhances customer satisfaction but also enables NIO models to offer a 15% premium over their competitors [10].

3.2. Key Issues in the Digitalization of the New Energy Vehicle Industry

Despite the demonstrable benefits outlined above, the rapid digitalization of the NEV industry is not without its considerable challenges. The very technologies that drive efficiency and innovation also introduce new complexities and vulnerabilities, which are particularly acute for certain market participants.

3.2.1 Data security and privacy risks

The digitalization of new energy vehicles generates a large amount of sensitive data (such as users' driving habits, location information, and battery performance data), which brings serious safety hazards. The Cybersecurity and Infrastructure Security Agency (CISA) of the United States Department of Homeland Security reported that in 2023, there were 42 data breaches in the global new energy vehicle industry, affecting 12 million users. Among them, the Internet of Vehicles platform of a certain European new energy vehicle brand was attacked by hackers, and the real-time location data of 500,000 users was leaked [11]. At the enterprise level, the digitalization of the supply chain also increases the risk of core technology leakage. Brown et al. pointed out that 30% of new energy vehicle manufacturers have lost their competitive edge due to battery management system (BMS) data leakage caused by third-party suppliers [6].

3.2.2 High digitalization costs and technical compatibility issues

Small and medium-sized new energy vehicle enterprises are confronted with significant financial and technological barriers. The China Machinery Industry Federation (CMIF) estimates that the cost of digital transformation for small and medium-sized new energy vehicle enterprises in China accounts for 8% to 12% of their annual revenue, while for large enterprises, it is only 5% to 7% [12]. These costs include purchasing artificial intelligence software, upgrading industrial robots, and employee training, which are difficult for most small and medium-sized enterprises to bear. Furthermore, traditional production equipment (such as old production lines) is incompatible with new digital technologies. Zhang Qi et al. found that the cost of equipment transformation accounts for 40% of the total digital investment of small and medium-sized enterprises, further delaying the implementation process [4]. A survey of 100 small and medium-sized Chinese new energy vehicle enterprises in 2023 revealed that 60% of them listed "high costs and incompatibility with technology" as the top reason for terminating digital projects [12]. This survey data directly links the dual burdens of high capital expenditure and legacy system incompatibility to project failure, highlighting them as the primary execution barriers for SMEs.

4. Suggestions

4.1. Implementing a Multi-Layered Cybersecurity and Privacy Framework

One of the foremost challenges identified in the digitalization of the NEV industry is the risk of data breaches and privacy violations. To address this, enterprises should establish a multi-layered cybersecurity framework that incorporates end-to-end encryption, zero-trust access control, and continuous vulnerability testing. According to the Cybersecurity and Infrastructure Security Agency (CISA), incidents of large-scale user data leakage have already exposed the urgency of robust safeguards [11]. Companies also need to collaborate with government agencies and industry consortia to develop standardized security protocols, reducing fragmentation in data management. Furthermore, embedding privacy-by-design principles into vehicle networking and customer applications will both enhance user trust and ensure compliance with global data regulations [6,11].

4.2. Alleviating the Financial Burden on SMEs through Policy and Modular Solutions

To alleviate the disproportionate financial burden on SMEs, a multi-stakeholder approach is required. Small and medium-sized NEV enterprises are disproportionately burdened by the costs of digital upgrades. The China Machinery Industry Federation (CMIF) estimates that digital investment

consumes 8–12% of SME annual revenues, compared with only 5–7% for large firms [12]. To mitigate this challenge, governments and industry associations should expand subsidies, tax incentives, and low-interest financing channels targeted at SMEs. On the enterprise side, adopting modular digitalization strategies—prioritizing cloud-based supply chain systems or predictive maintenance—can yield higher short-term returns while limiting capital outlays [4,6]. Shared platforms such as software-as-a-service (SaaS) also allow SMEs to access advanced technologies without large upfront investments, thereby narrowing the gap with industry leaders [12].

4.3. Fostering Integration through Open Standards and Phased Upgrades

Addressing the critical barrier of technical incompatibility requires a focus on open standards and phased integration. The incompatibility of legacy production lines with new technologies often delays transformation. Research shows that equipment replacement accounts for up to 40% of SME digital investment, becoming a major source of project failure [4]. To overcome this, enterprises should embrace open industrial standards and interoperability frameworks, enabling integration between old and new systems. Large-scale manufacturers like Volkswagen and BYD have demonstrated the feasibility of gradually introducing digital twin modules while retaining parts of traditional production lines, thereby reducing transition costs [5,9]. At the ecosystem level, co-development among automakers, software developers, and equipment suppliers can foster backward-compatible solutions, while workforce training ensures that engineers can effectively manage hybrid production environments [3,9].

4.4. Developing a Sustainable Talent Pipeline via Industry-Academia Collaboration

A lack of specialized digital skills also constrains transformation. Studies confirm that intelligent manufacturing and big-data-driven R&D can significantly boost efficiency, but only if firms have access to trained professionals capable of managing these systems [3,4]. To address this, NEV enterprises should collaborate with universities and technical institutes to establish joint training programs while offering continuous upskilling opportunities internally. Creating cross-functional teams that combine IT experts, engineers, and market analysts can accelerate innovation by reducing departmental silos [7]. On an industry-wide level, talent-sharing alliances would allow SMEs to access skilled personnel on a project basis, balancing labor demand and supply across the sector [12].

4.5. Promoting Digitalization of Charging and Service Ecosystems

The underdeveloped digitalization of charging networks has become a bottleneck. Data from the China Association of Automobile Manufacturers (CAAM) shows that only 40% of public charging piles are connected to digital management platforms [2]. To improve utilization, NEV enterprises and policymakers should accelerate integration into unified platforms offering real-time availability, predictive maintenance, and pricing transparency. Collaborative ventures between automakers, energy providers, and municipalities can ensure nationwide compatibility and user accessibility [2,9]. Moreover, innovative services—such as mobile booking applications, vehicle-to-grid energy interaction, and AI-driven charging optimization—would enhance customer experience and stabilize energy grids. This downstream integration ensures that digitalization extends beyond vehicle manufacturing to the entire service ecosystem [7,10].

5. Conclusion

This study has highlighted the dual nature of digitalization in the new energy vehicle industry: while it provides substantial benefits in terms of operational efficiency, customer satisfaction, and competitive advantage, it also introduces new challenges such as data security risks, high costs, and technical incompatibility. The findings underscore that successful digital transformation requires more than adopting new technologies; it demands comprehensive strategies that balance efficiency with resilience.

The research also carries broader significance. From a business perspective, the optimization strategies discussed—ranging from cybersecurity enhancement to cost-sharing models for SMEs—offer actionable pathways for enterprises to strengthen competitiveness in a rapidly evolving industry. From a social perspective, fostering digitalization in NEVs contributes to global sustainability goals by accelerating the replacement of traditional fuel vehicles and improving the supporting infrastructure, such as charging networks. On a practical level, the insights provided serve as a guide for policymakers, industry leaders, and smaller firms seeking to navigate the complexities of digital adoption.

While this analysis provides a framework for understanding the digital transformation of the NEV industry, it is important to acknowledge its boundaries. Nevertheless, this study is not without limitations. It primarily relies on secondary data, which, while valuable for establishing trends, lacks the depth of firm-level perspectives that primary data, such as surveys and interviews, could provide, which could offer more nuanced insights into the organizational and cultural barriers behind the statistics. Future research could address this gap by conducting empirical studies on digital implementation at both leading and smaller NEV enterprises. Additionally, comparative studies across different national markets could enrich the understanding of contextual differences in digital adoption.

In conclusion, the digitalization of the new energy vehicle industry is both inevitable and indispensable. By addressing the key challenges identified in this paper through coordinated strategies, the industry can ensure that digitalization not only drives competitiveness but also contributes to sustainable mobility worldwide. Navigating this dualism successfully is the defining challenge and opportunity for the NEV sector in the coming decade.

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