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Analyzing Key Factors Impacting Disruptive Innovations in New Energy Vehicle (NEV) Sector: A Multi-Case Study in China

[1]Jingjun Lei, [2]Logaiswari Indiran, [3]Umar Haiyat Abdul Kohar, [4]Haibing Liu

[1,2,3]Faculty of Management, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia, [4]Wuhan University of Science and Technology, Wuhan Hubei Province, China

Corresponding Author Email: leijingjun@graduate.utm.my

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Abstract

This research employs a multi-case analysis and semi-structured interviews with executives from Tesla China, NIO, Wuling, and BYD to explore the catalysts and barriers to disruptive innovations in China's New Energy Vehicle (NEV) market. The findings reveal a shared commitment to advancing battery technology, sustainability, and user experiences. The study identifies collaboration and government policy support as key factors facilitating infrastructure expansion. It underscores persistent challenges, including infrastructure deficiencies, complex regulatory procedures, customer acceptance hurdles, and cost constraints. The paper scrutinizes the strategic measures adopted by these firms to address these challenges, underscoring the pivotal role of government policies in shaping the industry's trajectory. In summary, the insights garnered augment the comprehension of the dynamic Chinese NEV industry, offering a comprehensive perspective on the factors steering innovative breakthroughs. This research serves as a valuable guide for industry practitioners and policymakers in navigating the challenges and fostering sustainable innovation in this rapidly evolving sector.

Keywords: Disruptive Innovations, Chinese NEV Landscape, Key Drivers, Barriers, Exploration

Introduction

China stands out as one of the largest and economically significant developing countries globally, with a governmental emphasis on fostering the growth of the New Energy Vehicle (NEV) industry as a pivotal strategy for mitigating energy consumption, carbon emissions, and smog (Jiang & Xu, 2023; Zhang & Qin, 2018) The rapid expansion of NEVs in China has been evidenced by notable developments in recent years, as highlighted by (Liu and Zhou, 2022). In 2019, China achieved a milestone in NEV sales, reaching 1.24 million units and solidifying its position as the leading country in global NEV sales (Zeng et al., 2023). Furthermore, projections indicate substantial growth, with the estimated stock of electric vehicles ranging

from 9 million to 20 million by 2020 and expanding to a range of 40 million to 70 million by 2025 (Zhang et al., 2023).

The transformative impact of disruptive innovations within the New Energy Vehicle (NEV) sector is particularly pronounced in China, currently recognized as the world's foremost NEV market (Xiong & Cheng, 2023; Yang et al., 2023). NEVs differ significantly from traditional petrol-driven vehicles due to the disruptive innovation of engine and transmission parts, offering Chinese designers ample creative space (Dhakal & Shakyab, 2022). Chinese NEV companies communicate narratives of Chinese technology and culture globally through captivating vehicle designs. Despite this, the precise determinants influencing these innovations and the challenges encountered by key market players remain inadequately elucidated in the context of the Chinese NEV market. This paper through a comprehensive analysis of the catalysts and barriers shaping disruptive innovations in China's NEV market, with a specific focus on major industry players—BYD, Tesla, NIO, and Wuling, which represent the top four contenders in the Chinese NEV market (Lyu et al., 2023). These entities assume pivotal roles as architects of substantial change, and this study aims to unravel the intricacies inherent in disruptive innovations within the Chinese NEV landscape, driven by the imperative to address a discernible research void.

Extant literature has extensively explored the impediments and catalysts inherent within the New Energy Vehicle (NEV) market. Zhang et al (2023) discerned a significant disparity between Chinese NEVs and their global counterparts, particularly in the realm of complete vehicles and key components. The primary challenges encompass the irrational distribution of innovation resources and the imperative for advancements in core technologies. Concurrently, Ji et al (2019); Liu and Zhou (2022) highlighted the deficiency in consumer education as a potential issue. In contrast, Jianlong Wu et al (2018) underscored market demands, governmental policies, and disruptive technologies as the principal propellants of NEV innovation.

Scholars outside China have scrutinized these elements, with Parmar et al (2021) arguing that the absence of supportive policies, infrastructure, and skilled personnel significantly hinders the development of NEV innovation in India. Notwithstanding, a holistic examination of the critical factors influencing disruptive innovations, especially within the Chinese context, remains conspicuously absent in contemporary literature.

This study augments the existing corpus of knowledge by undertaking a qualitative multi-case analysis of four prominent entities in the Chinese NEV market: Tesla China, NIO, Wuling, and BYD. Utilizing a qualitative semi-structured interview methodology, this research addresses a two-pronged issue: pinpointing the key drivers of disruptive innovations in the Chinese NEV market and understanding the challenges these corporations face in their innovation pursuits. The aim is to furnish a comprehensive view of the Chinese NEV industry dynamics, providing insights that could guide industry practitioners and policymakers.

The ensuing sections of this paper are structured as follows: Section 2 provides a review of relevant literature, while Section 3 delineates the employed methodology. Section 4 presents and interprets the empirical findings, succeeded by a discussion in Section 5 and the conclusion in Section 6.

Literature Review

Disruptive Innovation in Auto Industry

Christensen categorizes innovation into two distinct types: sustaining technologies and disruptive technologies. Sustaining technologies focus on enhancing product performance,

while disruptive technologies introduce an entirely novel value proposition to the market. The primary consumer base for disruptive technologies lies on the fringes of the existing market, making them inherently new and appealing due to being "cheaper, simpler, smaller, and, frequently, more convenient to use" (Christensen, 1997). Consequently, disruptive technologies often result in inferior performance for established companies.

In 1997, Christensen contemplated the impact of electric vehicles (EVs) disrupting the automotive market: "No automotive company is currently threatened by electric cars, and none contemplates a wholesale leap into that arena. The automobile industry is healthy. Gasoline engines have never been more reliable. Never before has such high performance and quality been available at such low prices. Indeed, aside from governmental mandates, there is no reason why we should expect the established car makers to pursue electric vehicles. But the electric car is a disruptive technology and potential future threat." Christensen (2013) Christensen's Innovator's Dilemma implies that successful companies, paradoxically, must disrupt themselves to sustain their longevity. For the traditional automotive industry, this involves transitioning away from Internal Combustion Engines (ICE) to alternative powertrains (Hops, 2016).

New Energy Vehicle Industry

The global transportation industry, which accounts for almost 33% of the world's total energy usage, highlights the pressing necessity for energy preservation (Zhang & Qin, 2018). Road travel is a major cause of global warming and air pollution, particularly in China where vehicle exhaust is a significant source of severe air pollution Liu et al (2021); Sheng & Ling-Yun (2016) Leading countries around the globe are actively developing and implementing strategies to promote the expansion of their domestic New Energy Vehicle (NEV) sector (Brendel et al., 2018). The NEV sector is seen as a crucial opportunity by the Chinese government and original equipment manufacturers (OEMs) to enhance their innovation potential and bring about a significant transformation in the automobile industry (Qin & Xiong, 2022). However, the early stage of energy storage device development in China (Wang, 2022) requires increased efforts to accelerate the technological aspects of NEV progress (Yuan et al., 2015). Therefore, it is crucial to apply specific technical innovation strategies in order to overcome these significant technological obstacles.

From a global standpoint, numerous nations have provided policy backing for the advancement of New Energy Vehicles (NEVs) (Zhang et al., 2014). Clear objectives for NEV development have been articulated by the United States and Germany (Strupeit & Palm, 2016). China, in recent times, has implemented various policies to support NEV growth (Li et al., 2016). Notably, as far back as 2009, China's industry adjustment plan included incentives for NEVs, although it did not initially consider their classification (Xu & Su, 2016). Over the years, the landscape of NEVs has evolved, with Hybrid Electric Vehicles (HEVs), Fuel Cell Vehicles (FCVs), and Pure Electric Vehicles garnering increased attention (Wang et al., 2017). Correspondingly, national policies have adapted to these changes in NEV types (Kong, 2016). The past decade has witnessed the transition of NEVs from laboratory experiments to mainstream market products (Wang et al., 2017). The NEV industry experienced remarkable growth in 2018, often referred to as the inaugural year of significant NEV development (Luo et al., 2021). In recent times, China has emerged as the world's largest NEV market, a feat attributed to the diversified government policies that have fostered the rapid evolution of the NEV industry (Li et al., 2016).

Key Drivers of NEV Industry

The ascent of the New Energy Vehicle (NEV) industry, as a representative emerging sector, is attributed to breakthroughs in energy batteries, motors, and electric controls. In contrast to the business ecosystem, the innovation ecosystem underscores interdependence in technological advancements (de Vasconcelos Gomes et al., 2018), serving as a key element in exploring the underlying motives of innovation. Innovation, a crucial driver of socioeconomic change, relies on focal enterprise enterprise location, player diversity, complementary resource availability, and symbiotic relationships, influencing the evolution of the innovation ecosystem (Adner & Kapoor, 2010, 2016; Chen et al., 2014; Fransman, 2010; Kwak et al., 2018; Luo, 2018; Jinxi Wu et al., 2018). Complex technological co-innovation among manufacturers and component suppliers propels the formation, expansion, and reconstruction of the NEV co-innovation chain, driving the industry's sustainable development within the innovation ecosystem.

Market demand serves as a crucial catalyst for driving innovation in the New Energy Vehicle (NEV) industry, with widespread consumer adoption influencing stakeholders to prioritize commercial innovation over pure technological research (Kimble & Wang, 2013; Lu et al., 2014). Scholars, focusing on market demand, consumer adoption, and penetration, observe the impact of both rational and perceptual factors on consumers' preference for NEVs over traditional fuel vehicles (Xu & Su, 2016). Consumption preferences shape the development of Plug-in Electric Vehicles (PEVs), and distinct preferences persist among Chinese and American consumers irrespective of subsidies (Helveston et al., 2015). Consumer demand, often overlooked, plays a pivotal role in propelling NEV industry development and engaging various stakeholders (Bakker et al., 2014; Lu et al., 2014). The innovation ecosystem, characterized by multilateral interdependence and a layered value adoption chain, is integral for delivering comprehensive innovation solutions (Adner, 2006, 2017; Hienerth et al., 2014; Ritala et al., 2013). Unlike traditional systems, the innovation ecosystem prioritizes realizing innovation value, with market feedback influencing subsequent rounds of innovation, ultimately determining the sustainable development of the NEV industry through consumer satisfaction with value creation and delivery efficiency.

The global recognition of China as a frontrunner in adopting New Energy Vehicles (NEVs) is attributed to its distinct policy force, aiming to boost core technology development and reduce vehicle prices (Liu & Kokko, 2013; Zhang & Bai, 2017). Both national and regional incentives play a pivotal role in catalyzing Plug-in Electric Vehicles (PEVs) (Zhou et al., 2015). The dynamic transformation of NEV policies, shifting from government to market selection and production to consumption orientation, emphasizes the need for a bottom-up policy formulation path (Jiang et al., 2018). Focal national policies support key components, power systems, and reliable electric vehicles, necessitating urgent new policies for network development and fast charger construction (Du et al., 2017; Neaimeh et al., 2017). While tax incentives and demonstration policies yield high satisfaction with low importance, subsidies, technical and infrastructure supports hold high importance with lower satisfaction in China (Li et al., 2017). Notably, the influential policy of "no traffic restrictions for NEVs" requires enhanced charging infrastructure standards in the future (Sun et al., 2017). The innovation ecosystem underscores the importance of aligning business model innovation strategies with national policy goals, particularly for enterprises with resource constraints (Chen et al., 2014; Li & Garnsey, 2014; Walrave et al., 2018). Policies play a pivotal role in guiding emerging industry innovation ecosystems, aligning innovation strategies with government paces for success (Estrin, 2009; Li & Garnsey, 2014). The NEV industry addresses public externalities,

and policy coordination is vital for complementary player interactions within the sector innovation ecosystem, particularly under China's strong administrative intervention (Fransman, 2018). China stands as a crucial focus in NEV industry research, having been dependent on policy support for rapid development over the last two decades (Zhang & Bai, 2017).

Key Barriers of NEV Industry

The existing policy landscape in China for new energy vehicles (NEVs) reveals significant investments in technology R&D, but challenges persist. Yang et al (2021) found that despite substantial investments, China's industrial policies have not fostered an ideal environment for relevant companies or advanced technology. The focus on complete vehicles in NEV industry policy has led to an imbalance in technological development between upstream and downstream sectors (Dong & Liu, 2020; Li, 2020). Scientific and technological services, particularly those provided by universities, play a crucial role in enhancing innovation capabilities (Yang et al., 2023). China must overcome obstacles such as a shortage of skilled scientists and legal barriers to accelerate NEV industrialization (Wu et al., 2020; Yang et al., 2021). Key technological breakthroughs and cost reduction in NEV manufacturing are essential for establishing an intelligent, networked automobile industry chain (Wu et al., 2020). Policies supporting government subsidies, innovation, and improved industrial chains are vital for the growth and technological progress of NEV manufacturing under the new economic normal (Wu et al., 2017).

The challenges facing Electric Vehicles (EVs) in China include inventive product designs, sophisticated power systems, new drive trains, and the establishment of an electrical vehicle charging infrastructure. Replacing traditional vehicles with EVs across the entire value chain presents complex technological and logistical obstacles (Parmar et al., 2021). In the Indian NEV market, barriers encompass a lack of stable EV manufacturing policies, insufficient government incentives, the absence of an independent government body, limited EV models, low consumer awareness, high dependency on battery imports, inadequate infrastructure, and a higher upfront cost of EVs. Additionally, a shortage of skilled manpower poses a significant challenge to the Indian EV industry (Kimble & Wang, 2013).

Methodology

Multiple Case Study Methodology and Case Selection

The study employs a multiple case study methodology, examining four prominent Chinese New Energy Vehicle (NEV) companies—Tesla China, NIO, Wuling, and BYD, within the manufacturing industry. In line with Creswell's approach (Creswell & Poth, 2013), this method delves into real-life, contemporary bounded systems over time, involving comprehensive data collection from various sources to present detailed case descriptions and themes (p. 97). The choice of a multiple case study analysis is grounded in reasons provided by (Gustafsson, 2017), enabling the exploration of data within and across these companies, predicting diverse or similar outcomes for expected reasons (Yin, 2009).

Moreover, the multiple case study design facilitates cross-case comparisons, shedding light on distinctions and similarities among these companies (Baxter & Jack, 2008; Stake, 1995), thereby contributing valuable insights to the literature (Vannoni, 2015). Given the unique supply chains of these companies, an exploratory analysis is essential, aligning well with the case study methodology (Cousin, 2005). This methodology proves particularly beneficial for qualitative analyses and a theory-testing approach, enhancing the

comprehension of complex phenomena (Siggelkow, 2007; Yin, 2009), as pertinent to the investigated topic. Furthermore, the use of multiple case studies enables real-time data collection, mitigating weaknesses associated with retrospective reconstruction and reinterpretation errors (Alblas & Wortmann, 2014).

The case selection process followed a convenient sampling criterion, emphasizing easy accessibility and information availability (Voss, 2010). While research case selection often adheres to specific criteria (Veldman et al., 2011), our focus revolved around three crucial factors pertinent to the Chinese New Energy Vehicle (NEV) industry, particularly examining major automotive companies—Tesla China, NIO, Wuling, and BYD: (1) size of the case study, which prioritizing homogeneity in terms of revenue dimension, with a specific emphasis on big and listed enterprises within the Chinese NEV industry. (2) Industry, which ensures homogeneity based on the sector of activity within which the case studies operate, specifically within the Chinese NEV sector. (3) This targeted selection approach aimed to analyze successful cases (Patton, 2002) by focusing on forerunner organizations with mature and profitable businesses. The chosen entities, Tesla China, NIO, Wuling, and BYD, had already implemented good performance in NEV market and related technology or business model innovations.

Data Collection and Analysis

From an extensive review of existing research, the study developed a semi-structured interview protocol with open-ended questions for engaging with key respondents from the companies. The protocol, guided interviews with six first-line managers and senior researchers. Selecting first-line managers was strategic as they hold decision-making authority for implementing managerial practices in business model design (Augier & Teece, 2009; Helfat & Martin, 2015; Massa & Tucci, 2013). Given the scope and novelty of the case studies in the new energy market, the number of interviewees ensured credibility, transferability, dependability, and confirmability of gathered information (Guba & Lincoln, 1994; Morse, 2000). Each key respondent underwent at least two interviews, with sessions lasting from one and a half to one hour, totaling over six hours.

The primary datasets explored themes such as the drivers of disruptive innovations in the Chinese New Energy Vehicle (NEV) industry, the role of collaborations and partnerships, barriers to innovation, the impact of regulatory frameworks and government policies, and the influence of technology. Interview questions addressed included:

(i) Could you pinpoint what you perceive as the primary drivers fueling disruptive innovations in the Chinese New Energy Vehicle (NEV) industry?
(ii) In what ways do collaborations and partnerships within the industry contribute to propelling disruptive innovations in the landscape of NEVs?
(iii) From your perspective, what major barriers do you see hindering the advancement of disruptive innovations in the Chinese NEV market?
(iv) How do regulatory frameworks and government policies influence and shape the terrain of disruptive innovations within the Chinese NEV industry?
(v) To what extent do government incentives and policies wield influence in either promoting or hindering disruptive innovations in the New Energy Vehicle (NEV) sector?
(vi) In what ways does technology contribute to or pose challenges for disruptive innovations in the Chinese New Energy Vehicle (NEV) industry?

During the analysis phase, we began with within-case analysis, providing insights into each NEV company's approach. We mapped the drivers and challenges in disruptive innovation proces and business model innovation. Subsequently, a cross-case analysis compared and synthesized patterns, identifying similarities and differences across cases. Employing coding procedures and software for interview analysis, the study created case-specific illustrations and organized framework aspects in tables, ensuring the trustworthiness of results (Flick, 2004).

Findings

Company of BYD

Established in 1995 with an initial investment of US$300,000 and a workforce of 20, BYD Company Limited has demonstrated remarkable growth, maintaining an average annual increase of 70%. Headquartered in Shenzhen, Guangdong Province, the company boasts a global presence, operating 20 factories worldwide, producing a diverse range of products from IT components to electric vehicle (EV) components. Beyond its roots in China, BYD has strategically expanded internationally, with factories in Russia, Syria, Egypt, Sudan, the USA, and Brazil. Notably, BYD has secured its position as the leading New Energy Vehicle (NEV) sales company in China and globally. This early global expansion is underpinned by BYD's mature technology and a strategic initiative to capitalize on emerging EV markets (Masiero et al., 2016).

In a BYD manager interview, key drivers of disruptive innovations in the Chinese NEV industry were highlighted, including a strong commitment to R&D, strategic collaborations, and a focus on sustainable solutions such as cutting-edge battery tech, electric drivetrains, and intelligent connectivity. Emphasizing the importance of collaborations and partnerships, BYD actively engages with tech companies, research institutions, and government bodies to accelerate groundbreaking technologies. Barriers to NEV market innovation, such as regulatory uncertainties, infrastructure challenges, and consumer perceptions, were identified, requiring collaborative efforts and engagement with policymakers. The manager also discussed the role of regulatory frameworks and government policies, highlighting their support in creating a conducive environment for NEV innovation. Government incentives, subsidies, and policies promoting sustainable transportation were emphasized, with BYD aligning strategies to drive innovation and meet regulatory and consumer expectations. Lastly, the interview addressed the pivotal role of technology in BYD's disruptive innovations, acknowledging both its driving force and challenges, including the need for continuous investment and adaptation to evolving standards. Overall, BYD's commitment to innovation and strategic collaborations positions it as a leader in the evolving NEV industry.

"Technological innovation is the foundation of BYD's survival. In the face of a hundred years of change, only by mastering core technologies can enterprises stand out in the fierce market competition; only by strategically being one step ahead of others and crossing into high-threshold industries can they win the development advantage. BYD will continue to ramp up technological innovation, plough into the manufacturing industry, and contribute more to the national economy's high-quality development."

Company of Tesla China

Since entering China in 2014, Tesla (China) has achieved significant success, dominating the mid-to-high-end new energy vehicle market with models like Model 3, Model S, Model X, and Model Y. In Q3 2021, the company reported $3.11 billion in sales in China, constituting

48.5% of its $6.41 billion global sales during the same period. Model 3 and Model Y rank among the top three in China's new energy passenger vehicle market. Tesla's wholly-owned Gigafactory in Shanghai, with plans to invest $187.91 million for expansion, aims to meet rising demand in China and the Asia-Pacific region. with real-time strategy contributing to its success. Despite challenges in other markets, Tesla's robust performance in China remains a bright spot, with over 1,500 EVs sold per store on average in the first ten months of 2023, showcasing continuous growth from 2022 (Liu & Zhou, 2022; Xinyi et al., 2022).

In a comprehensive interview with the Tesla manager, the primary catalysts driving disruptive innovations in the Chinese New Energy Vehicle (NEV) industry were elucidated. Tesla's standpoint underscored unwavering innovation, a customer-centric ethos, and a commitment to sustainable energy solutions, particularly in the domains of battery efficiency, autonomous driving capabilities, and energy storage. Collaborations and partnerships emerged as foundational to propelling disruptive innovations, with Tesla championing open innovation and strategic alliances. The interview also delved into barriers hindering disruptive advancements, such as charging infrastructure, regulatory complexities, and consumer education, showcasing Tesla's proactive engagement in overcoming these hurdles. The influence of regulatory frameworks, government policies, government incentives, and the pivotal role of technology in Tesla's disruptive innovations were also explored. In essence, Tesla's stance as a leader in fostering innovation, collaboration, regulatory navigation, strategic alignment with incentives, and cutting-edge technology was underscored throughout the interview.

"First things first, innovation isn't just a buzzword at Tesla; it's practically our middle name. We're not here to follow trends; we're here to set them ablaze. From the drawing board to the factory floor, we're relentless in pushing the boundaries of EV tech. It's not just about making a car; it's about crafting an experience that screams, "Welcome to the future!"

Company of NIO

NIO Inc., established in 2014 and publicly listed on the U.S. stock market on September 12, 2018, as well as in Singapore and Hong Kong in 2022, stands at the forefront of the Chinese new energy vehicle sector. With its headquarters in Hefei, NIO has pioneered innovative business concepts and made substantial investments in scientific research, particularly focusing on optimizing battery life, engine performance, assisted driving, and onboard artificial intelligence. Despite recent challenges posed by the epidemic, NIO's new energy vehicles, renowned for their affordability and exceptional driving experience, have demonstrated remarkable sales growth. NIO holds the fourth position among the top ten sales in the Chinese NEV market (Wang et al., 2023).

NIO, a pioneering force in the Chinese NEV sector, spearheads disruptive innovations through advancements in battery tech, user-centric experiences, and strategic collaborations. The company addresses barriers like charging infrastructure gaps and regulatory complexities as opportunities for innovation. Collaborating closely with regulators, NIO aligns with supportive policies to drive positive changes. Government incentives significantly influence NIO's strategies, promoting innovation while navigating potential policy shifts. At the core of NIO's disruptive innovations lies cutting-edge technology, propelling breakthroughs in battery tech and connectivity. The bayobolt, a patented technology, stands as a key driver, ensuring precise and swift 15-second battery exchanges, exemplifying NIO's commitment to redefine sustainable mobility.

"As a staff at NIO, I see several key drivers fueling disruptive innovations in the Chinese NEV industry. Firstly, our cutting-edge battery technology is a game-changer. The bayobolt, a patented technology, ensures precise and robust battery connections, making the battery exchange process quick and efficient. Then, our focus on enhancing the user experience sets us apart. Our innovative Battery-as-a-Service (BaaS) model and NIO Power infrastructure redefine how users interact with and consume electric power. It's all about making the user experience seamless and enjoyable."

Company of SAIC-GM Wuling

The Hongguang MINIEV, SAIC-GM Wuling's first four-seat new energy vehicle, targets short-distance travel scenarios. Launched in three configurations on July 24, 2020, it marked the beginning of a "small era" in people's travel. The versions—easy, comfortable, and enjoyable—were priced at RMB 28,800, RMB 32,800, and RMB 38,800, respectively. The MINIEV Macaroon, introduced on April 8, 2021, expanded the lineup with Fashion and Enjoy versions at RMB 37,600 and RMB 43,600. Later variants, including the Autumn Colour and Macaroon Sandwich, further enriched the series, contributing to its status among the top 10 in new energy vehicle sales in China (Hao et al., 2023; Kennedy, 2020).

SAIC-GM-Wuling drives disruptive innovation in China's NEV industry by prioritizing practical, affordable, and sustainable mobility solutions. Emphasizing collaboration, they engage with partners and government bodies. The Hongguang MINI EV exemplifies space efficiency and practicality. Overcoming barriers, Wuling invests in infrastructure, advocates for stable policies, and promotes consumer education. Collaborations play a vital role in integrating technologies. Regulatory frameworks and government incentives guide industry direction. Wuling strategically aligns with government incentives for cost-effective EV solutions. Technology is central, contributing to breakthroughs while posing challenges. Wuling views technology duality as an opportunity to shape a future of sustainable and intelligent mobility.

"The Hongguang MINI EV is designed to prioritize space and practicality over flashy aesthetics. Unlike cars focused solely on looking good with ostentatious and enchanting designs, the MINI EV opts for practicality, durability, and broad consumer appeal. It's all about functionality rather than excessive style. In essence, the Hongguang MINI EV embodies a "design in pursuit of function," aiming to cater to a wide range of consumers and various applications."

Key Drivers

The disruptive innovations in the Chinese New Energy Vehicle (NEV) industry are propelled by several key drivers, each contributing to the transformative landscape. Firstly, technological advancements stand out as a primary driver. Firms like Tesla China lead the way with breakthroughs in battery technology, electric drivetrains, and intelligent connectivity. For instance, Tesla's focus on long-range electric vehicles with advanced autopilot features showcases the transformative power of technology in reshaping the NEV industry. Secondly, consumer response is also an important driver, a user experience-focused approach plays a pivotal role in driving innovation. NIO, recognized for its commitment to user-centric design, prioritizes affordability, ease of use, and meeting diverse consumer needs. This emphasis on user experience is exemplified by NIO's battery-swapping technology, providing a seamless and efficient solution for electric vehicle owners.

Collaborations and partnerships emerge as a third crucial driver. BYD's strategic collaborations with global partners and local governments in the development of electric vehicles and battery technology underscore the significance of collective efforts. Such collaborations allow for the integration of diverse expertise, accelerating the pace of innovation and market adoption. Lastly, sustainability commitment is integral to the industry's disruptive evolution. Wuling's emphasis on creating NEVs that contribute to a greener future demonstrates the alignment of disruptive innovations with broader environmental goals. The Hongguang MINI EV's practical design philosophy, focusing on functionality and broad consumer appeal, exemplifies how sustainability and practicality can drive innovation hand in hand.

Government policy is instrumental in guiding the evolution and innovation of New Energy Vehicles (NEVs) in China. A prime example of this is BYD's success in the Chinese NEV market, largely attributed to strategic utilization of supportive government policies. BYD's innovative efforts, including advancements in battery technology and electric vehicles, align with government incentives and regulations, illustrating the transformative power of industry-government synergy in the NEV sector. Government policies, from R&D incentives to NEV adoption subsidies, foster an environment conducive to disruptive innovation. This has enabled companies like BYD, which overtook Tesla as the global EV sales leader, to thrive in the dynamic Chinese NEV market.

In sum up, the key drivers of disruptive innovations in the Chinese NEV industry—technological advancements, user experience focus, collaborations, government policy, and sustainability commitment—work synergistically to reshape the industry. These drivers, exemplified by leading firms like Tesla China, NIO, BYD, and Wuling, collectively contribute to a dynamic landscape where electric vehicles become more accessible, user-friendly, and aligned with environmental sustainability goals.

Key Barriers

The Chinese New Energy Vehicle (NEV) industry confronts multifaceted barriers that necessitate strategic solutions for disruptive innovations. Firstly, the challenge of insufficient charging infrastructure, especially in less urbanized regions, hampers the practicality of NEVs. For instance, the limited availability and accessibility of charging stations in rural areas create range anxiety among consumers, hindering the widespread adoption of electric vehicles. Secondly, the complex regulatory landscape poses a significant hurdle, requiring companies to adapt to varying policies. Tesla China, for instance, navigates through different regional standards, showcasing the need for a flexible regulatory strategy to ensure compliance and innovation in the rapidly evolving sector.

Another formidable barrier is lack of consumer education, which is not achieving widespread consumer acceptance, marked by concerns such as range anxiety and hesitancy toward new technologies. NIO's approach of actively collaborating with regulators to align goals with supportive policies reflects the effort to overcome this challenge. Thirdly, cost constraints, particularly the price of batteries, present a barrier to mass adoption. BYD addresses this by investing in research and development to make advancements in battery technology and lower manufacturing costs, demonstrating the industry's commitment to innovative cost-effective solutions. Overcoming these barriers demands a comprehensive approach from major automotive companies, including infrastructure development, advocacy for standardized regulations, consumer education, and innovative cost-effective solutions to foster sustainable growth in the industry.

Discussion

Prior research emphasizes the critical importance of technical improvements as a primary motivator. The findings back this up, emphasizing how advances in battery technology, electric drivetrains, and intelligent connections generate disruptive technologies (Jiang et al., 2018; Li et al., 2017; Liu et al., 2018). Notably, this aligns with the view that technological skill will continue to be a determining factor in the market success of electric vehicles. The findings also show that customer response, collaborations and partnerships, sustainability commitment, and government regulation are driving disruptive innovation in China's NEV market. At the same time, established research pays heed to market demand and government regulation (Jianlong Wu et al., 2018), all of which are consistent with the findings in the Chinese NEV disruptive innovation route.

Similarly, obstacles such as infrastructure limitations, regulatory difficulties, and consumer acceptance are common themes in the existing literature. Factors affecting EV manufacturing include government policy imbalances, inadequate support services, financial pressures, technological and logistical challenges, limited EV models, and inadequate infrastructure (Dong & Liu, 2020; Ji et al., 2019; Parmar et al., 2021; Wu et al., 2021; Xu & Chen, 2020; Zheng et al., 2023). These findings reaffirm these constraints, giving insight on their subtle expressions in the Chinese NEV business.

Comparing the findings to the current literature reveals similarities and differences, as seen in Table 1. While technology improvements remain a driving factor, this finding's emphasis on user-centric approaches, strategic collaborations, and a commitment to practical solutions adds levels of understanding. This sophisticated perspective leads to a more complete understanding of the complex dynamics that drive disruptive breakthroughs. Barriers identified, such as infrastructure gaps, legislative difficulties, and consumer acceptance, are consistent with previous research. However, the study delves deeper into the specific manifestations of these challenges in the Chinese context, such as a lack of consumer education, a complex regulatory landscape that differs from other countries' NEV markets, and provides granular insights critical for industry stakeholders and policymakers.

By combining the findings of this study with the current body of literature, a thorough overview of the New Energy Vehicle (NEV) industry can be obtained. There are two main consequences for industry practitioners and policymakers. These findings emphasize the need for customized tactics that effectively combine technical progress with user-focused methods, strategic partnerships, and feasible solutions backed by favorable government regulations.

Furthermore, the study acts as a spark for future research endeavors. Exploring certain characteristics in more depth becomes possible for scholars due to their nuanced comprehension of impediments and drivers in the Chinese NEV industry. Potential future investigations may explore the progressive function of rules, the intricacies of strategic cooperation, and the shifting terrain of consumer acceptance.

By incorporating these findings with the current body of knowledge, a comprehensive comprehension of the NEV environment is achieved. The implications gained from the analysis provide practical insights, while the comparative analysis and identification of research gaps provide a more detailed investigation of disruptive developments in the Chinese NEV sector.

Table 1
Comparing the Findings to The Current Literature

Items	Findings in This Study	Current study	Authors
Key Drivers	• Technological Advancements • Consumer Response • Collaborations and Partnerships • Sustainability Commitment • Government policy	✓ Technological Innovation ✓ Market Demand ✓ Government Policy	➢ Jianlong Wu et al. (2018) ➢ Liu et al. (2018) ➢ Jiang et al. (2018) ➢ (Li et al., 2017)
Key Barriers	• Insufficient Charging Infrastructure • The Complex Regulatory Landscape • Lack of Consumer Education • Cost Constraints	✓ imbalance government policy ✓ lack of support service for technology ✓ government financial pressure ✓ technological and logistical obstacles ✓ Lack of a stable policy for EV manufacturing ✓ Limited EV models	➢ Dong and Liu (2020) ➢ Xu and Chen (2020) ➢ Ji et al. (2019) ➢ Wu et al. (2021) ➢ Parmar et al. (2021) ➢ Zheng et al. (2023)

Conclusion

The findings in this study found the key drivers of DI in the Chinese NEV industry include technological advancements, user experience focus, collaborations, government policy, and sustainability commitment to working synergistically to reshape the industry. In addition, it underscores persistent challenges, including infrastructure deficiencies, complex regulatory procedures, customer acceptance hurdles, and cost constraints.

The study underscores the pivotal role of key factors in steering disruptive innovation. The commitment of BYD, Tesla China, NIO, and Wuling to advanced technology, user-focused improvements, strategic partnerships, practical solutions, government policy support, and sustainability collectively demonstrate the industry's dedication to technological advancement, enhanced user experience, collaboration, and sustainability. These driving forces, exemplified by each case, highlight the holistic approach adopted by industry leaders.

However, the research also uncovers persistent challenges that demand ongoing attention. Significant hurdles stem from infrastructure shortcomings, complex regulations,

customer acceptability issues, financial constraints, market competitiveness, and the pressing need for consumer education. The strategic measures undertaken by these companies, as discussed in the study, illuminate potential strategies to address these challenges, providing valuable insights for industry professionals and policymakers alike.

It's important to acknowledge certain limitations in this study. The cases discussed may not fully encapsulate the broad spectrum of the entire Chinese NEV sector. Furthermore, the sector's dynamic nature implies that some findings may become outdated. The research primarily focuses on leading industry players, potentially overlooking valuable insights from smaller and less visible competitors. Additionally, the study may not fully account for all cultural, economic, and geopolitical factors influencing the Chinese NEV sector's dynamics.

This analysis has implications that extend beyond individual cases, offering valuable insights for shaping the future trajectory of the Chinese NEV market. Policymakers can gain a deeper understanding of the importance of enacting consistent regulations, fostering infrastructure development, and providing incentives that nurture an environment conducive to innovative ideas. Industry stakeholders receive strategic guidance to navigate a competitive landscape marked by technological advancements and evolving consumer behavior. The study also lays the groundwork for future research efforts, encouraging scholars to delve deeper into specific aspects of the NEV industry for a more thorough understanding.

In conclusion, the in-depth analysis of multiple cases significantly contributes to the understanding of the complex dynamics influencing disruptive innovations in the Chinese NEV market. The systematic arrangement of influential factors and challenges provides a comprehensive view of the industry's dynamics. The research findings offer valuable guidance for informed decision-making and fostering sustained innovation in the Chinese NEV industry as it continues to evolve and advance towards a sustainable and technologically advanced future

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