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Supply Chain Management as a Strategic Tool for EU Market Expansion:
A Comparative Study of BYD and Hyundai in the New Energy Vehicle Industry

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As a non-native English speaker, I made use of AI-based language tools to support the linguistic refinement of this thesis. These tools were employed exclusively for language correction, stylistic improvement, and clarity of expression, in order to ensure that my own ideas, arguments, and analyses are communicated clearly and comprehensibly. All research design, analytical content, interpretations, and conclusions presented in this thesis are entirely my own.

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List of Abbreviations

3TG	Tantalum, Tin, Tungsten, and Gold
ACEA	European Automobile Manufacturers' Association
AFIR	Alternative Fuels Infrastructure Regulation
BEV	Battery Electric Vehicle
BHRRC	Business & Human Rights Resource Centre
BMS	Battery Management System
BYD	Build Your Dream
CBAM	Carbon Border Adjustment Mechanism
CCS	Combined Charging System
CEM	Customer Experience Management
CEFV	Center for Environmentally Friendly Vehicle
CLSC	Closed-Loop Supply Chain
CPC	Communist Party of China
CPFR	Collaborative Planning, Forecasting, and Replenishment
CPO	Certified Pre-Owned
CQI	Customer Quality Integration
CRM (Management)	Customer Relationship Management
CRM (Materials)	Critical Raw Materials
CSR	Corporate Social Responsibility
CSRD	Corporate Sustainability Reporting Directive
CSDDD	Corporate Sustainability Due Diligence Directive
CVD	Countervailing Duties
DC	Direct Current
DRC	Democratic Republic of the Congo
E-GMP	Electric-Global Modular Platform
EoL	End of Life
EPRS	European Parliamentary Research Service
ERM	Enterprise Risk Management
ESG	Environmental, Social, and Governance
ESRS	European Sustainability Reporting Standards
ETS	Emissions Trading System
EU	European Union

EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
FDI	Foreign Direct Investment
FTA	Free Trade Agreement
GBA	Global Battery Alliance
GIZ	German Corporation for International Cooperation
GRI	Global Reporting Initiative
HHI	Herfindahl–Hirschman Index
GSCM	Green Supply Chain Management
HAN	Highly Advanced National
HEV	Hybrid Electric Vehicle
HMC	Hyundai Motor Company
HME	Hyundai Motor Europe
HMG	Hyundai Motor Group
HMGICS	Hyundai Motor Group Innovation Center Singapore
HMMC	Hyundai Motor Manufacturing Czech
IAA	International Automotive Exhibition
ICE	Internal Combustion Engine
ICCU	Integrated Charging Control Unit
IEA	International Energy Agency
IOU	I Owe You
IoT	Internet of Things
IRO	Impacts, Risks, and Opportunities
KIGAM	Korea Institute of Geoscience and Mineral Resources
KOMIR	Korea Mine Rehabilitation and Mineral Resources Corporation
KPI	Key Performance Indicators
LFP	Lithium Iron Phosphate
LLC	Limited Liability Company
MEB	Modular Electric Drive Toolkit
NCAP	New Car Assessment Programme
NEV	New Energy Vehicle
NGO	Non-Governmental Organization
NMC	Nickel Manganese Cobalt
OECD	Organisation for Economic Co-operation and Development

OLED	Organic Light-Emitting Diode
PCAM	Precurcor Cathode Active Material
PHEV	Plug-in Hybrid Electric Vehicle
R&D	Research and Development
SCM	Supply Chain Management
SDF	Software-Defined Factories
SME	Small and Medium-sized Enterprises
SOP	Start of Production
SSCM	Sustainable Supply Chain Management
SUV	Sport Utility Vehicle
TEN-T	Trans-European Transport Network
UK	United Kingdom
US	United States
V2L	Vehicle-to-Load
WLTP	Worldwide Harmonized Light Vehicles Test Procedure
WTO	World Trade Organization

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1. Theoretical Part

1.1. Introduction

1.1.1. Research Question

This thesis addresses the following research question: How do East Asian new energy vehicle producers — BYD and Hyundai — use supply chain management strategies to address the challenges of expanding into the EU market?

The study focuses on the EU-27 and the category of new energy vehicles (NEVs), defined here as battery-electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel-cell electric vehicles (FCEVs) (International Energy Agency 2025a), while excluding conventional hybrid electric vehicles (HEVs) and other vehicle types that do not rely on external charging or hydrogen-based propulsion (International Energy Agency 2024).

The analysis concentrates on the period 2020–2025, when key EU regulatory instruments that materially shape automotive supply chains entered into force or were significantly tightened — namely fleet CO_2 standards (Regulation (EU) 2019/631), the new EU Battery Regulation (Regulation (EU) 2023/1542), and the transitional Carbon Border Adjustment Mechanism (CBAM) regime (2023–2025, with the definitive regime from 2026) (European Union 2019, 2023a, 2023b). Positioning the cases in this window also captures the market-access asymmetries that directly condition SCM choices: the EU imposed countervailing duties on China-made BEVs following its anti-subsidy investigation (with firm-specific rates such as BYD ≈17%) (European Commission 2024), while South Korea's vehicles benefit from the EU–Korea Free Trade Agreement, which removed tariffs on nearly all industrial goods (European Union and Republic of Korea 2011). These policy differences shape localisation timing and sourcing design for Chinese BYD and Korean Hyundai in Europe.

The theoretical framework guiding this research is grounded in supply chain management strategies. Effective SCM enables companies to gain and sustain long-term competitive advantages, contributing to greater stability in the industry's development. As information technology advances and demand grows, supply chains must become more intelligent and adaptive in order to address performance challenges (Liu and Hao 2024, 2; Yu 2024, 91). Advanced SCM models support NEV firms in successfully expanding into global markets (Qi 2023, 46), though companies may adopt different strategies to achieve this goal (Wu 2023, 272). The NEV supply chain is widely regarded as one of the most complex systems, spanning raw-material procurement, component processing, vehicle assembly, distribution, and after-sales service (Niu 2023, 271). This thesis therefore employs a structured framework that disaggregates SCM into five criteria — Sustainability & Corporate Social Responsibility; Innovation & Competitiveness; Policy & Material Access; Risk Management, Resilience & Firm Governance; and Brand & Quality Management — mapped across the upstream, midstream, and downstream value chain.

Existing scholarship on internationalisation and supply chain management in the automotive sector has predominantly focused on global NEV industry trends — especially Tesla (Bai, Yan, and Yan 2023; Olorunfemi 2024) — or on European incumbents such as Volkswagen, Škoda and Renault in the European context. BYD, while increasingly attracting scholarly attention, is still mostly examined through domestic or regional lenses, leaving the EU-specific challenges of its expansion underexplored. Moreover, much of the existing literature frames the issue in terms of European incumbents' competitive risks, rather than analysing the EU-specific adaptation challenges of Chinese entrants (Tagliapietra, Trasi, and Sebastian 2025; Tschiesner et al. 2024). Hyundai is likewise frequently treated as a traditional automaker, and research on its transition to a NEV-focused manufacturer remains limited (Hahn, Duplaga, and Hartley 2000). It is rarely included in NEV-focused case studies.

This thesis addresses that gap by focusing explicitly on East Asian entrants to the EU market, where complex regulatory, infrastructural and political factors interact with firm-level supply chain choices.

1.1.2. Growth Opportunities and Supply Chain Challenges in the New Energy Vehicles Industry

As global consciousness regarding climate change and environmental protection escalates and energy challenges become more acute, new energy vehicles (NEVs), in particular battery-electric vehicles (BEVs), are increasingly perceived as environmentally sustainable substitutes for traditional fuel-powered cars. Governments and consumers around the world are showing growing interest in buying ecological alternatives in order to reduce greenhouse gas emissions (Wu 2023, 271).

The International Energy Agency (IEA) states in its 2023 annual report the global registrations of approximately 14 million new energy vehicles (including battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs)) (8). In 2024, global electric car sales reached 17 million units, marking a 25% increase compared to the previous year, following a 35% increase in 2023. According to available statistics for the year 2023, the largest market share belongs to China, representing 60% of total global electric car sales, followed by Europe with 25%. The

United States shows a 10% market share in electric cars, while the rest of the world accounts for only 5%. About 20–21% of all global car sales are electric vehicles (IEA 2024).

The Chinese and European governments are demonstrating strong determination in implementing government-led carbon neutrality initiatives. The Communist Party of China (CPC) showed its commitment to achieve a carbon peak by 2030 and carbon neutrality by 2060. In order to support these aims, the Central Committee introduced comprehensive measures in the Fourteenth Five-Year Plan for National Economic and Social Development and Vision for 2035 (The State Council of the People's Republic of China, 2021). The European Green Deal, introduced by the European Commission, states that all 27 EU Member States have dedicated themselves to transforming the EU into the first climate-neutral region by 2050. To achieve this objective, they vowed to diminish emissions by by at least 55% by 2030, in comparison to 1990 levels (European Commission, 2023a). "Accelerating the shift to sustainable and smart mobility" is explicitly mentioned in Section 2.1.5 of the European Green Deal and encompasses the expansion of charging infrastructure for low- and zero-emission vehicles (European Commission 2019). According to Regulation (EU) 2019/631, from 2035, the EU will enforce a fleet-wide CO_2 emission limit of 0 g CO_2/km for new passenger cars and vans, effectively achieving full decarbonisation of new vehicle sales (European Commission 2025a). This creates excellent opportunities for NEV manufacturers.

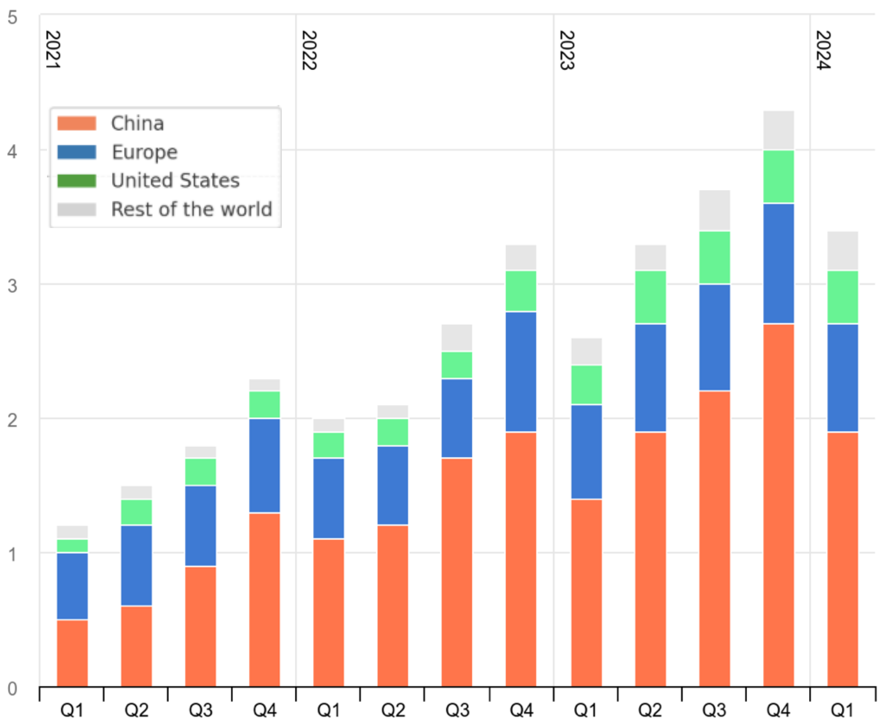

Figure 1: Quarterly Electric Car Sales by Region, 2021–2024 (IEA 2024)

European governments are promoting the transition to electric mobility not only through regulatory frameworks but also through public engagement initiatives. Examples include events such as the Wiener Elektrotage in Vienna, where policymakers, manufacturers, and consumers interact in the context of sustainable mobility and electric vehicle adoption (Wiener Elektrotage 2025).

Despite these favourable growth conditions and expectations of an accelerated transition towards electrified mobility driven by technological progress (Richmond 2024), the new energy vehicle industry remains relatively young. As a result, it is still highly volatile and not yet sufficiently mature to provide firms with strong long-term risk resilience. Even leading manufacturers like Tesla have experienced sudden declines in demand in the European market due to political and reputational shocks, illustrating the sensitivity of the NEV industry to product cycles, corporate governance, and broader political dynamics (Dnistran 2025; Inagaki and Li 2025). More broadly, the NEV market faces growing challenges arising from geopolitical uncertainty, regulatory intervention, and trade-related tensions, all of which significantly affect internationalisation strategies and supply chain stability.

In order to remain competitive in the global market, companies must manage their supply chains effectively to adapt to unexpected disruptions and the specific requirements of target markets. This thesis examines the supply chain management strategies of leading NEV producers in China and South Korea through case studies of BYD and Hyundai. The aim is to analyse how these firms address the challenges of expanding into the European market and achieving competitive positioning through their supply chain strategies.

1.1.3. Case Study Selection: BYD and Hyundai

This thesis employs a comparative case study approach focusing on BYD and Hyundai as two leading new energy vehicle (NEV) producers from East Asia. The selection of these cases is motivated by their strategic relevance to the European market and their contrasting supply chain configurations, which allow for a meaningful comparison of different approaches to managing international expansion under regulatory, geopolitical, and market uncertainty.

For much of the past decade, Tesla served as the primary reference point in the European electric vehicle market, reflecting its early technological leadership, strong performance characteristics, and influential brand positioning (Wu 2023, 271). More recently, however, competitive dynamics have begun to shift. In 2024, BYD surpassed Tesla in global electric vehicle sales for the first time, driven largely by its dominant position in the Chinese domestic market (The Economic Times 2025). While BYD remains a relatively new consumer brand in

Europe, this development contributed to increased attention to Chinese manufacturers and their potential impact on European market competition.

This shift in competitive visibility became particularly evident in 2025, when it was first reported in May that BYD had sold more cars in Europe than Tesla (Inagaki and Li 2025). According to brand-level registration data disseminated by JATO Dynamics, Chinese BYD and Korean Hyundai Motor Group, including Hyundai and Kia brands, constituted the sole manufacturers from East Asia to feature among the ten most-registered electric vehicle brands in Europe during April 2025, in conjunction with predominantly European and U.S.-based competitors (Dnistran 2025). Registration data are reported at the brand level rather than at the group level. Although the performance of the Kia brand within Hyundai Motor Group (HMG) is closely interconnected with that of Hyundai Motor Company (HMC) due to shared research and development structures (HMC 2024a), this study focuses exclusively on Hyundai Motor Company as the analytical unit and does not analyse Kia separately in order to limit analytical complexity.

The reported monthly rankings do not imply long-term market leadership, but the concurrent presence of BYD and Hyundai among Europe's top-registered electric vehicle brands marked a visible shift in competitive perception. Importantly, it also distinguished BYD and Hyundai from other East Asian automakers whose footprint in Europe remains comparatively limited, thereby reinforcing their suitability for comparative analysis.

Beyond market visibility, BYD (Build Your Dreams; 比亚迪, *Bǐyàdí*) is a particularly relevant case because of how its supply chain has developed over time and how closely this development is linked to battery manufacturing. Founded in China in 1994, according to the company's official records, BYD started as a battery producer and quickly became a major player in the nickel–cadmium battery market (BYD n.d.a). Its early success was largely driven by cost-efficient manufacturing methods, which allowed the company to secure a significant share of global demand. This battery-focused origin later shaped BYD's broader strategy and explains its strong preference for vertical integration.

The move into automotive manufacturing came gradually. BYD entered the sector in the early 2000s and launched its first mass-market new energy vehicle in 2008. From there, the company expanded further into mobility-related fields, including infrastructure projects such as its monorail system. These steps suggest that BYD's ambitions were never limited to car production alone. Throughout this period, the company kept key technologies and components under close internal control, reinforcing its integrated business model (Yu 2024, 92).

In recent years, however, this approach has started to change. BYD has begun to open selected parts of its supply chain and to cooperate more actively with external suppliers. This shift appears to be a response to rising regulatory pressure, sustainability expectations, and the practical challenges of operating in highly regulated foreign markets, particularly the European Union. Seen as a whole, BYD's path — from a battery specialist to a vertically integrated NEV producer, and now toward a more selectively open and data-driven supply chain — offers a useful basis for analysing how integrated firms adapt their strategies when entering highly regulated markets, such as the European Union (Yu 2024, 93).

Hyundai Motor Company (현대자동차, Hyundai) provides a contrasting but equally relevant case for comparative analysis. Founded in 1967, the company has a long-standing presence in global automotive markets and extensive operational experience in Europe. Its early development included assembling the Ford Cortina at its Ulsan plant in 1968, followed by the launch of Korea's first mass-produced and exported passenger car, the Pony, in 1975 (HMC n.d.a). This long industrial history distinguishes Hyundai from newer entrants and shapes its approach to production, supplier relations, and market governance.

Hyundai's transition toward electric mobility began more gradually than that of BYD. The introduction of the IONIQ model in 2016 marked the company's first major step into electrification, a move that was later reinforced by the unveiling of the dedicated E-GMP platform in 2020 and the establishment of the IONIQ sub-brand to scale battery-electric vehicles across multiple segments (HMC 2020a; Kia Motors America 2020). Rather than pursuing deep vertical integration, Hyundai has maintained a partnership-based supply chain strategy for electric vehicles, particularly in the European market.

For Europe, battery cells for Hyundai's BEVs are primarily sourced from external suppliers such as LG Energy Solution and SK On (HMC 2020a, 2023). This reliance on long-term supplier partnerships reflects a different strategic response to technological uncertainty, capital intensity, and regulatory requirements compared with BYD's integrated model. Seen in this light, Hyundai's combination of established manufacturing capabilities, platform-based electrification, and collaborative supply chain governance makes it a suitable counterpoint to BYD for analysing how different supply chain strategies shape competitiveness and resilience in the European NEV market.

Taken together, BYD and Hyundai Motor Company illustrate two distinct yet strategically significant approaches to NEV production and internationalisation. Both firms are actively expanding their electric vehicle portfolios in Europe, including the compact and more affordable segments (Johnson 2025; Williams 2025). At the same time, they differ markedly in their supply chain governance, degree of vertical integration, and modes of market entry. These differences make them particularly well suited for examining how supply chain management strategies shape competitiveness and resilience in the European NEV market.

1.1.4. Research Question Relevance

The research question is relevant to several groups of stakeholders who are directly affected by the supply chain strategies of East Asian NEV producers entering the EU market.

EU policymakers and regulators. The European Union has recently enacted stringent regulatory measures such as the EU Battery Regulation, the Carbon Border Adjustment Mechanism (CBAM), and tightened CO_2 fleet standards, which require firms to adapt their supply chains to meet traceability, reporting, and localisation obligations (European Union 2019, 2023a, 2023b). Insights into how BYD and Hyundai structure their supply chains for EU compliance are therefore critical for anticipating enforcement challenges and policy outcomes.

BYD, Hyundai, and peer NEV firms. For the firms themselves, comparative analysis clarifies how different trade regimes shape EU entry. BYD must contend with EU countervailing duties on China-made BEVs, whereas Hyundai benefits from tariff-free access under the EU–Korea Free Trade Agreement (European Commission 2024; European Union and Republic of Korea 2011). Understanding how supply chain management mitigates such asymmetries is valuable not only for these two producers but also for other Chinese and Korean entrants considering EU expansion.

Suppliers and logistics partners. Battery manufacturers, component suppliers, and logistics providers must align with localisation and reporting timetables. Supplier decisions on gigafactory siting, battery passport traceability, and sustainable logistics flows depend heavily on how BYD and Hyundai design their EU supply networks (HMC 2020b, 2023; SK Innovation 2021; Yu 2024).

Consumers and fleet operators in the EU. Supply chain resilience shapes the availability, pricing, and reliability of NEVs for end-users. Model shortages, delayed deliveries, or limited after-sales coverage can directly influence consumer adoption and fleet electrification decisions. This makes the analysis of supply chain design highly relevant to market confidence in NEVs (IEA 2024).

Investors and financial institutions. Financiers evaluate the capital intensity and risk profiles of EU localisation projects, from battery plants to distribution hubs. Supply chain strategies signal resilience and governance capacity, influencing both private equity and public funding decisions (IEA 2024).

Academia and research. Finally, the study contributes to academic debates on internationalisation and supply chain management by shifting attention from Tesla and European incumbents towards Chinese and Korean entrants. It highlights how East Asian firms operationalise SCM under EU-specific regulatory and infrastructural conditions, an underexplored but increasingly significant field.

1.2. Literature Review

1.2.1. Introduction

The purpose of this literature review is to deconstruct the research question by examining how supply chain management (SCM) strategies are conceptualised in the NEV industry and how they relate to firms' international expansion challenges. It first clarifies the definitions of key terms (EV, NEV, SCM) and then synthesises five core criteria derived from existing research — Sustainability & Corporate Social Responsibility; Innovation & Competitiveness; Policy & Material Access; Risk Management, Resilience & Firm Governance; and Brand & Quality Management. Each criterion is subsequently examined through the upstream, midstream, and downstream dimensions of the NEV value chain, providing a structured analytical lens for evaluating the case studies of BYD and Hyundai.

1.2.2. Definitions

1.2.2.1. Electric Vehicles and New Energy Vehicles

The first major challenge emerged at the very outset of the research, involving the fundamental task of defining a key term. Although the terms "electric vehicles" and "new energy vehicles" are often used interchangeably, they differ significantly in terms of the types of vehicles they encompass. Using the term without a clear understanding can lead to the misinterpretation of existing research and statistical data.

Generally speaking, in public and policy discourse, the term "electric vehicle" (EV) is often used broadly to refer to vehicles employing electric propulsion technologies. However, this loose usage can obscure important technical and regulatory distinctions, which are essential in academic and research contexts.

The International Energy Agency (IEA) defines electric vehicles (EVs) as including battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), and in some contexts also includes hybrid electric vehicles (HEVs). Fuel cell electric vehicles (FCEVs) are generally classified separately and fall under the category of zero-emission vehicles (ZEVs), together with BEVs, as both produce zero tailpipe emissions; ZEVs do not include PHEVs or HEVs

(IEA 2025a). In its official electric vehicle statistics, the IEA excludes HEVs and focuses on BEVs and PHEVs, as HEVs cannot be externally charged (IEA 2024).
The term "new energy vehicles" (NEVs, or 新能源汽车 *xīn néngyuán qìchē*) is officially used in Chinese policy documents (The State Council of the People's Republic of China 2020). According to the Chinese Ministry of Finance, it refers to BEVs, PHEVs (including E-REVs — extended-range electric vehicles), and FCEVs. HEVs are not included in China's subsidy programme for the same reason they are excluded from IEA reports (Shanghai Municipal Tax Service 2023).
The South Korean government does not have its own definition in official documents. In subsidy programmes, there is a distinction between BEVs, PHEVs, and FCEVs. In general, the definitions align with those of the IEA (Ministry of Foreign Affairs, Republic of Korea 2024).
This research adopts new energy vehicles (NEVs) as the primary umbrella term throughout the analysis, as it provides the broadest and most precise conceptual framework for addressing the research question. Unlike the term electric vehicles (EVs), which is often used inconsistently in international literature and statistics, NEVs explicitly encompass battery-electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs). This distinction is particularly important for the present study, as one of the analysed firms, Hyundai Motor Company, has strategically positioned hydrogen fuel cell technology (FCEVs) as a core component of its eco-friendly mobility strategy. In contrast to manufacturers that rely exclusively on BEVs, Hyundai has pursued a dual-path approach to electrification, reflecting a product diversification strategy that is central to understanding its supply chain and market-expansion decisions and therefore cannot be omitted from the analysis (HMG 2017, 10). Moreover, plug-in hybrid electric vehicles (PHEVs) constitute a critical component of BYD's European market-entry strategy (Pontes 2025), further underscoring why a ZEV-based definition would be too restrictive for the purposes of this study.
HEVs, which cannot be externally charged, will not be included in this research, as they are internationally excluded from the ZEV/NEV concept. Instead, this study focuses on BEVs, PHEVs, and FCEVs, which are central to market expansion strategies and policy incentives in the European Union. If HEVs are included in some existing statistics, this will be explicitly mentioned.
In this research, the term "European market" refers specifically to the EU market (EU-27), as it is unified by common regulatory frameworks governing new energy vehicles. Any reference to European countries outside the EU-27 is explicitly indicated and does not form part of the core empirical analysis.

To maintain analytical clarity and avoid excessive complexity, the scope of the study is further limited at the firm and product levels. Although Hyundai Motor Group encompasses multiple automotive brands, including Hyundai, Kia, and Genesis, this thesis focuses exclusively on Hyundai Motor Company as the flagship automotive entity. Accordingly, references to "Hyundai" throughout the thesis should be understood as referring to Hyundai Motor Company unless explicitly stated otherwise. While the brands within the group share certain research, development, and platform resources, each brand pursues distinct branding strategies, model portfolios, and market positioning. A comprehensive analysis of all group brands would therefore exceed the scope of a single master's thesis.

A similar limitation applies to BYD. Although BYD operates across a wide range of industries, including solar energy systems, buses, rail transport, and commercial vehicles, this study concentrates solely on BYD's passenger new energy vehicle activities relevant to the European market. Other business segments are excluded, as they involve different regulatory frameworks, market conditions, and supply chain structures that fall outside the focus of this research.

Where data availability does not allow for a clear distinction between individual brands within a corporate group, this limitation is explicitly acknowledged, and such data are interpreted with caution in line with the defined analytical scope.

1.2.2.2. Supply Chain Management Strategies

Supply chain management (SCM) typically involves a network of multiple organisations, starting with raw-material suppliers and extending through component suppliers, sub-assemblers, final assemblers, and distribution channels, ultimately reaching the end consumers (Hahn, Duplaga, and Hartley 2000, 33). It entails overseeing the entire production process of goods or services with the goal of maximising quality, ensuring timely delivery, enhancing customer experience, and improving profitability (Song 2023, 29). SCM encompasses a wide range of activities that were once handled by separate functional departments, such as marketing, engineering, production, purchasing, distribution, and logistics (Hahn, Duplaga, and Hartley 2000, 33).

While the concept of supply chain strategy predates it, Fisher's (1997) framework was foundational in shaping the strategic alignment of supply chains with product characteristics, laying the groundwork for differentiating efficiency- and responsiveness-based approaches in modern supply chain management strategies (109). Supply chain strategy represents a company's response to the demands of the commercial environment. Given the ever-changing nature of this environment, supply chain strategies must also be adaptable and responsive to changes (Basnet and Seuring 2016, 87). The performance of a supply chain is directly influenced by a company's overarching strategy. Specifically, a firm’s process strategy affects supply chain operations through factors such as process efficiency, marketing alignment, and the extent of innovation adopted.

Companies may choose from a range of supply chain strategies depending on their goals and market conditions. These strategies include negotiating with multiple suppliers, establishing long-term partnerships with a select few, pursuing vertical integration, forming joint ventures, participating in Keiretsu networks, or operating as virtual companies that engage suppliers on an as-needed basis. Another increasingly popular approach is the integrated supply chain, which emphasises collaborative planning, forecasting, and replenishment (CPFR), alongside the use of blanket orders and standardisation. Each of these strategies offers distinct advantages and aligns with different business models, risk tolerances, and competitive objectives (Dinu Popa 2014, 35).

Therefore, a supply chain strategy is a comprehensive framework that directs the management of all activities related to sourcing, procurement, production, and logistics. It involves close coordination and collaboration with channel partners, including suppliers, intermediaries, third-party service providers, and customers. A crucial element of an effective supply chain strategy is its alignment with the organisation’s mission, vision, and overall strategic objectives (Shah and Kirche 2025).

The new energy vehicle industry chain is typically divided into three segments: upstream, midstream, and downstream. The upstream supply chain comprises key material and component suppliers that provide core parts for production, such as non-ferrous metals and chemical raw materials. These components are then passed to the midstream supply chain, which is responsible for vehicle manufacturing and technological development. Finally, the products move to the downstream supply chain, where they are sold to customers through dealers. In addition, the downstream segment also includes after-sales support and charging services for end users (Yu 2024, 92).

This study adopts the division of supply chain management into upstream, midstream, and downstream segments to classify and evaluate the criteria for supply chain strategies. The literature review will provide a detailed overview of each criterion, highlighting its role in effective supply chain management and its contribution to enhancing competitive advantage in the global market.

1.2.2.3. Challenges of EU Market Expansion for East Asian NEV Producers

Existing research highlights that expanding into the EU market presents not only regulatory and logistical barriers but also intense competitive pressures from established European manufacturers. East Asian NEV producers such as BYD and Hyundai face a multifaceted environment shaped by stringent EU sustainability legislation, trade remedies, and market structure.

On the regulatory side, compliance with the EU Battery Regulation, the Carbon Border Adjustment Mechanism (CBAM), and Corporate Sustainability Reporting Directive (CSRD) imposes strict traceability and localisation requirements across the entire supply chain (European Union 2022, 2023a, 2023b). Tariffs and anti-subsidy measures targeting Chinese-made BEVs further complicate entry and raise cost pressures (European Commission 2024).

Upstream, concentration in critical materials and export-control frictions expose firms to price and supply shocks, necessitating multi-sourcing, hedging, and chemistry flexibility (Elshkaki 2020, 13). The building EU footprint adds further hurdles — permitting, skills, and supplier co-location — alongside logistics bottlenecks and battery hazmat constraints (Brumerčíková, Buková, and Černá 2024, 157–160; Soares et al. 2023, 17–20; Tagliapietra, Trasi, and Sebastian 2025, 4–6).

Finally, entrants face powerful local competitors with entrenched plants, supplier ecosystems, and brands (VW Group, Stellantis, Renault, BMW, Mercedes), which raises the bar on localisation depth, after-sales coverage, and perceived ESG legitimacy (Muñoz 2025).

The European market-specific challenges identified here are examined in detail for each analytical criterion in the empirical part of this thesis.

1.2.3. Sustainability and Corporate Social Responsibility

Sustainability and corporate social responsibility (CSR) are core themes in the literature on supply chain management in the NEV industry. Scholars in the most recent and relevant studies — such as Zheng Shuxiang (2024); Bai Enyu, Yan Guowei, Yan Xiaohang (2023); Wang Haokai and Zhang Han (2024); Soares Laene Oliveira (2023); Niu Pengbo (2023); Yu Zejun (2024), among many others — explicitly emphasise the importance of sustainability and social responsibility for the NEV sector.

Sustainability in the NEV supply chain is not only an environmental imperative but also a strategic business opportunity. In this study, Park Byung-chul analyses various criteria influencing customer purchase intentions. According to his findings, eco-friendliness contributes most significantly to the formation of social value and ultimately influences EV buyers' final decisions (Park 2023, 113). Sustainability in the automotive industry has moved beyond ethics to become a core strategic requirement for enduring market competitiveness (Paudel 2025). Moreover, in the European Union, sustainability and CSR are not optional reputational factors but binding market entry conditions. The EU Battery Regulation (Regulation (EU) 2023/1542) requires traceability of critical raw materials, a "battery passport" for large batteries, and due diligence obligations covering human rights and environmental risks in the upstream supply chain (European Union 2023a).

According to my observations, researchers who focus on case studies of specific firms tend to highlight the positive developments and ecological success of the NEV industry. For example, Zheng Shuxiang (2024), in his study "Analysis of Tesla's Sustainable Supply Chain Management", emphasises the company's environmental and social impact at various stages of the supply chain. A similar tone can be found in the case study of BYD conducted by Wang Haokai and Zhang Han (2024). Some researchers do mention critical points and environmental risks, but in general, the positive connotation surrounding the NEV industry remains stable and largely unquestioned. For instance, Yu Zejun (2024), in his study of BYD, acknowledges the necessity of carefully balancing cost-effectiveness with sustainability, yet still highlights "BYD's prominence in the automotive and green energy sectors."

The picture changes when we examine studies specifically focusing on the environmental impact of the EV supply chain and the use of lithium, cobalt, and nickel. These studies do not take economic profit into account and adopt a much more critical perspective. Esiri et al. (2023) assess the environmental footprint of the electric vehicle supply chain, raising concerns about raw-material extraction — particularly land degradation and air and water pollution caused by nickel mining — as well as ethical issues related to cobalt mining in the Democratic Republic of Congo (223). Moreover, battery production requires high energy input and involves the use of hazardous solvents and chemicals. Electric motors rely on rare earth elements, which can generate toxic waste and radiation risks (Esiri et al. 2023, 221).

Murugan et al. (2022) highlight the growing use of lithium-ion batteries over the next decade, which will complicate their disposal and increase the need for efficient recycling. Rüdisüli et al. (2022) compare different types of NEVs in terms of net carbon emissions and seasonal energy system implications. Their findings show that BEVs generally produce the lowest greenhouse gas emissions — but with the important caveat that this depends on the use of low-carbon electricity, a factor that is often overlooked (18).

Scholars like Gu et al. (2018), Ekatpure (2023), and Wang and He (2023) advocate boosting sustainability in the EV supply chain by adopting circular economy principles. Closed-loop supply chains (CLSCs) enable the reuse and recycling of materials, reducing the need for virgin raw materials and minimizing waste. For instance, the recycling of lithium-ion batteries can significantly reduce the environmental footprint of EVs by recovering valuable materials like lithium, cobalt, and nickel. However, battery recycling, while a promising sustainability strategy, remains economically unviable under current market conditions unless supported by policy incentives or simplified models (Ekatpure 2023, 2). Government policy can significantly improve EV battery recycling by raising collection prices and volumes (Wang and He 2023, 21).

Therefore, the most relevant aspect of supply chain management in the NEV industry is sustainable supply chain management. This branch of supply chain management focuses on strategies to mitigate sustainability-related risks (Soares et al. 2023, 10). Supply chains are considered sustainable when they incorporate ethical and environmentally responsible business practices into a practical and competitive framework. Full transparency across all stages is essential, with sustainability efforts covering everything from raw-material sourcing to product returns and recycling (Bai, Yan, and Yan 2023, 175).

One more similar concept used in the NEV-related literature is green supply chain management (GSCM). Green supply chain management specifically addresses the environmental aspects of the supply chain — reducing ecological impact at every stage from sourcing to recycling (Zhang 2022, 71). Based on these definitions, green supply chain management can be considered a subset of sustainable supply chain management (SSCM).

Chinese researchers especially often use ESG as a comprehensive framework of principles to evaluate a firm's non-financial performance across three key dimensions: Environmental (E) — the enterprise’s impact on natural ecosystems, including emissions reduction, resource efficiency, and green innovation; Social (S) — responsibilities to employees, customers, and the broader society, such as labour rights, consumer protection, and philanthropic engagement; Governance (G) — the quality of internal controls, ethical management, transparency, and stakeholder accountability (Du 2025; Fu and Wu 2023; Wang 2024b; Zhang 2024; Zhang and Li 2024; Zhang, Yao, and Suo 2025).

1.2.4. Innovation and Competitiveness

The NEV industry is a relatively new sector that is still in the process of development (Borucka, Stopka, and Kozlowski 2024, 66). Innovation can be considered one of the key factors in the competitive race among different brands (Wang 2024c, 289). Companies that develop superior technologies can enhance their global competitiveness through more efficient manufacturing and improved product features. The significant role of technological innovations, especially in battery technology and charging infrastructure, is highly emphasised in various studies (Hu et al. 2021, 151; Lin 2024, 13; Niu 2023, 27; Olorunfemi 2024, 6; Wang 2024a, 198).

Innovation is essential not only for staying ahead within the NEV industry but also for remaining competitive in the broader automotive market, particularly when competing with traditional internal combustion engine vehicles (Chen and Li 2024, 23; Zane, Jaiswal, and Tribbitt 2024, 46).

Notable advancements in battery technology, including enhanced energy density and expedited charging capabilities, can increase electric vehicle performance and make NEVs more attractive to consumers (Wang 2024a, 198). Xie, Zhao, and Ding (2024) claim that technological innovation significantly drives NEV sales, particularly through improvements in batteries, electric motors, and charging systems (17). Authors define key factors influencing NEV competitiveness based on the existing literature: purchase price and costs, energy prices, charging infrastructure, policy measures and driving range. Almost all of these factors are significantly influenced by technological innovations (Xie, Zhao, and Ding 2024, 4). The same factors are mentioned by other scholars (Qiu, Thoo, and Zhan 2024, 1497).

Moreover, Wang, Tang, and Pan (2018) found in their empirical study in Shanghai that technological performance is more important for consumers than environmental awareness from the previous point (288). One empirical study is not sufficient to draw definitive conclusions — especially since it was conducted in China, while the focus of this paper is the European market. Nevertheless, it can still be stated that technological innovation-driven advancement is one of the crucial factors for boosting competitiveness in the NEV industry.

However, Chen and Chen (2023) used Rothaermel's innovation matrix researching the different impact of incremental innovation, disruptive innovation, architecture innovation, and radical innovation. They combined it with Ansoff's market strategies to create the following strategic framework: incremental innovation supports market penetration, disruptive innovation aligns with market development, architectural innovation suits product development, and radical innovation is most appropriate for diversification.

Incremental innovation is primarily concerned with the enhancement of pre-existing technologies. The advantages of such innovation are generally manifested in improved technical performance and supplementary features that increase customer satisfaction. This type of innovation requires less time and effort and is best suited for well-established markets. On the other hand, disruptive innovation creates opportunities for new entrants to contest the dominance of established market leaders. It often introduces technologies that cater to non-mainstream markets, eventually reshaping consumer expectations. The best example of this is the rise of electric vehicles, which, despite their higher prices compared to traditional and hybrid cars, are profoundly transforming consumer preferences and market structures.

Architectural innovation helps by introducing existing technologies to new markets. It relies on combining existing components in novel ways to create new products, depending heavily on patents or proprietary technologies. For example, Tesla has exemplified architectural innovation through the modularization of component functionalities. While the connections between components remain unchanged, developing individual component functions results in changes at the module level. This enables product upgrades by replacing entire modules without the need for a full vehicle replacement, allowing consumers to access newer and improved products without waiting for a new model year.

Radical innovation targets entirely new technologies and markets. It involves the exploration of unknown technological territories and represents significant technological breakthroughs, often associated with new inventions, patents, or business models. Such a form of innovation usually needs extensive research and development, experimentation, regulatory approval, and market adaptation. A prime illustration of radical innovation is the whole transition from internal combustion engines to electric motors. It represents a fundamental shift in vehicle design and engineering in general (Chen and Chen 2023, 5).

This implies that not all technological investments are equally effective for a given SCM strategy. Their efficiency largely depends on the specific market context and the company’s strategic goals. Thoughtless investments in technology can result in unnecessary financial losses.

Choi (2018) also highlights that the dynamic between technological innovation (technology-push) and consumer demand (demand-pull) varies across different markets. A significant question is which comes first: technological innovation that precedes market demand, or demand that drives innovation. The paper compares two markets — the United States, considered a lead market, and Germany, viewed as a non-lead market for EVs in 2018. The findings suggest that in well-established markets, technological innovation tends to lead market development, while in non-lead markets, its influence on demand is more limited. Choi argues that technology-push policies (e.g., R&D subsidies) are more effective in early-stage industries. Although demand-pull policies (e.g., consumer subsidies) support diffusion, they do not initiate innovation. For long-term industry evolution, a balanced policy mix is recommended. First movers in lead markets like the U.S. are more likely to influence global demand trends. Firms should therefore prioritise R&D and demonstration projects rather than reacting to uncertain early market signals (669).

Recent statistics show that the EU market accounts for 25% of the global NEV share (IEA 2024). Germany — originally presented in Choi's study as a conservative market leaning toward clean diesel — has since introduced new policy packages to accelerate EV adoption. Today, it can be considered one of the leading markets and should be treated accordingly. This shift should influence the supply chain management strategies of East Asian companies expanding into the EU.

The findings in the article by Xie, Zhao, and Ding (2024) clearly distinguish the effects of technological innovation across the upstream, midstream, and downstream segments of the NEV industry chain. The research shows that patent quality in the upstream sector significantly and positively influences NEV sales. Innovation in upstream materials contributes to the entire value chain, is closely linked to sustainability and corporate social responsibility, and can guide strategic R&D priorities and policy support for raw-material development.

Midstream innovations — including batteries, electric drives, electronic control systems, automotive electronics, chassis, and body components — are critical drivers of sales, because they directly impact vehicle performance. The downstream sector primarily involves charging infrastructure and related services. Improved charging solutions help reduce range anxiety and increase consumers' willingness to buy EVs. Thus, technological innovation at all levels of the industry chain has a positive impact on NEV sales. However, midstream innovations, particularly in battery technology, show the strongest correlation with sales performance (Xie, Zhao, and Ding 2024, 16).

1.2.5. Policy and Material Access

Innovation and technological advancements play a central role in firm competitiveness; however, automakers do not exist in isolation. Every firm also faces a complex set of external conditions such as governmental policies, market barriers, geopolitical tensions, and restricted access to critical raw materials. These factors can either support or hinder firm performance. The following section examines how policy frameworks and material dependencies shape the opportunities and limitations faced by various NEV producers.

Global NEV market growth is inseparable from strong governmental support (Borucka, Stopka, and Kozlowski 2024, 67). Sheldon and Dua (2024) analysed the dynamic role of subsidies in promoting global electric mobility. A study of 23 countries shows that EVs are cost-competitive only with incentives (15). Encarnação et al. (2018, 25) and Haan, Santonja, and Zaklan (2023, 30) also emphasize the high-cost issue in their studies. Fluchs (2021) calls the high purchase price of electric vehicles the most significant barrier to potential customers. Encarnação et al. (2018) claim that neither consumers nor manufacturers will initiate the transition to NEVs without initial public support due to costs and coordination failures (30). Gil Ribeiro and Silveira (2024), in their research on the European NEV market, also argue that financial incentives remain essential to improve the cost-competitiveness of electric vehicles, particularly in countries where total cost of ownership remains high. However, their effectiveness is not uniform across member states and should be continuously reassessed and optimised. Incentives alone are insufficient — without supporting infrastructure and contextual adjustments, they may fail to ensure meaningful market penetration. A more differentiated and flexible policy mix is therefore required (17).

The need to improve the infrastructure, especially charging stations, is highlighted in different studies as part of governmental strategies to improve the EV market (Bencivelli et al. 2024, 6; Hildermeier et al. 2023, 8; Littlejohn and Prost 2019, 5; Siebenhofer, Ajanovic, and Haas 2021, 7). The governmental financial support of the NEV industry in general consists of direct subsidies to consumers and tax exemptions (Srivastava et al. 2022, 5). Scholars such as Lieven (2015), Santos and Davies (2020), Kaplanović and Živojinović (2022), Liu, Huang, and Yang (2017), and many others evaluated the efficiency of such initiatives in their research. This study does not examine these policies in detail, as they affect the NEV market as a whole but do not directly impact NEV manufacturers. In summary, the findings show that countries like China and Norway, which adopt complementary policy approaches, serve as successful models for designing future-ready NEV policies (Srivastava et al. 2022, 23).

A distinctive feature of the Chinese case is that governmental policies support not only consumers but also incentivise domestic battery and vehicle production, giving manufacturers a competitive edge (Wang 2022, 8). The Chinese government views the NEV sector as a strategic industry and has actively supported its development through a range of coordinated policies. Initiatives such as Made in China 2025 and the 2020 New Energy Vehicle Industrial Development Plan have played a key role in advancing the domestic NEV industry (Bencivelli et al. 2024, 5). Grants for R&D are considered to be a highly effective tool for promoting the NEV industry (Littlejohn and Prost 2019, 36; Santos and Davies 2020, 330). According to Naumanen et al. (2019), China dominates patenting in nearly every technological sub-area of heavy-duty electric vehicle development (9).

South Korea is also among the countries with the most effective government policies for promoting NEVs (Sheldon and Dua 2024, 8). Major Korean firms such as LG Energy Solution, Samsung SDI, and SK On — alongside their Chinese counterparts — are global leaders in the battery sector, supported by a strong domestic industrial policy (Bencivelli et al. 2024, 4). Regarding charging infrastructure, South Korea also remains at the forefront of NEV adoption driven by coordinated infrastructure policy (Bencivelli et al. 2024, 5). Lee and Mah (2020) explore how South Korea's industrial policy has promoted EV development through coordinated R&D investment, SME support, and battery sector collaboration. Through major investments in R&D programmes like the Highly Advanced National (HAN) initiative and the Global Top Environmental Technology Project, and the establishment of the Center for Environmentally Friendly Vehicle (CEFV), the South Korean government significantly advanced domestic capabilities in EV technology (Lee and Mah 2020, 75). However, according to Lee and Mah, it is not enough to compete with global market leaders. The South Korean government should strengthen R&D support for SMEs, especially ventures producing EV components, as they play a crucial role in the EV supply chain. Additionally, to avoid policy delays and inefficiencies caused by inter-ministerial conflicts — particularly between environmental and economic ministries — the government must clearly define responsibilities and establish coordination mechanisms (Lee and Mah 2020, 78).

Interestingly, despite the widely recognised success of government incentives in China, Chinese-speaking scholars also tend to express criticism. For example, Han (2019) identified the problem of "subsidy cheating," where manufacturers install only the minimum battery capacity required to qualify for subsidies (152). Gao (2019) highlights institutional shortcomings and the lack of standardisation. Overly generous subsidies have encouraged short-term thinking among NEV producers. There are no unified standards for charging equipment or components, and safety and testing standards remain underdeveloped (83–84).

Overall, the Chinese rise in the NEV sector resulted from a strategic, state-led industrial policy, coupled with supply chain dominance and strong state intervention, making it unprecedented. Europe is China's largest NEV export destination, accounting for 40% of China's BEV export revenues (Bencivelli et al. 2024, 3). In response to the perceived threat to its domestic NEV industry, the EU has implemented defensive measures such as anti-subsidy investigations and, notably, tariffs aimed at addressing what it considers unfair competitive advantages. However, these actions must be carefully balanced against broader objectives, including affordability, climate goals, and maintaining industrial competitiveness (Bencivelli et al. 2024, 9).

South Korean automakers do not fall under EU restrictions. Moreover, the EU–South Korea FTA led to the phased removal of tariffs on passenger cars and auto parts by 2016, significantly reducing trade barriers and facilitating market access for Korean automakers in the EU (Juust, Vahter, and Varblane 2021, 8–9).

However, Chinese NEV manufacturers hold another significant advantage: China currently dominates access to critical materials such as lithium, cobalt, nickel, and rare earth elements.

According to Jetin (2023), China controls 35% of the nickel, 50% of lithium, 70% of cobalt, and 90% of rare earth elements processing capacity worldwide, largely due to long-standing state-led strategies aimed at vertical integration and international investment. This dominance provides China with significant leverage over the global battery value chain and enables its manufacturers to secure materials more effectively than competitors in Europe or the United States (10).

1.2.6. Risk Management, Resilience and Firm Governance

However, the previously discussed factors are not only associated with advantages but also with risks. For example, China's extended control over raw materials results in vulnerabilities, particularly in the context of global price volatility. As Wang et al. (2023) show, surging prices of these critical materials — with lithium rising by up to 438% in early 2022 — could dramatically hinder EV adoption, particularly in China, by increasing vehicle costs and reducing competitiveness with ICE vehicles. Moreover, control over mining operations does not necessarily imply domestic availability. According to Elshkaki (2020), China possesses only 7% of global lithium reserves, 6% of cobalt, and 4.7% of nickel (2). China's cobalt reserves could be depleted before 2030 unless recycling rates exceed 90% (Zeng and Li 2015, 17).

Han Xinning (2019) emphasizes that dependence on subsidies can also hinder long-term competitiveness (152). These subsidies often neglect the environmental and social costs incurred in the Global South (Agusdinata et al. 2022, 5).

Therefore, NEV supply chains are particularly vulnerable to disruptions from raw-material scarcity, geopolitical tensions, and evolving regulatory landscapes (Soares et al. 2024, 9). Effective strategies to manage these aspects are crucial for maintaining competitiveness and sustainability.

Various studies highlight major risk categories such as geopolitical, regulatory, operational, environmental, financial, and ethical risks:

1) Geopolitical risks include export bans, sanctions, trade tensions, resource nationalism, and foreign dependency (cobalt in the DRC, nickel in Indonesia, refining in China) (Kim and Kang 2023; Li and Sukhotu 2025; Nguyen et al. 2021; Ren et al. 2024; Soares et al. 2023; Wang et al. 2023; Zeng and Li 2015).
2) Regulatory risks typically arise from governance and compliance challenges like subsidy-dependence, selective ESG disclosure, greenwashing exposure, challenges arising from regulations such as the EU Battery Regulation (European Union 2023a),

and safety standards (Du 2025; Kumar et al. 2024; Lou, Islam, and Billington 2023; Meafa et al. 2025; Wang 2024b; Zhang 2024).

3) Operational risks include logistics-related risks, such as routing and charging constraints, plant stoppages, supplier capacity limitations, transport, fire or weight-related risks, as well as issues related to inventory and lead times, and technological failures (Brumerčíková, Buková, and Černá 2024; Carnovale et al. 2025; Chu et al. 2020; Li 2024; Pavić, Pandžić, and Capuder 2023; Vasantha et al. 2025; Wang et al. 2020; Wang, Zhou, and Feng 2019).
4) Financial risks — supply chain financing, credit defaults, and depreciation of assets, commodity price volatility, capital intensity, liquidity risk, subsidy exposure, cost overruns (Bui et al. 2024; Herre, Dalton, and Söder 2019; Liu and Zheng 2024).
5) Environmental risks are lifecycle emissions, mining impacts, water and land use, waste and recycling, pollution incidents (Ahuchogu, Sanyaolu, and Adeleke 2024; Rüdisüli et al. 2022; Zeng and Li 2015; Zhang 2022).
6) Ethical risks — labour rights and child labour, community impacts, greenwashing, supply chain audits and traceability, health and safety (Soares et al. 2023; Wang 2024b; Zeng and Li 2015; Zhang 2024).

In order to mitigate risks, firms need to prioritise strong corporate governance to build stable supply chain resilience (Lou, Islam, and Billington 2023, 12). Resilience is the capability of a supply chain to anticipate, adapt to, and recover from disruptions (Pettit, Fiksel, and Croxton 2010, 8). It differs from traditional risk management. Traditional risk management focuses on identifying hazards and implementing controls based on historical data and assumptions. Its weakness is that it cannot adequately address low-probability, high-consequence events or truly unforeseeable disruptions (Pettit, Fiksel, and Croxton 2010, 4). Supply chain resilience is framed as a complement to risk management. It equips a supply chain to survive unforeseen disruptions, adapt, and even grow by developing capabilities such as flexibility, visibility, adaptability, anticipation, and recovery (Pettit, Fiksel, and Croxton 2010, 5-6). Key resilience strategies discussed in the literature include:

- Diversification and flexibility. Use of multiple suppliers, dual sourcing, and alternate logistics routes to avoid single points of failure; combine with geographic dispersion and capacity options in order to reroute and ramp quickly (Kumar et al. 2024, 2170–2173; Pettit, Fiksel, and Croxton 2010, 18–20).
- Digitalisation and AI integration. Apply AI optimization and real-time tracking (IoT) and re-planning to improve forecasting, routing, and scheduling under uncertainty. It

cuts detection latency and smooths recovery (Bentaher and Rajaa 2022, 120; Rane et al. 2024, 167–168).

- Multiplex network analysis for risk mapping. Map hub dependencies, joint suppliers, and fragile country-pair links. Network position matters when selecting an appropriate resilience strategy. Central nodes (highly connected firms) need strong detection and monitoring, while dense clusters enable faster recovery and pre-agreed detours (Carnovale et al. 2024, 20; Ren et al. 2024, 346–347).
- Visibility and traceability. Digital capabilities, including blockchain and IoT, have emerged as essential tools in enhancing visibility and traceability (for example, origin of critical minerals), improving auditability and speed of recalls in NEV supply chains (Bentaher and Rajaa 2022, 122; Rane 2024, 164–166).
- Strategic localisation without over-concentration. Regionalising upstream/midstream shortens paths and reduces cross-border rupture exposure, pair localisation with multi-sourcing inside the region. Pre-plan make-in-region vs. import strategies and pricing responses (Bencivelli et al. 2024, 2–3; Ren et al. 2024, 346–347).

Corporate governance plays the role of a foundation for resilience because it aligns incentives, sets risk guardrails, and embeds risk management into day-to-day supply chain decisions (Lou, Islam, and Billington 2023, 30). One of the most significant structural choices is whether to internalise bottlenecks (vertical integration) or diversify externally (multi-sourcing). Jetin (2023) argues that persistent materials shortages are pushing EV firms away from highly externalised global production networks and back toward a model in which automakers exercise control over the whole supply chain, known as vertical integration (3).

The advantages of vertical integration include: supply security — more localised networks suffer less damage under country-level shocks (Ren et al. 2024, 346–347); cost and coordination benefits — vertical integration can lower production costs, hedge critical-mineral price volatility, and make control over the entire supply chain easier (IEA 2025b, 136–137); strategic autonomy in scarce inputs, therefore lower dependence on external blocs (Jetin 2023, 6–8). There are also related disadvantages, such as capital intensity, long lead times and permitting constraints, so vertical integration may not solve near-term shortages (Jetin 2023, 16). Moreover, bringing key tiers inside the firm shifts dependency inward and increases concentration, which amplifies the chance that a failure in one internal node becomes a single point of failure for the whole chain (IEA 2023, 99–100, 2025b, 145).

By contrast, multi-sourcing can boost diversification and flexibility to reroute and balance technologies as markets and policies shift; the IEA underlines that partnerships along the supply chain and agile sourcing are crucial in today's more consolidated but fast-moving battery market (IEA 2025b, 145–146). Cooperation can accelerate innovation and R&D integration — working with several battery partners and start-ups lets firms access different chemistries and capabilities, accelerating learning and time-to-market (IEA 2023, 99–100, 2025b, 145). But more independent partners increase integration, data-sharing, and cybersecurity burdens; without strong data governance the benefits leak (Bentaher and Rajaa 2022, 123–124). Moreover, if diverse suppliers share the same joint hubs or fragile country pairs, shocks still propagate — diversification must be network-aware (Ren et al. 2024, 346–347).

1.2.7. Brand and Quality Management

Branding and quality management represent increasingly decisive elements in the NEV industry, linking consumer perceptions with operational reliability. The literature highlights important differences between legacy automakers transitioning from ICEs and pure EV manufacturers. Traditional automakers frequently depend on legacy and sub-branding to illustrate electrification. Consumer surveys show that legacy brands are associated with trust, dependability, and value for money, but are weaker in perceptions of innovation (Boyce and Stern 2024). Heritage itself functions as a strategic brand resource: it conveys continuity, authenticity, and credibility, offering consumers a psychological safety net in uncertain markets (Hudson and Balmer 2013, 352–53; Urde, Greyser, and Balmer 2007, 8–10). These insights explain why firms transitioning to EVs rely on heritage-driven sub-branding to signal modernity while retaining brand trust. For instance, BMW launched its EV-specific sub-brand BMW i, purpose-built for electric mobility and associated with high innovation and design credentials (BMW Group 2011). Similarly, Audi recently introduced an EV-only brand in China, purposefully removing its four-ring logo to appeal to younger, tech-oriented customers (Hawkins 2024).

On the other hand, EV-native firms such as Tesla, NIO, or BYD define their identity entirely through innovation, sustainability, and lifestyle positioning. Evidence shows that perceived customer value mediates the link between innovation and brand competitiveness in the EV market (Li, Liang, and Cheng 2021, 12–13). Research on how brand image reshapes the EV market in Bangkok concludes that brand image plays a central mediating role, translating technology acceptance and innovation into consumer confidence and purchase intent. This highlights a key practical insight: automakers must not only pursue technological innovation but also cultivate brand identities that resonate emotionally and socially with buyers (Pruksarungruang 2023, 453–54). The study on EV adoption in Spain highlights the importance of status signalling for image-motivated consumers. This group tends to choose EVs only when they are the more expensive option, treating higher prices as a marker of exclusivity (Buhmann and Rialp Criado 2023, 14). The findings about the Chinese market show that brand associations, perceived quality, and brand loyalty play a decisive role in shaping consumer attitudes and purchase intentions for EVs in China, whereas brand awareness alone has no significant effect on purchase intention. A key finding is that perceived price weakens the relationship between attitude and purchase intention, indicating that even consumers with favourable attitudes may hesitate when they perceive EVs as expensive (Zheng et al. 2025).

Various EV manufacturers choose different market positioning strategies depending on brand identity and market characteristics. Tesla has consistently leveraged a premium and innovation-driven approach, supported by direct sales and over-the-air software updates, while BYD has emphasized affordability and cost-efficient sustainability strategies. In contrast, Tata Motors has positioned itself in the mass market through affordability, with sustainability initiatives and after-sales services reinforcing trust (Wang 2024c, 295–296).

Empirical work also demonstrates that brand equity affects supply chain cooperation: brand equity not only drives consumer demand but also structures cooperation outcomes between EV manufacturers and suppliers. Well-known brands wield bargaining power, while ordinary brands depend on partnerships to survive (Fan, Huang, and Wang 2021, 10). Moreover, according to Holloway (2024), strong branding buffers supply chain disruptions by preserving brand loyalty and trust, especially when brands communicate transparently and manage crises responsively (7).

Liu et al. (2025) argue that Customer Quality Integration (CQI) is a particularly important mechanism to improve quality performance. It includes systematic after-sales service, collection of customer feedback, and proactive management of product recalls (800-802). By embedding the customer into supply chain quality processes, firms strengthen perceived quality and satisfaction, which in turn promotes repeat purchasing and brand loyalty (Liu et al. 2025, 804). Complementing this structural integration, research on Customer Experience Management (CEM) tools demonstrates how digital platforms, after-sales apps, and Customer Relationship Management systems (CRM) enhance customers' perceived value across functional, price, emotional, and social dimensions (Xu et al. 2024, 12–14).

In the EV sector, where recalls and software updates are highly visible, these practices ensure that supply chain responses are not only operationally effective but also reinforce consumer trust as a form of resilience. This convergence of integration and experience management shows that quality management is inseparable from brand equity: responsive after-sales, transparent recall practices, and consistent customer engagement act as resilience strategies in the customer-facing supply chain. Finally, the digitalisation of quality management, often referred to as Quality 4.0, is reshaping practices in the EV sector. By integrating real-time data capture, predictive analytics, and interconnected quality management systems, firms can pre-empt product recalls, accelerate innovation cycles, and embed continuous improvement into supply chain processes (Prashar 2023, 2440–2442).

1.3. Analytical Framework

1.3.1. Overview of Analytical Framework

Building on the literature review, the analysis will compare BYD and HMC across five criteria: (i) Sustainability & Corporate Social Responsibility, (ii) Innovation & Competitiveness, (iii) Policy & Material Access, (iv) Risk Management, Resilience & Firm Governance, and (v) Brand & Quality Management. To minimise overlap and keep indicators tractable, each criterion is primarily mapped to the upstream–midstream–downstream structure of the NEV value chain and applied where its impact is greatest (with cross-links noted when essential) (Yu 2024, 92). Given the thesis focus on EU expansion, all indicators are EU-adapted (e.g., EU Battery Regulation compliance, EU-relevant infrastructure, and EU consumer outcomes).

1.3.2. Criteria of Analytical Framework

1.3.2.1. Sustainability and Corporate Social Responsibility

According to the academic debates outlined in the literature review, NEV manufacturers are expected to demonstrate their commitments by providing transparent information about their sustainability and social responsibility practices. The key question is whether these efforts represent genuine environmental impact or are merely marketing tools aimed at attracting more customers.

Recent work foregrounds lifecycle impacts (mining externalities, energy intensity of cell production, hazardous solvents, rare-earth processing), ethical risks (labour rights, child labour, community impacts), and the importance of traceability and transparency through ESG and sustainable supply chain management (SSCM) — especially under EU rules.

The Corporate Sustainability Reporting Directive (CSRD), entering into force in stages from 2024, extends disclosure obligations to non-EU firms with substantial EU activity, including supply chain transparency and ESG reporting. For NEV producers, this implies mandatory disclosure of greenhouse-gas emissions along the entire value chain and measurable social and governance indicators (European Union 2022). In addition, the Due Diligence Directive (CSDDD), currently advancing through EU institutions, will reinforce requirements for firms to identify, prevent, and mitigate social and environmental risks across their supply chains (European Commission 2022).

From a competitive perspective, these frameworks elevate sustainability and CSR from a "soft" reputational asset to a hard compliance gatekeeper for access to the EU market. Firms that fail to establish sustainable supply chain practices risk fines, reputational damage, and barriers to entry. Conversely, producers that demonstrate proactive ESG integration may benefit from preferential access to public procurement, subsidies, or green-finance instruments under the EU Green Deal and taxonomy for sustainable activities (European Commission 2023a). For East Asian NEV firms, sustainability is therefore not only about consumer appeal but also about meeting stringent EU regulatory thresholds that directly shape localisation, supplier selection, and long-term competitiveness.

The literature positions sustainable supply chain management (SSCM) as the umbrella that integrates ethical and environmental practices with competitive performance across all stages — from raw-material sourcing to product returns and recycling (Bai, Yan, and Yan 2023, 175). It also notes that firm-specific case studies often stress positives (Tesla in Zheng 2024; BYD in Wang and Zhang 2024), while environmental-impact studies adopt a more critical stance (Esiri et al. 2023; Murugan et al. 2022).

SCM dimension. In this thesis, Sustainability & CSR is assessed at the production tiers — upstream (responsible sourcing, critical-minerals due diligence, supplier ethics) and midstream (environmental intensity of production, energy management, recycling-readiness at the plant level). Downstream environmental aspects are excluded at this stage. This keeps the criterion aligned with where firms exercise the most direct operational control, avoids overlap with the Brand & Quality Section (which covers user-facing outcomes).

Pros. A key driver of the NEV industry's value proposition and growth potential, aligned with European environmental standards (due diligence, battery passport, recycled content); focuses on firm-controlled production tiers (upstream sourcing, midstream manufacturing); links upstream risk control to stakeholder trust and market acceptance; supports long-run cost and risk reduction through process efficiency and circularity.

Cons. Disclosures are uneven and often self-reported, especially beyond Tier 1, creating greenwashing and verification risks; available research, particularly firm-centric case studies, may be biased; cross-country and cross-tier differences hinder strict comparability without common regulatory anchors; downstream end-of-life (EoL) aspects are acknowledged qualitatively but not fully evaluated, as public evidence and firm-level comparability remain underdeveloped relative to upstream sourcing and midstream production.

The indicators. Critical-minerals traceability coverage (Li/Co/Ni/REE) (upstream); recycling-readiness at the plant level (e.g., contracts/pilots with recyclers; process integration) (upstream and midstream); battery-production environmental intensity (midstream); supplier ESG-audit coverage (upstream); ethical safeguards and remediation (labour, community) (upstream and midstream); plant-level energy controls (midstream).

Evidence base. ESG and annual reports, supplier codes of conduct, and plant-level disclosures.

Expectations. Based on their corporate profiles and regulatory positions, it is expected that BYD will highlight vertical integration and recycling initiatives as proof of sustainability leadership but may face credibility challenges around upstream raw-material traceability and external verification of labour and environmental standards. Hyundai, by contrast, is likely to emphasise compliance with EU disclosure frameworks (CSRD, CSDDD) and highlight supplier ESG audits in collaboration with Korean battery partners, while showing slower progress on circularity and in-house recycling.

1.3.2.2. Innovation and Competitiveness

As discussed in the literature review, innovation is a primary driver of competitive advantage in the NEV sector (Wang 2024c, 289). The strongest, most observable effects are located in the midstream (cells, e-drive, electronics, manufacturing systems), while upstream technology options (chemistry, materials) and downstream technical performance (e.g., charging speed, reliability) shape consumer acceptance, cost, and time-to-market.

Leading NEV companies are actively involved in the construction of charging stations as part of their supply chain management strategy to improve market conditions. For example, Tesla initiated the Supercharger network, which represents a global fast charging infrastructure initiative (Tesla n.d.a). BYD is also taking part in the improvement of the charging infrastructure. A recent project announced by BYD aims to deploy 15,000 ultra-fast 1 MW charging stations across China, significantly reducing charging times and supporting the scaling of high-performance NEVs (Akhtar 2025).

Applying the Chen and Chen (2023) innovation classification to the European NEV market — which has already passed the early adoption phase yet remains far from saturation — it can be considered that architectural and incremental innovation exert the greatest near-term impact on EU competitiveness (cost, charging time, manufacturability, refresh speed). Disruptive innovation in open, public fast charging acts as a market-making amplifier when firms co-build infrastructure used by multiple brands. Radical innovation is treated as an option value.

SCM dimension. This criterion is assessed primarily at the midstream (manufacturing efficiency, automation and digitalisation, platform engineering, battery and charging technology, software). The downstream includes charging infrastructure and user experience, where firms invest in open, public fast charging networks that improve market conditions beyond their own customers. To avoid overlap, user-facing services remain under Brand & Quality.

Pros. Central to cost competitiveness, charging performance, and time-to-market; charging-network participation acts as market-making innovation that supports broader NEV adoption (not merely a brand service), aligning with EU consumer acceptance; observable through public technical claims, platform disclosures, network coverage and independent tests.

Cons. Company claims and patent counts do not always map to usable advantage; factory-efficiency disclosure is uneven; test conditions and network metrics vary (hindering strict comparability); attribution across tiers can be imperfect when multiple partners operate the same network.

The indicators. Manufacturing efficiency (if disclosed); automation and digitalisation maturity; battery and charging performance; other technical characteristics; software cadence; charging infrastructure (market-making); patents.

Evidence base. Company technology reports and plant briefs; investor and press releases on platforms and manufacturing; independent charging tests and homologation data; user manuals; credible network sources.

Expectations. In the European market, innovation is the decisive arena of competition with incumbent brands, many of which are investing heavily in next-generation batteries, software integration, and fast charging networks. BYD is expected to leverage its vertical integration in battery production to offer lower costs and stable supply, while pushing its technological credibility. Hyundai Motor Company is likely to emphasise platform efficiency (E-GMP), software cadence, and partnerships with Korean battery champions to signal competitiveness. Both firms must demonstrate that their batteries, platforms, and charging technologies can equal or surpass European rivals — since in the EU context, technological superiority rather than price alone is the route to long-term acceptance and market share.

1.3.2.3. Policy and Material Access

Policy settings and access to critical inputs condition how quickly and affordably NEV firms can scale in the EU. Trade remedies and FTAs shape market access (by final-assembly origin), while export controls and supply concentration affect upstream security of lithium, nickel, cobalt, graphite, and rare earths. EU regulatory requirements (e.g., battery passport, due diligence, recycled content timelines) add a compliance layer that firms must operationalise through traceability systems and localisation choices.

SCM dimension. This criterion spans upstream and downstream: upstream for access to and concentration of critical materials (and exposure to export controls); downstream for EU market access via assembly origin, FTAs, subsidies, and localisation. To avoid overlap, ethical and environmental audits belong under Sustainability & CSR, and operational incident recovery falls under Risk Management, Resilience & Firm Governance.

Pros. Explains the cost, compliance, and speed of EU scaling; links policy context to concrete firm responses (local plants, supplier diversification, reporting systems); evidence is largely public (company announcements, regulator notices), making it easy to analyse.

Cons. Policies change quickly; causal attribution is difficult to isolate; company announcements may be aspirational (plant opening dates and SOP dates may slip); supplier contracts are often confidential; cross-country differences make strict comparability difficult — so all evidence should be date-stamped and phrased cautiously.

Indicators. Battery passport and due diligence readiness (upstream and downstream); export-control sensitivity (upstream); critical-materials concentration (upstream); FTA and subsidy tailwinds (downstream); EU localisation status (downstream); tariff and trade-remedy exposure (EU) (downstream).

Evidence base. Company annual, ESG, and investor reports; press releases on EU plants and SOP dates; reputable trade and regulatory summaries (duties, FTAs, incentives); supplier announcements; policy compliance statements. Record the source and year for each entry and use conservative wording where figures are not regulator-verified.

Note on boundaries. Social and ethical supplier audits are scored under Sustainability & CSR; logistics operations (routes, ports, time-to-recover) fall under Risk Management, Resilience & Firm Governance if discussed there. Localisation is referenced contextually in this section (as it interacts with duties and FTAs), but detailed assessment of localisation choices is conducted under Risk Management, Resilience & Firm Governance to avoid overlap.

Expectations. In the EU market, BYD faces headwinds from tariffs on China-built BEVs, which will pressure the company to accelerate localisation (e.g. its planned Hungary plant) and ensure readiness for the EU battery passport and due diligence obligations. However, BYD benefits from China's strong access to lithium, nickel, and rare earths, giving it a relative input advantage compared to European incumbents who are more exposed to supply insecurity. Hyundai, by contrast, enjoys tariff-free access under the EU–Korea FTA and already operates assembly in Europe, giving it a more immediate compliance and market-entry advantage. The benchmark against European firms will be whether both BYD and Hyundai can secure critical raw materials and scale localisation fast enough to sustain competitive pricing and EU policy alignment.

1.3.2.4. Risk Management, Resilience and Firm Governance

As discussed in the literature review, classic risk management, which focuses on identifying and mitigating known risks, differs conceptually from supply chain resilience, which emphasises the ability to anticipate, adapt to, and recover from disruptions (Pettit, Fiksel, and Croxton 2010, 4). In the context of NEV supply chains, the literature commonly distinguishes six major categories of risk: geopolitical risks (such as export controls, sanctions, and trade tensions); regulatory risks (including compliance with the EU Battery Regulation, CBAM, and reporting requirements); operational risks (logistics disruptions, supplier capacity constraints, production stoppages); financial risks (commodity price volatility, capital intensity, subsidy dependence); environmental risks (lifecycle emissions, mining impacts, recycling challenges); and ethical risks (labour rights, child labour, community impacts, and traceability failures).

This section first outlines how these risk categories are expected to manifest in the European context and then specifies how the two case study firms will be assessed in terms of their responses through either classic risk management measures or broader resilience-oriented initiatives. For NEV supply chains, the principal resilience levers identified in the literature include supplier diversification, network design and regional localisation (while avoiding new single points of failure), digital visibility and traceability across supply chain tiers, and the strategic trade-off between vertical integration and multi-sourcing. Corporate governance provides the organisational backbone that integrates these measures, aligning risk awareness, decision-making authority, and long-term resilience objectives within the firm (Lou, Islam, and Billington 2023, 30).

SCM dimension. This criterion is assessed primarily at the midstream level, where firms exercise the greatest degree of operational control over supplier structure, production-network design, localisation decisions (avoiding single points of failure), digital visibility and traceability, incident response, and governance. Upstream and downstream elements are referenced only insofar as they shape or reveal midstream resilience — for example, upstream concentration affecting midstream supply security, or downstream recall execution demonstrating recovery capability. The analytical focus remains on the midstream as the operational core where risk exposure translates into firm-level resilience outcomes.

Pros. Explains a firm’s ability to absorb shocks and restore output (such as tariffs and export controls, supplier issues, plant and port disruptions); makes similarities and differences visible through observable, public signals (dual-sourcing, number and location of plants, presence of risk governance).

Cons. Public evidence on disruptions and time-to-recover is sparse; disclosures beyond Tier 1 are limited; causal attribution is difficult to isolate from concurrent factors; future "contingency" claims may be aspirational. All findings should be date-stamped and phrased cautiously.

Indicators. Localisation and network dispersion for EU; supplier diversification; controlled-tier depth (battery chain); digital visibility and traceability maturity; incident response and time-to-recover (qualitative); governance of risk.

Evidence base. Annual and ESG reports, supplier announcements, plant maps and press releases (EU localisation, SOP years), reputable trade coverage of incidents and recoveries, and high-level policy statements. Recording the year for each entry is essential.

Note on boundaries. Localisation is analysed here as a resilience design choice (multi-node capacity, dispersion, reduced exposure to chokepoints), not as a policy outcome.

Expectations. In the European context, BYD will need to demonstrate that it can mitigate tariff shocks and logistics risks by accelerating localisation and diversifying suppliers beyond China, but its strong reliance on domestic Chinese production may leave resilience gaps if disruptions occur. Hyundai, by contrast, benefits from an established European production footprint and joint ventures, which strengthens its risk posture, yet still depends heavily on Korean battery partners, creating exposure to supply concentration. Both firms will be measured against European incumbents, which are increasingly pressured by EU policy to disclose and harden their supply chains. The key question is whether BYD and Hyundai can match or surpass the resilience standards set by European automakers, where transparent governance and rapid recovery from disruptions are becoming critical competitive differentiators.

1.3.2.5. Brand and Quality Management

As set out in the literature review, brand acts as a mediator between technical capability and purchase intention, while quality management (CQI, Quality 4.0, CEM, CRM) translates operational reliability into trust and loyalty. For EU expansion, visible after-sales systems, recall handling, and customer communication shape acceptance and word of mouth beyond the launch phase.

SCM dimension. This criterion is applied downstream. It assesses how firms support customers in the EU (service coverage, recall execution, complaint handling) and how they institutionalise learning loops (CQI/CEM) that feed improvements back to production. To avoid overlap, charging performance and infrastructure are evaluated under Innovation & Competitiveness, and supplier ethics and ESG under Sustainability & CSR.

Pros. Converts operations into demand and retention outcomes; provides EU-specific, observable signals (recall notices, service footprints, app features); complements resilience by showing how quickly firms communicate and remedy issues; feasible to document from public sources.

Cons. Brand-perception data are not perfectly comparable across countries; much evidence is self-reported (marketing bias); effects are hard to disentangle from price, product age, and media cycles; service-coverage counts are proxies and can overstate or understate actual capacity.

Indicators. After-sales service coverage (EU); recall handling and communication quality (EU); CQI maturity; CEM/CRM digitisation (remote diagnostics, booking, status tracking, direct communication); brand equity and awareness (EU).

Evidence base. EU safety and recall notices and company communications; brand service locators and partner listings; app release notes and help pages; annual and ESG reports (quality/customer sections); reputable third-party reviews and surveys. Recording the year and source for each entry is essential. It is needed to qualify statements where data are global rather than EU-specific.

Note on boundaries. This section does not evaluate charging experience or public fast charging build-out; those are treated as market-making infrastructure under Innovation & Competitiveness, not as a brand perk.

Expectations. In the EU market, BYD is an almost unknown brand to many consumers and will need to invest heavily in brand-building and trust creation. Beyond product launches, BYD is likely to face challenges in establishing reliable after-sales systems and brand recognition, as European consumers place high value on service coverage, recall transparency, and communication. Its rapid entry strategy means that service networks may initially lag behind product launches, which could weaken trust if quality issues arise. Hyundai, by contrast, already benefits from established European brand equity and service infrastructure, which provides a competitive head start in after-sales and customer loyalty. However, it must translate this advantage into visible quality improvements and maintain responsiveness to recalls and customer concerns. Against European incumbents, both BYD and Hyundai will be judged not only on product performance but also on whether their after-sales and quality management systems can meet or exceed the standards that EU consumers have come to expect.

1.3.3. Summary of Analytical Framework

Table 1 Summary of the Analytical Framework

No.	Criteria	SCM dimension	Examples of SCM strategy	What to measure	How to measure
1.	Sustainability & CSR	Upstream, Midstream	Raw-material sourcing (lithium, cobalt), battery recycling, labour standards, setting and enforcing a Supplier Code of Conduct, plant emission and energy control	• Public traceability statement • Ethical safeguards • Plant-level emission and energy controls • Recycling-readiness	ESG and anual reports, certifications, Supplier Code of Conduct, supplier disclosure, plants' disclosure, any third-party assurance
2.	Innovation & Competitiveness	Midstream, Downstream	Manufacturing efficiency, automation, AI implementation, battery tech, software, public fast charging build-out	• Charging time • Platform name and models on it • Power class • Manufacturing efficiency • Automation and digitalisation maturity	Production efficiency rates, R&D investments, independent charging test, tech reports, credible network press, homologation data
3.	Policy & Material Access	Upstream, Downstream	Use of governmental policy, subsidies, response to trade regulations, critical raw-material sourcing, localisation incentives	• Tariff exposure • FTA and subsidies • Export-control sensitivity • Critical-material supplier breadth • Battery regulations • EU localisation	Policy and subsidy data, trade and import statistics, resource concentration indices (e.g. HHI), mining and refining ownership, company announcements
4.	Risk Management, Resilience & Firm Governance	Midstream	Corporate governance models, supplier diversification, logistics flexibility, multi-node production, localisation and network dispersion for EU, digital visibility	• Supply chain disruptions • Time-to-recovery • Plants supplying the EU • Controlled-tier depth • Digital visibility maturity • Documented incident demonstrating recovery	Supplier base diversity, incident history, number of controlled tiers, share of localised vs. outsourced logistics, plant maps

				• Risk governance committee	
5.	Brand & Quality Management	Downstream	Quality control systems, after-sales service, customer satisfaction, recall handling and communication; CQI loop	• EU service coverage • Recent EU recall • CQI maturity • CEM/CRM features • Brand equity	Quality reports, consumer ratings, market surveys, EU recall notices, ESG annual reports, third-party reviews

2. Empirical Part

2.1. Sustainability and Corporate Social Responsibility

2.1.1. EU Legislative Framework

This section examines how the sustainability and corporate social responsibility practices of BYD and Hyundai align with the EU legislative framework. In particular, attention is given to key regulatory instruments shaping corporate environmental and social performance, including the EU Green Deal (European Commission 2023a), the Fit for 55 package (European Commission 2021), the Corporate Sustainability Reporting Directive (CSRD) (European Union 2022), the Corporate Sustainability Due Diligence Directive (CSDDD) (European Union 2024a), the EU Battery Regulation (2023/1542) (European Union 2023a), and Regulation (EU) 2019/631 on CO_2 emission performance standards for new passenger cars and light commercial vehicles (European Union 2019), as well as the Carbon Border Adjustment Mechanism (CBAM) (European Union 2023b), which introduces carbon pricing for imported high-emission materials.

The EU Green Deal (COM (2019) 640) is not a binding piece of legislation but a strategic policy roadmap that sets the goal of climate neutrality and guides subsequent laws. It serves as a framework shaping the legislative environment. Electrifying road transport is viewed as an essential step in reducing emissions from mobility (European Commission 2019). The EU Green Deal includes Green Industrial Competitiveness, which aims to promote the net-zero technology sector in the EU (European Commission 2023b). Additionally, the circular economy forms another core pillar of the EU Green Deal, drawing attention to the issue of effective battery recycling (European Commission 2019).

In the year 2021, the European Commission initiated the Fit for 55 package — a comprehensive set of legislative proposals designed to translate the strategic objectives of the European Green

Deal into binding EU law and ensure a 55 percent reduction in greenhouse gas emissions by 2030 (European Commission 2021).

The Corporate Sustainability Reporting Directive (CSRD 2022/2464) was adopted as a legislative follow-up to the European Green Deal's commitment to strengthening sustainability disclosure. It must be transposed into the national legislation of all EU Member States to ensure consistent implementation across all 27 countries. According to Articles 1–3 of the Directive and the amendments to Directive 2013/34/EU, companies must disclose sustainability information covering environmental, social, and governance (ESG) topics in their management reports (European Union 2022). The double materiality principle is applied, which means companies must report "information necessary to understand the undertaking's impacts on sustainability matters, and information necessary to understand how sustainability matters affect the undertaking's development, performance and position" (European Union 2022, Art. 19a(1)). This means that companies are required to report not only on how their activities affect people and the environment, but also on how social and environmental factors create financial risks and opportunities for their business, in accordance with the European Sustainability Reporting Standards (United Nations Environment Programme Finance Initiative 2024). Companies are also obligated to provide their management reports in an electronic reporting format, available on their websites, free of charge to the public (European Union 2022, Recital (55), Art. 29d). According to Articles 19a and 29a, ESG reports should include: business model and strategy, including compatibility with the transition to a sustainable economy and limiting global warming to 1.5 °C in line with the Paris Agreement; sustainability policies and due diligence; principal actual and potential impacts (both positive and negative); KPIs and metrics. Moreover, information must cover not only the company's own operations but also its upstream and downstream value chains, where relevant and proportionate. According to Article 34 of Directive 2013/34/EU, as amended by Directive (EU) 2022/2464, sustainability information must be verified by an independent statutory auditor or audit firm to ensure its reliability (European Union 2022).

The Corporate Sustainability Due Diligence Directive (Directive (EU) 2024/1760) is another measure stemming from the EU Green Deal, which must be implemented at the national level in all 27 Member States. It entered into force on 25 July 2024 and must be transposed by all member states by 26 July 2026. At the current stage, the EU Member States are drafting their national transpositions laws and companies are preparing to map their value chains, develop due diligence systems and align governance structures. Enforcement will begin after national laws enter into force, starting in 2027. The goal of the CSDDD is to transform the voluntary sustainability principles into binding legal obligations across the entire supply chain. Companies will be obligated to adopt a due diligence policy with a code of conduct and risk management system, identify and assess risks of human-rights violations or environmental harm, take preventive and corrective measures, and monitor their effectiveness. Supervision will be carried out by designated national authorities empowered to impose administrative fines and to cooperate within an EU-level network (European Union 2024a).

In addition to the directives mentioned above, two highly relevant regulations apply: the EU Battery Regulation (2023/1542) (European Union 2023a) and Regulation (EU) 2019/631 on CO_2 emission performance standards for new passenger cars and light commercial vehicles (European Union 2019). Both are fully binding and directly applicable in all Member States. The final goal of the regulation is to achieve an emission limit of 0 g CO_2/km for new cars to reach the EU's climate-neutrality goal by 2050. The implementation is gradual, but manufacturers are already required to comply with the standards. Since 2020, the EU requires manufacturers' fleets of new cars to emit on average no more than 95 g CO_2/km, and new vans no more than 147 g CO_2/km (European Union 2019, Art. 1).

The EU Battery Regulation (Regulation (EU) 2023/1542) is designed to ensure that all batteries placed on the EU market are sustainable, circular, and ethically sourced. It directly affects the NEV industry. Batteries used in NEVs must be accompanied by a carbon footprint declaration (European Union 2023a, Art. 7). Companies are required to carry out supply chain due diligence for cobalt, lithium, nickel, and natural graphite, addressing both environmental and human rights risks. This information must be disclosed and verified by an independent third party. The provisions on supply chain due diligence for critical raw materials entered into application on 18 August 2025 (Arts. 48–52). Looking ahead, strict rules on recycling will also apply. From 18 August 2031, electric vehicles and industrial batteries sold in the EU must contain a minimum share of recycled raw materials in their active components — 16% cobalt, 85% lead, 6% lithium, and 6% nickel (European Union 2023a, Art. 8). Starting from 18 February 2027, all batteries placed on the EU market must carry a QR code giving access to a digital battery passport, which contains key information on the battery's composition, origin, and sustainability performance, in accordance with Article 77 (European Union 2023a, Art. 13).

Another EU legislative act that has a significant impact on non-EU automotive manufacturers such as BYD and Hyundai is the Carbon Border Adjustment Mechanism (CBAM, Regulation (EU) 2023/956). It introduces a carbon pricing system for imports of carbon-intensive materials. The objective is to harmonise carbon cost burdens between European Union manufacturers and external producers, mitigate carbon leakage, and promote low-emission production on a global scale (European Union 2023b). CBAM is still in its transitional phase but is already shaping corporate strategy for any company importing carbon-intensive materials into the EU. Starting from 2026, importers will have to purchase and surrender CBAM certificates reflecting the embedded CO_2 content of imported goods. The price will be linked to the EU Emissions Trading System (ETS) carbon price (European Union 2023b, Art. 6).

2.1.2. Remaining Challenges in EU Sustainability Governance

Even under the CSRD rules, auditing has become stricter, but ESG reporting remains largely self-reported, meaning that greenwashing can still occur (European Union 2022, Art. 34). In other words, not all environmental claims made by firms are independently verified and may therefore be unreliable or misleading.

Taking action against greenwashing is also one of the central narratives in EU environmental policy discussions. In this context, the Green Claims Directive was proposed by the European Commission in 2023 (European Commission 2023). At present, the future of this law remains uncertain. The latest update came on 25 June 2025, when the European Commission announced a possible withdrawal of the Green Claims Directive due to the complex, administratively burdensome, and costly requirements set out in the proposal, which were seen as hindering rather than supporting companies' sustainability transition efforts (European Parliament 2025, Latham & Watkins 2025).

However, there remains a binding Directive (EU) 2024/825 on empowering consumers for the green transition through better protection against unfair practices and improved information, which all EU Member States must transpose into national law by March 2026. The Directive directly targets greenwashing and misleading environmental claims in consumer communication, requiring companies to provide verifiable and evidence-based information about the environmental performance of their products (European Union 2024b).

Moreover, all the laws mentioned above are being implemented gradually, and EU sustainability legislation, including the CSRD, is currently in a transitional phase. This means that the available ESG data should be used for academic analysis with caution. In addition to ESG reports, third-party assurance observations will also be taken into consideration in this section to identify any known cases of violations.

Taken together, these instruments establish sustainability, traceability, and due diligence as binding market-entry conditions for NEV manufacturers operating in the EU. The following subsections assess how BYD and Hyundai currently align with, or fall short of, these requirements.

2.1.3. BYD

2.1.3.1. ESG Performance Analysis through Sustainability Report

The most recent BYD Sustainability Report from 2024 follows the HKEX (Hong Kong Exchanges and Clearing Limited) ESG Reporting Code and the SZSE (Shenzhen Stock Exchange) Guidelines, while also partially referencing other international reporting standards, including the ESRS. It covers BYD Company Limited and its subsidiaries (BYD Company Limited 2024, 2).

The report highlights the company's philosophy and key achievements, particularly its promotion of decarbonisation, advanced innovations for sustainable development, equal opportunities for employees, active cooperation with stakeholders, fulfilment of social responsibilities, adherence to high ethical standards, and contributions to global environmental protection (BYD Company Limited 2024, 17). Various ecological and social projects around the world are presented, including educational initiatives (BYD Company Limited 2024, 19–20). The report also provides an overview of BYD's Sustainability Management system, established to achieve the company's sustainability goals (BYD Company Limited 2024, 23), and highlights the benefits of vertical integration (BYD Company Limited 2024, 17).

The current requirements under Regulation (EU) 2019/631 on CO_2 emission performance standards set average limits of no more than 95 g CO_2/km for new passenger cars and 147 g CO_2/km for new vans (European Union 2019, Art. 1). For BYD, these standards are relatively easy to meet, as most of its models available on the European market are fully electric, producing 0 g CO_2/km (BYD Auto Austria n.d.). The company's hybrid models emit approximately 26 g CO_2/km, as measured under WLTP standards (Auto-Data.net 2025). Since March 2022, BYD has completely ceased the production of internal combustion vehicles, focusing exclusively on battery-electric and plug-in hybrid models (Wang 2024b, 168). Additionally, the company is striving to achieve carbon neutrality across its entire value chain by 2045 by improving energy-saving technologies and optimising its energy mix. The report shows that BYD plans to reach 35% green electricity by 2025 and aims for a 50% overall carbon reduction by 2030 (BYD Company Limited 2024, 44). The company's own solar energy and energy storage technologies provide it with an advantage in achieving this goal (BYD Company Limited 2024, 51). Energy-saving projects are mentioned for the factories in Taizhou and Huizhou (BYD Company Limited 2024, 45). BYD also reports compliance of its manufacturing processes with environmental protection laws and manages not only gas emissions but also other types of hazardous waste (BYD Company Limited 2024, 55).

The company's environmental impact is also reflected in the development and sale of not only private cars but also rail vehicles, buses, cleaning trucks, port tractors, slag trucks, and mixer trucks for urban construction, operating across city roads, logistics, public transportation, sanitation, ports, and airports (BYD Company Limited 2024, 46).

BYD also reports on its pilot project for a "Battery Passport" in cooperation with the Global Battery Alliance (GBA) (BYD Company Limited 2024, 50), which aligns closely with the EU Battery Regulation (European Union 2023a, Arts. 77–79) and can be seen as good preparation for meeting the EU requirements that will come into force in 2027.

The circular economy is also highlighted in the Sustainability Report (BYD Company Limited 2024, 59). All BYD models demonstrate reusability rates of 86–88% and recyclability rates of 97–98% (BYD Company Limited 2024, 60). BYD is also actively involved in battery recycling and has already established two recycling facilities that have processed over 10,000 tons of power batteries (BYD Company Limited 2024, 62).

By integrating various standards and systems related to quality management, occupational health, environmental safety, and social responsibility, BYD has developed a comprehensive code of conduct and human resources management framework. The company adheres strictly to the principles of equal opportunity and merit-based recruitment, ensuring non-discrimination based on nationality, race, gender, or religion. It also strictly prohibits forced labour, human trafficking, child labour, and any other practices that violate human rights (BYD Company Limited 2024, 92). The report shows that among 968,000 employees worldwide, there were no recorded incidents of employee discrimination (BYD Company Limited 2024, 94).

BYD promotes employee wellbeing through a comprehensive benefits system that combines financial and social support. It offers activity and medical funds, childcare and education assistance, subsidised housing, dormitories, canteens, and zero down-payment car purchase schemes. Employees receive full statutory leave entitlements, with additional family-friendly measures such as breastfeeding rooms. The company also provides extensive shuttle-bus transport across 30 industrial parks and operates the BYD School for employees' children. These measures reflect BYD's commitment to fair compensation, work–life balance, and a people-centred corporate culture (BYD Company Limited 2024, 99–100).

BYD's comprehensive internal policies are designed to ensure that suppliers comply with laws and regulations concerning environmental protection, social responsibility, and corporate governance, thereby minimising risks within the supply chain. All suppliers are required to sign the Code of Conduct for BYD Suppliers and the BYD Supplier Anti-Commercial Bribery Commitment, and to complete the Corporate Social Responsibility Survey. Moreover, BYD sets supplier audit frameworks, with particular emphasis on key raw-material audit for 3TG conflict minerals (tantalum, tin, tungsten, and gold) (BYD Company Limited 2024, 109). The BYD Supply Chain ESG Management Regulations set out supplier requirements in areas such as labour standards, occupational health and safety, environmental management, and related practices (BYD Company Limited 2024, 111).

2.1.3.2. ESG Compliance with CSRD and ESRS Standards

BYD has a European subsidiary, BYD Europe B.V., headquartered in the Netherlands, with its first European manufacturing facility located in Hungary (BYD Europe n.d.a). This indicates that BYD's EU operations fall within the scope of the CSRD and meet the applicable size thresholds (more than 250 employees, more than €40 million in turnover, or more than €20 million in total assets). Therefore, BYD Europe B.V. will be required to publish its first ESG disclosures in accordance with ESRS standards for the 2025 financial year (reporting in 2026). According to BYD Europe B.V.'s most recent filed financial statements, the company is actively preparing to comply with the CSRD, including the engagement of an external advisor (Kamer van Koophandel 2025, 8).

The current Sustainability Report already aligns with several ESRS standards; however, some aspects — particularly those related to negative impacts — are still in preparation and are planned to be reported in the coming years (BYD Company Limited 2024, 140–143).

The report includes a section on double materiality, as required by the ESRS (BYD Company Limited 2024, 25). This topic is one of the main distinctions between the ESRS and HKEX frameworks (European Financial Reporting Advisory Group 2023, ESRS 1 §§ 37–39; Hong Kong Exchanges and Clearing Limited 2022, Part A § 11(1)). BYD correctly distinguishes between impact and financial perspectives and describes a four-step assessment process that broadly follows ESRS 2 IRO-1 (European Financial Reporting Advisory Group 2023, ESRS 2 §§ 51–52). The company identifies 34 impact factors and 33 risk and opportunity factors, showing awareness of the value-chain breadth (European Financial Reporting Advisory Group 2023, ESRS 1 §§ 39, 43, 47–48).

However, the analysis remains mostly qualitative and lacks evidence of the quantitative thresholds required by ESRS 1 § 42. Input on financial materiality is limited to internal managers and a few experts, and the results are not mapped to topical ESRS datapoints (European Financial Reporting Advisory Group 2023, ESRS 2). Overall, BYD outlines a double materiality process but does not yet meet CSRD-level depth or consistency.

The report does not demonstrate digital reporting readiness and is available only in PDF format on the company website. There is no statement confirming that the sustainability disclosures were prepared in XHTML/ESEF format or tagged according to the ESRS XBRL taxonomy, as required under the CSRD (Bergthaler and Espinosa 2024). This poses a challenge for the future. The current assurance by SGS is narrow and qualitative. It covers only group-level data and does not verify data traceability or compliance with the updated HKEX climate requirements. Under the CSRD, however, sustainability statements must undergo statutory, ESRS-based assurance with verified traceability and full compliance checks — meaning BYD's current assurance process would require substantial reinforcement (BYD Company Limited 2024, 152; European Union 2022, Art. 26).

Supply chain due diligence still leans toward 3TG. BYD describes mechanisms in line with OECD Guidance, but its concrete questionnaire and audits focus on tantalum, tin, tungsten, and gold. The EU Battery Regulation due diligence revolves around cobalt, lithium, nickel, and natural graphite; that alignment is not yet evidenced in the same detail (European Union 2023a, Art. 48). Moreover, the KPI sections present the percentage of human rights assessments only for Tier 1 suppliers providing key vehicle components, without mentioning any actions related to human rights protection for Tier 2 and Tier 3 suppliers involved in the mining and refining of critical raw materials (BYD Company Limited 2024, 132). The ESRS framework obliges undertakings to disclose sustainability information covering the entire upstream and downstream value chain (European Financial Reporting Advisory Group 2023, ESRS 1 §§ 31–33; ESRS 2 § 49–56).

Therefore, BYD's ESG reporting provides a useful yet provisional basis for assessing the company's sustainability performance. It demonstrates intent and progress — such as the development of product carbon footprints and participation in the GBA Passport pilot — but still falls short of the disclosure depth and control mechanisms required under the ESRS. Accordingly, the report should be used with caution and complemented by EU-specific data and filings once the CSRD reporting obligations apply to BYD's European operations.

2.1.3.3. Scholarly Perspectives and External Assessments of BYD's ESG Performance

Since it is impossible to rely solely on the official ESG report, this analysis next verifies whether any violations have been recorded by independent organisations or scholars.

In general, scholars who have analysed BYD's ESG performance in case studies widely acknowledge the importance of ESG factors. According to Fu and Wu (2023), BYD's ESG management significantly enhanced its crisis resilience during the Wuhan lockdown, leading to higher cumulative returns compared to peers (103). Du (2025) and Zhang et al. (2025) also emphasise the positive impact of ESG performance on financial outcomes. Zhang (2024) reports a significant reduction in emission intensity, with emission intensity decreasing from 0.265 to 0.190 tonnes per CNY 10,000 of revenue between 2020 and 2022 (173).

Other scholars, such as Wang (2024b) and Zhang (2024), point out the inadequacy of ESG disclosure practices in China. Although BYD began voluntary ESG reporting in 2010, unified and standardised corporate disclosure guidelines were introduced in China only in 2024 and remain relatively underdeveloped (Wang 2024b, 167–168; Zhang 2024, 2). Scholars argue that ESG disclosures are selective and that companies, including BYD, tend to omit negative information (Wang 2024b, 169; Zhang 2024, 5). In his research, Wang lists several environmental incidents caused by BYD in China that were reported by local authorities but never acknowledged by the company itself (Wang 2024b, 169). BYD, along with other NEV manufacturers, has also been criticised by Amnesty International (2024a, 2024b) and Human Rights Watch (2024). Moreover, the Brazilian Public Labour Prosecutor’s Office investigated an incident involving alleged slave-like working conditions during the construction of a BYD plant in Brazil (Makortoff 2024). These issues will be examined in the next subsections.

2.1.3.3.1. Upstream

According to the sustainability report, BYD has introduced a carbon reduction plan, mandating that all suppliers embed carbon management requirements across their lifecycle processes (BYD Company Limited 2024, 45). While BYD claims oversight of Tier 1 suppliers and the possibility of removing non-compliant partners, no concrete evidence is provided of due diligence measures extending to lower tiers or remediation processes for identified harms (Amnesty International 2024b, 32; BYD Company Limited 2024, 132). According to Greenpeace East Asia, BYD also fails to disclose any supplier-related climate governance, including renewable electricity targets or supplier carbon-reduction commitments (Bao, Li, and Zhang 2025, 29).

Amnesty International also notes the absence of clear policies on battery material sourcing (2024b, 31). Human rights violations and environmental risks associated with the mining of minerals used in the NEV industry represent serious issues that require attention. BYD lacks transparency because it does not disclose information about its suppliers’ smelting, refining, or mining sites. The report makes no reference to Indigenous Peoples’ rights (Amnesty International 2024a). Therefore, BYD discloses limited information on mitigating human rights risks in its battery supply chain. The company scored only 11 out of 90 points in Amnesty International’s 2024 evaluation, ranking last among the 13 examined NEV manufacturers (Amnesty International 2024b, 33).

Human Rights Watch has also expressed dissatisfaction with BYD’s performance, warning that the aluminium supply chain used in car production may be linked to forced labour in China’s Xinjiang Uyghur Autonomous Region, a region in northwest China known for the government’s ongoing repression of Uyghurs and other Turkic Muslim groups. Even though independent field research on labour transfers in Xinjiang is currently not feasible due to strict government restrictions across China and within the region, Human Rights Watch analysed available source materials and continues to insist on the existence of links between Xinjiang’s aluminium industry and labour transfer practices. Moreover, once an aluminium ingot has been melted and combined with other materials, it becomes impossible to trace whether or to what extent it originated from Xinjiang — allowing potentially tainted aluminium to enter domestic and global supply chains unnoticed. In July 2023, Human Rights Watch asked several NEV manufacturers to provide information about their aluminium supply chains and the measures they were taking to eliminate exposure to forced labour in Xinjiang. BYD was among the companies that did not respond to the request (Human Rights Watch 2024).

The Business & Human Rights Resource Centre (2025) has accused BYD of failing to respond to allegations of environmental abuses related to nickel mining activities in Indonesia. Similarly, the AEER (Aksi Ekologi & Emansipasi Rakyat) (2024, 15) draws attention to the limited environmental protection within Indonesia’s nickel industry, demonstrating a link between BYD and Huayou Indonesia through battery-cell partners, alongside elevated ESG risk — despite BYD’s heavy use of LFP chemistry (low nickel) in most models (BYD Europe 2025b). BYD’s battery portfolio is overwhelmingly dominated by LFP chemistry, which accounted for 99% of BYD’s global output in 2023 (Bao, Li, and Zhang 2025, 34).

2.1.3.3.2. Midstream

Wang identified ten cases of environmental incidents at BYD plants in China between 2011 and , which were omitted from the company’s ESG reports. These incidents involved manufacturing sites in Changsha, Xi’an, Tianjin, and Shenzhen, and included cases of excessive emissions and water pollution (Wang 2024b, 169).

Among the incidents mentioned above, the most recent occurred in Changsha in the spring 2022, when local residents gathered in front of the factory gates to protest a strong paint-like odour, which residents claimed was affecting their health. The issue also gained attention online. Following mass complaints and local demonstrations, the Changsha city government announced an official investigation into BYD’s emissions (Changsha Ecology and Environment Bureau 2022). BYD publicly denied the allegations, stating that its emissions complied with national regulations, but pledged to take measures to address the odour problem

(BYD Auto 2022). The BYD Changsha plant reportedly suspended production for rectification work, with management promising a complete reform and expedited corrective actions (Yang 2022).

Another significant incident occurred in 2024 during the construction of BYD's plant in Brazil. The Brazilian Federal Labour Prosecutor's Office identified 163 Chinese workers living and working in conditions classified under Brazilian law as "analogous to slavery". Inspectors reported overcrowded and unsanitary housing, excessive working hours, and the confiscation of passports (Ministério Público do Trabalho 2024). BYD stated that the violations were linked to the contractors, announced the suspension of cooperation with them, and pledged to assist the investigation. The affected workers were to be relocated to a hotel (Makortoff 2024). After some delays, the plant was officially opened on 9 October 2025, thereby becoming BYD's largest factory outside China (Rocha 2025).

2.1.4. Hyundai Motor Company

2.1.4.1. ESG Performance Analysis through Sustainability Report

As of 7 November 2025, Hyundai has published its reports for 2024 and 2025. The analysis above refers to the BYD Sustainability Report 2024, as the BYD Sustainability Report 2025 has not yet been released. To ensure consistency in comparison, the discussion here will primarily focus on the Hyundai Sustainability Report 2024, while the updates introduced in the 2025 report will be mentioned at the end.

The Sustainability Report begins with a brief overview of the company's sustainability governance and key achievements across environmental, social, and governance dimensions, highlighting international acknowledgement of its sustainable practices (HMC 2024a, 10). Hyundai has been highly recognised by S&P Global for its sustainability practices, achieving a score of 75 out of 100 and ranking within the top 1% of the global automobile industry (HMC 2024a, 11; S&P Global 2024). The report then proceeds with a section on double materiality analysis (HMC 2024a, 14–16).

It is important to note that Hyundai does not produce only electric vehicles; total sales figures show that NEVs account for 16.5% of its sales, meaning that the majority of its cars are still ICE vehicles (HMC 2024a, 6). However, the company has announced plans to transition to a fully electrified portfolio. In Europe, this transition is expected to be completed by 2035. At present, Hyundai does not yet produce all-electric buses or heavy-duty trucks, but these models are planned for release by 2028 (HMC 2024a, 17, 25). Consequently, Hyundai is also improving its ICE vehicles to further minimise gas emissions. The company must comply with fleet-average CO_2 emission requirements, which are set at 95 g CO_2/km according to European law (European Union 2019, Art. 1; HMC 2024a, 27). For example, the Kona models show that the ICE versions emit between 135 and 141 g CO_2/km, and the HEV version emits 108 g CO_2/km (Hyundai Motor UK 2024, 3). The goal is for NEVs to account for 30% of Hyundai's total European sales by 2026, which should help the company meet fleet average CO_2/km standards (HMC 2024a, 26).

In addition to its transition to NEVs, Hyundai has joined the RE100 global decarbonisation initiative and plans to use 100% renewable electricity worldwide by 2045. This goal has already been achieved at its European production facility in the Czech Republic (HMC 2024a, 24). The ESG report shows emission reductions and energy-saving activities at major plants in Asan, Jeonju, Beijing, Mexico etc. (HMC 2024a, 23).

Hyundai is also investing heavily in hydrogen fuel-cell systems as part of its "multi-pathway" decarbonisation approach. Hyundai Motor Group has been an active member of the Hydrogen Council since its launch at the World Economic Forum, highlighting the company's commitment to hydrogen as a central pillar of global energy transition (HMC 2024a, 11). In addition to its leadership role in the Hydrogen Council, Hyundai Motor Company is also developing clean hydrogen production projects based on organic waste (HMC 2024a, 40).

Hyundai Motor Company has developed a comprehensive circular economy framework centred on the entire battery life cycle. Together with Hyundai Glovis and Hyundai Mobis, the company established a virtuous battery circulation system that covers the recovery, diagnosis, reuse, remanufacturing, and recycling of second-life EV batteries. This approach reduces dependence on virgin materials and supports compliance with the EU Battery Regulation requirements for recycled content, supply chain due diligence, and the forthcoming Digital Battery Passport (HMC 2024a, 41). However, according to the latest available report, the system remains in a phased implementation stage. Recycling volumes are not clearly disclosed, and no external verification is provided; therefore, full compliance with EU regulatory requirements is still under development (Hyundai Glovis 2024, 9). Other ecologically related activities noted in Hyundai's Sustainability Report are related to biodiversity and the management of other hazardous chemicals (HMC 2024a, 44–48).

The Sustainability Report also gives significant attention to social issues, highlighting human rights and human resources management (HMC 2024a, 56). This section covers programmes that promote diversity and prevent discrimination, as well as health, safety, and welfare initiatives within the corporation, and attention to human rights issues throughout the entire supply chain (HMC 2024a, 57–63).

In 2023, Hyundai Motor Company maintained a comprehensive global network of Tier 1 suppliers and began expanding visibility into Tier 2 and lower-tier partners. The company prioritised key suppliers that represent the majority of its procurement value and initiated broader mapping of critical sub-suppliers, reflecting a gradual shift toward deeper supply chain transparency and sustainability management (HMC 2024a, 66). Hyundai enhanced its supply chain due diligence by screening Tier 1 suppliers for risks such as forced labour through external databases and initiating a pilot program to map and assess high-risk suppliers. The company plans to extend this approach to key upstream materials, including aluminium, batteries, steel, tyres, and polysilicon, aiming for broader risk visibility across its global value chain. Hyundai conducts on-site audits of suppliers identified as high-risk based on location, business type, and prior assessment results. Hyundai has established a phased plan to expand supply chain mapping from direct (Tier 1) suppliers to deeper tiers (HMC 2024a, 67).

Hyundai has established a comprehensive framework for responsible minerals management based on the OECD Due Diligence Guidance. The status of suppliers using tin, tantalum, tungsten, gold, and cobalt is currently under review. In 2024, Hyundai conducted on-site visits to cobalt and copper mines in the Democratic Republic of the Congo to assess sustainability, labour, and safety conditions, marking a shift in the company's approach from desk-based verification to field-level inspection (HMC 2024a, 70).

2.1.4.2. ESG Compliance with CSRD and ESRS Standards

Hyundai operates several major EU subsidiaries, including Hyundai Motor Europe GmbH (HME) in Offenbach, Germany, and Hyundai Motor Manufacturing Czech (HMMC). HME alone reports 258 employees and approximately €2.4 billion in revenue, bringing it within the scope of the CSRD (HME n.d.f).

This section analyses the compliance of Hyundai's 2024 Sustainability Report with the ESRS and examines whether any improvements have been made in the 2025 report.

Both reports are prepared in accordance with GRI standards and are designed to align with the ESRS (HMC 2024a, 124, 2025a, 144).

Hyundai's sustainability reports already map disclosures to multiple ESRS topical standards, while acknowledging a phased approach to fuller value-chain coverage and assurance. The reports include an explicit double materiality assessment that separates impact materiality from financial risks and opportunities and describes a multi-step process for topic selection, IRO identification, quantification, prioritisation, and integration with ERM — drawing directly on ESRS guidance and expanding the topic universe from the prior year. In 2024 Hyundai identified 27 impact issues and 25 risk and opportunity issues; in 2025 it reports 40 impact issues and 41 risk and opportunity issues and adds health and safety for own and value-chain workers among impact topics, signaling broader ESRS readiness (HMC 2024a, 14–17, 2025a, 14–18). Hyundai's double materiality analysis is described and partially quantified, but it remains largely qualitative against ESRS 1 §42 (European Financial Reporting Advisory Group (EFPAG) 2023, ESRS 2). The 2025 report states that thresholds were set for IRO scoring, yet neither year discloses clear quantitative cut-offs per topic or evidence of the numeric materiality thresholds the ESRS expects (EFPAG 2023, ESRS 2 App. B AR 16–17). The assessment relies mainly on internal evaluators, with 2025 adding interviews and surveys involving external experts and selected suppliers, but the sample and weighting are not detailed (HMC 2024a, 14–17, 2025a, 14–18). Overall, Hyundai outlines an ESRS-inspired process and shows progress year-on-year, but it still falls short of full CSRD- and ESRS-level depth, quantification, and value-chain verification.

Hyundai's 2024 and 2025 Sustainability Reports are still presented exclusively in PDF format on corporate and regional websites, without evidence of digital tagging or structured electronic reporting. Neither report includes a statement that disclosures were prepared in XHTML/ESEF format or tagged according to the ESRS XBRL taxonomy, as will be required for CSRD-compliant filings (Bergthaler and Espinosa 2024).

Hyundai's current due diligence focus still skews toward 3TG and cobalt, with only recent, partial expansion to other critical battery minerals. The 2024 report operationalises OECD processes mainly for tin, tantalum, tungsten, gold, and cobalt, including DRC site visits (HMC 2024a, 70). While Hyundai recognises EU Battery Regulation demands and outlines preparations, these are framed as plans and systems-building rather than complete alignment. In 2025, Hyundai broadens its perimeter — adding nickel, lithium, and natural graphite to the high-priority list and introducing a phased roadmap with further expansion slated for 2026 — yet this evidence remains still under development, not full coverage (HMC 2025a, 78).

Depth beyond Tier 1 remains limited in disclosure and assurance. Hyundai reports comprehensive Tier 1 screening and audits, but KPI tables show few high-risk identifications at key Tier 2 and a stronger emphasis on Tier 1 corrective actions; this suggests less mature visibility and action tracking in deeper tiers where mining and refining risks concentrate. In both 2024 and 2025, the assurance scope explicitly excludes suppliers' practices, meaning upstream social and environmental data that ESRS expects across the value chain are not independently verified (HMC 2024a, 2025a, 138).

Therefore, Hyundai is advancing from a 3TG and cobalt core toward EU-relevant critical minerals, and from Tier 1 control toward Tier N mapping, but full, assured traceability and human-rights controls across nickel, lithium, and graphite chains are not yet demonstrated at the level ultimately required by the CSRD, ESRS, and the EU Battery Regulation.

2.1.4.3. Scholarly Perspectives and External Assessments of Hyundai's ESG Performance

Since it is impossible to rely solely on the official ESG report, the next step is to verify whether any violations have been recorded by independent organisations or scholars.

Unfortunately, Hyundai has not been a common subject of case studies among scholars researching the NEV industry. Lee Ki-Hoon analysed Hyundai Motor Company in two works — one co-authored with Cheong In-Mo in 2011 and another published as a book chapter in 2013. The findings of both studies indicate that all Tier 1 suppliers of Hyundai Motor Company are required to obtain ISO 14001 certification (Lee 2013, 1099; Lee and Cheong 2011, 968). However, this is a basic environmental requirement and is insufficient to meet ESRS standards (SGS n.d.). Paudel (2025) reviewed Hyundai's sustainability reports from 2022 to 2024 in his study on corporate sustainability implementation in the Asian automotive industry. However, the paper is currently a preprint only and has not yet undergone peer review. According to his analysis, Hyundai's ESG performance appears relatively strong and mature, particularly in the areas of governance and disclosure, and is fully compliant with international GRI standards. The author assigns Hyundai consistently high scores — always above 4 out of 5 — but the evaluation is based on a self-constructed metric derived from content analysis rather than external data sources, and European frameworks are not taken into consideration in the analysis.

Hyundai was ranked as the third worst NEV manufacturer by Amnesty International in terms of addressing human rights issues. The company was also among those that did not respond to the allegations raised in the report (Amnesty International 2024b, 8). The same applies to the Business & Human Rights Resource Centre (BHRRC 2023), which requested clarification regarding Hyundai's possible links to alleged abuses in the Uyghur region.

Moreover, Hyundai makes extensive use of batteries with a high nickel content (Kane 2021). International organisations and NGOs such as Fair Finance Asia and Profundo (2024, 2025), the Business & Human Rights Resource Centre (2024), and Deutsche Gesellschaft für Internationale Zusammenarbeit [German Corporation for International Cooperation] (GIZ) (2022) identify Hyundai Motor Group as being integrated into Indonesia's nickel-based EV value chain — a connection that is considered both plausible and high-risk.

Additionally, there are ongoing disputes involving Hyundai and government bodies in both the United States and South Korea (Kyunghyang Shinmun 2025; MINBYUN 2024; U.S. Department of Labor 2024).

2.1.4.3.1. Upstream

In its report, Amnesty International criticises Hyundai for the lack of traceability regarding information on smelters, refiners, and mine sites. It also highlights that while the company pays attention to cobalt, it omits disclosure and due diligence measures for copper, lithium, and nickel. Hyundai refers to third-party audits, yet there is no evidence of consistent evaluation of these schemes or of additional actions being taken when deficiencies are identified (Amnesty International 2024b, 44). Indigenous Peoples' rights are not addressed in Hyundai's policy documents (Amnesty International 2024b, 43). The company scored only 21 out of 90 points in Amnesty International's 2024 evaluation, ranking third from the bottom among 13 examined NEV manufacturers (Amnesty International 2024b, 45).

In fact, Hyundai shows some improvement in its 2025 Sustainability Report. For example, unlike previous reports that omitted the issue entirely, the new report acknowledges the nickel problem and outlines plans to reduce the nickel content in its batteries. However, it still provides very few details regarding the specific mining sites involved (HMC 2025a).

Indonesian nickel production is widely recognised as environmentally and socially high-risk. A study by Fair Finance Asia and Profundo (2024, 19) shows that mining and smelting activities in Indonesian hubs cause deforestation, pollution, labour abuses, and high coal-based emissions. The BHRRC (2024, 8–15) documents similar impacts on small islands, linking these operations to global EV supply chains. The GIZ (2022, 40–46) report confirms that Indonesia's nickel processing is among the most carbon-intensive globally and calls for stronger environmental governance and due diligence measures. Hyundai's Karawang battery cell plant — a joint venture with LG Energy Solution, as noted by GIZ (2022, 31) — offers supply security and regional integration but also embeds the company in Indonesia's nickel-dependent value chain. While this investment can enhance resilience and innovation, it also inherits the upstream ESG and climate risks of Indonesian nickel, making transparency and verified responsible sourcing essential to its credibility.

Moreover, there is a substantiated risk of Hyundai Motor Group's exposure to forced labour in Xinjiang through its lead-acid battery supply chain — a concern the company has not fully addressed. Independent investigations by Sheffield Hallam University found that Camel Group, a battery manufacturer operating in Xinjiang and involved in state-run labour transfer programmes, publicly listed Hyundai and Kia among its customers (Sheffield Hallam University 2022).

2.1.4.3.2. Midstream

In May 2024, the U.S. Department of Labor filed a complaint against Hyundai Motor Manufacturing Alabama LLC for employing a 13-year-old child on an assembly line, in violation of the Fair Labor Standards Act. The case establishes joint liability across the supply chain, showing that Hyundai cannot evade responsibility for labour violations through subcontracting. It highlights systemic weaknesses in Hyundai's due diligence and governance practices (U.S. Department of Labor 2024).

In October 2025, South Korea's Supreme Court ruled that Hyundai Motor's long-term use of subcontracted drivers at its Namyang R&D centre constituted illegal dispatch, as the workers were effectively under Hyundai's direct control and should be recognised as its employees (Kyunghyang Shinmun 2025). The civic lawyers' group MINBYUN [Lawyers for a Democratic Society] welcomed the ruling, stating that major manufacturers cannot evade labour-law obligations through disguised subcontracting and urging Hyundai to reform its employment structure (MINBYUN 2025). The case highlights continuing weaknesses in Hyundai's labour governance and due diligence practices, complementing international findings of broader ESG risks across its value chain.

2.1.5. Comparative Assessment of BYD and Hyundai

A comparative assessment shows two contrasting ESG profiles. BYD, as a pure play NEV producer with no ICE output since 2022, is structurally better positioned to meet EU CO_2 and electrification targets and highlights vertical integration, recycling, and Battery Passport pilots. It pursues decarbonisation mainly through self-initiated internal programmes, focusing on renewable energy use and supply chain control. However, its ESRS alignment remains partial, assurance narrow, upstream transparency weak (especially on critical minerals), and several environmental and labour concerns have been documented externally but not fully acknowledged.

Hyundai, by contrast, combines a slower transition from ICE with a more developed governance and reporting architecture: its sustainability reports are systematically mapped to GRI and ESRS concepts, double materiality and responsible minerals frameworks, and show incremental expansion of due diligence and Tier N mapping. It advances decarbonisation through participation in the international RE100 initiative, signalling stronger global coordination but also greater public scrutiny. Yet it also falls short of CSRD-level depth and assurance, and faces serious allegations regarding child labour, illegal labour dispatch, Xinjiang exposure and high-risk Indonesian nickel.

Overall, both companies make visible progress but neither currently delivers fully CSRD and ESRS-consistent, value-chain-wide, independently assured ESG performance, underscoring the need for cautious interpretation of corporate reporting and reliance on external evidence.

2.2. Innovation and Competitiveness

2.2.1. European Market Competition Framework

Applying the framework developed in Section 1.3.2.2, the following empirical analysis contextualises innovation patterns within the European NEV market. As discussed earlier, Europe — one of the most regulated and competitive automotive markets in the world — provides a unique environment to examine how global NEV manufacturers deploy innovation to achieve both regulatory compliance and market growth. The region has moved beyond the early adoption phase but has not yet reached full market saturation (with NEVs accounting for around 25% of new registrations), making it a crucial testing ground for various types of innovation in electrification, battery performance, and charging infrastructure (IEA 2024). For the classification of innovations, this thesis adopts Chen and Chen's (2023, 5) framework, in which incremental innovation supports market penetration, disruptive innovation aligns with market development, architectural innovation corresponds to product development, and radical innovation is best suited for diversification.

To illustrate how innovation translates into competitive positioning, the following analysis briefly compares the technical characteristics of the best-selling NEV models in Europe using standard configurations from the German market. According to the latest Europe EV Sales Report for September 2025 by CleanTechnica, which aggregates official registration statistics from EV-Volumes and JATO Dynamics across the EU-27, EFTA, and UK regions, the top five models sold in the European market were the Tesla Model Y, Tesla Model 3, BYD Seal U (BEV+PHEV), Škoda Elroq, and VW ID.3 (Pontes 2025). Volkswagen ranked as the best-selling brand in both August 2025 (Bekker 2025a) and the January–September 2025 period (Pontes 2025). Data from January to September 2025 show that the leading brands by market share were the German manufacturers Volkswagen (11.2%), BMW (8.8%), and Mercedes-Benz (6.9%). The U.S. brand Tesla ranked fourth with 6.3%, followed by Sweden's Volvo with 5.5% (Pontes 2025). The August figures differ slightly, with Volkswagen still in first place, followed by Tesla, BMW, Škoda, and Audi, while Hyundai ranked sixth and BYD ninth (Bekker 2025a). This shows that Volkswagen, despite not having any of the top three best-selling models, maintains its leading position in overall sales thanks to the consistent performance of several moderately successful models.

The following section examines the technical characteristics of the leading models on the market. The exact price may vary depending on the configuration. For this research, standard versions are used. Prices are referenced from the German market, which represents one of the largest NEV markets in Europe (Bekker 2025b).

The starting price of the standard Tesla Model Y in Germany is approximately €40,000. Its WLTP range is 534 km, with a top speed of 201 km/h and an acceleration of 0–100 km/h in 7.2 seconds. It is a fully electric BEV model with 0 g/km CO_2 emissions. The Supercharging power reaches up to 250 kW, allowing a charge from 10% to 80% in about 27 minutes using a Tesla Supercharger. The battery capacity is around 75 kWh. Standard features include a panoramic glass roof, advanced safety systems, and a spacious cargo capacity of up to 2,158 litres with the rear seats folded. The vehicle also comes equipped with Tesla Autopilot, while the Enhanced Autopilot — with motorway driving and parking automation — or the Full Self-Driving package with near-autonomous capabilities add €3,800 to €7,500 to the base price (Tesla n.d.b).

The second most popular model in September 2025 is the Tesla Model 3, which is slightly cheaper, starting at €38,570 on the German market. The WLTP range is similar. The Model 3 accelerates faster due to its lower weight, reaching 0–100 km/h in 6.1 seconds. Top speed, battery capacity, and charging speed are identical, but it has roughly one third of the cargo space, with only 682 litres. Autopilot options are also the same (Tesla n.d.c).

While Tesla does not publicly disclose the exact battery chemistry used in each trim level in Germany, industry and trade sources suggest that the base variant of the Model Y produced in Germany features a structural LFP battery pack supplied by BYD (Westerheide 2023). For the Model 3, sources indicate that Tesla uses an LFP pack supplied by CATL (EV Database n.d.a).

The third most popular model, which records its highest sales in the PHEV version, is the BYD Seal U (Pontes 2025). The starting price for the German market is approximately €40,000 for the basic version. The BYD SEAL U DM-i Boost is a plug-in hybrid SUV combining a 1.5-litre petrol engine with an electric motor, delivering a total system output of 160 kW and acceleration from 0 to 100 km/h in 8.9 seconds. It reaches a top speed of 180 km/h and achieves an electric-only WLTP range of around 70 km, or up to 110 km in urban driving. Powered by BYD's in-house Blade Battery based on lithium iron phosphate (LFP) chemistry, it offers enhanced thermal stability and safety with a capacity of 18.3 kWh. CO_2 emissions are as low as 22 g/km under the Euro 6e standard. Charging power reaches up to 50 kW (10–80% in about 35 minutes). The model features front-wheel drive, a panoramic roof and comprehensive driver-assistance systems including adaptive cruise control, lane-keeping, automatic emergency braking, and blind-spot detection. The cargo capacity is up to 1,440 litres with the seats folded (BYD n.d.d). According to CleanTechnica, the model is highly competitive, as comparable vehicles are significantly more expensive: the VW Tiguan PHEV starts at €52,000, the Kia Sportage PHEV at €45,000, and the outgoing Toyota RAV4 PHEV at €52,500 (Pontes 2025).

The two European models in the 2025 Top-5, the Volkswagen ID.3 and the Škoda Elroq, represent the Volkswagen Group's compact and affordable electric segment built on the same MEB modular platform. The entry-level VW ID.3 Pure is equipped with a 52 kWh usable battery providing a WLTP range of up to 428 km. It reaches a top speed of 160 km/h, accelerates from 0 to 100 km/h in about 8.2 seconds, and supports charging up to 120 kW DC (10–80% in approximately 30 minutes). The cargo volume is 385 litres, and CO_2 emissions are 0 g/km as a fully electric BEV. The Škoda Elroq, positioned as a slightly larger compact SUV, combines practicality with similar efficiency. Its smallest configuration offers a 55 kWh battery and a WLTP range of about 400 km, with 0–100 km/h acceleration in roughly 8 seconds and a top speed of 160 km/h. The boot capacity is 470 litres, expanding to 1,580 litres with the rear seats folded. Both models feature advanced driver-assistance systems and regenerative braking. Together they illustrate the Volkswagen Group's incremental innovation strategy — focusing on efficiency, affordability, and mass-market accessibility rather than premium performance (Škoda Auto n.d; Volkswagen n.d). The prices of both models are highly competitive, even when compared with their Chinese rivals (Pontes 2025). Both the VW ID.3 and the Škoda Elroq are powered by lithium-ion batteries based on NCM chemistry (Buckley 2024, Mertes 2024).

2.2.2. European Charging Infrastructure

Charging infrastructure is one of the crucial factors in the development of the European BEV and PHEV market. Many customers remain cautious about switching to electrification, as reliable charging options are still limited. According to a European Automobile Manufacturers' Association (ACEA) report, as of 2023, 61% of all EU chargers were concentrated in just three countries — the Netherlands, France, and Germany — while the remaining 39% were spread across the other 24 EU Member States (ACEA 2024, 10). ACEA also highlights that NEV sales have vastly outpaced the growth of public charging infrastructure in the EU (10). The Alternative Fuels Infrastructure Regulation (AFIR) mandates the installation of a total charging capacity of at least 150 kW every 60 km along the TEN-T core network by 2025, and 350 kW heavy-duty chargers by 2030, aiming to address the uneven distribution of charging points between Western and Eastern Europe (European Union 2023c). By the end of 2023, only around one in seven charging points across the EU supported fast charging (ACEA 2024, 10). According to gridX (2025, 3), the number of charging stations increased by 37% in 2024, but this growth remains far from sufficient to meet Europe's electrification targets. The share of fast chargers in the total number rose by only 2% from 2023 to 2024 (gridX 2025, 15).

Major automakers are taking part in developing charging infrastructure and even building alliances. The new Spark Alliance — a partnership between IONITY, Fastned, Electra, and Atlante — links about 1,700 stations and more than 11,000 charging points across 25 countries, supplying 100% renewable energy (Spark Alliance 2025). Within this alliance, IONITY is backed by BMW Group, Mercedes-Benz, Ford, Hyundai Motor Group, and Volkswagen Group, while Atlante is supported by Stellantis (Atlante 2025; IONITY, 2025). In parallel, Tesla's V3 and V4 Superchargers, operating at up to 250–350 kW per stall, remain widely available in Europe and are increasingly open to non-Tesla vehicles (Tesla n.d.a).

2.2.3. BYD

2.2.3.1. Midstream

One of the most crucial technologies in the NEV industry is the battery, as it determines many key factors such as driving range, performance, and safety. BYD began as a battery manufacturer and today stands out as one of the few NEV brands that produces its own batteries in-house. Its BYD Blade Battery is widely recognised as one of the safest in the industry (BYD n.d.c). This represents a form of architectural innovation, as it builds on existing lithium iron phosphate (LFP) technology. The structure of the cell was redesigned to optimise the spatial layout of the battery, thereby improving energy density and increasing driving range (Shi 2023, 193).

In general, LFP batteries are safer than ternary lithium (NCM) batteries. Among reported spontaneous combustion incidents involving new energy vehicles, around 60% were attributed to ternary lithium batteries, while only about 5% were linked to lithium iron phosphate batteries (Shi 2023, 195). The BYD Blade Battery demonstrates superior thermal stability compared to conventional NCM and LFP battery cells. In nail penetration safety tests, while NCM batteries ignited and reached temperatures above 500°C and standard LFP batteries emitted smoke at 200–400°C, the Blade Battery showed neither fire nor smoke, maintaining surface temperatures of only 30–50°C (Shi 2023, 194). The safety performance of BYD vehicles has also been assessed by the European New Car Assessment Programme (Euro NCAP). According to the EV Database (n.d.b), all BYD models tested have achieved a five-star safety rating. Other advantages of the BYD Blade Battery include a much longer cycle life compared to typical

NCM batteries, lower production costs, and independence from scarce and environmentally hazardous minerals such as nickel and cobalt (Shi 2023, 196).

LFP batteries also have several disadvantages, including greater weight, slower charging speed, and reduced performance in very cold weather (Parrott 2024). However, according to Shi (2023, 195), BYD has improved the cold resistance of its LFP batteries. The BYD Blade Battery retains at least 90% of its discharge capacity even at −20°C.

A table listing all BYD BEV models currently available on the European market has been compiled to provide a closer examination, with examples of rival models included for comparison (see Table 3 in Appendix B).

Overall, the evidence suggests that BYD vehicles offer price advantages in certain categories and maintain high safety standards but lag behind their Korean and European counterparts in charging speed. Even other Chinese brands, such as XPeng or Leapmotor, which also use LFP batteries sourced from different manufacturers, demonstrate significantly better charging performance. For instance, the XPeng G9 AWD Performance, a direct competitor to the BYD Tang, achieves a charging speed of 1,620 km/h (range added per hour) compared to the Tang's 400 km/h.

Another question is how significant this difference is in the European context, where suitable high-power charging stations are still largely unavailable to fully capitalise on this advantage (see Section 1.2.2).

However, BYD is continuing to improve its battery technology, announcing the Blade Battery 2.0, which offers an extended range of up to 690 km, enhanced temperature resistance, and ultra-fast charging capabilities — while remaining both safe and cost-efficient (V2Charge 2025).

Moreover, as mentioned in Section 2.2.1, BYD has significantly outperformed its competitors in the European market's PHEV category with its hybrid model, the BYD Seal U, which has become the best-selling PHEV in Europe.

In the field of radical innovation, since 2023 BYD has been developing sodium-ion batteries through a joint venture with Huaihai FinDreams Sodium Battery Technology (Xuzhou) Co. Ltd. (Krampf 2024), although these batteries have not yet reached the commercialisation stage (Chen 2026).

In general, BYD's innovations extend beyond battery technology to include software and various other fields. According to findings by Chinese scholars, the company invested CNY 20.22 billion in R&D in 2022, employed nearly 70,000 R&D staff, and accumulated over

39,000 patent applications worldwide — representing one of the most extensive proprietary technology portfolios in the global EV industry (Wang, Li, and Zhang 2024, 451–452).

2.2.3.2. Downstream

BYD also plans to participate in the development of Europe's charging infrastructure, marking a potential breakthrough in this sector. During the IAA Mobility 2025 showcase in Munich, Executive Vice President Stella Li confirmed the upcoming installation of BYD's Flash Charging network in Europe (BYD 2025b). The company aims to deploy ultra-fast charging stations by Q2 2026, each capable of delivering up to 1,000 kW of DC power through a single CCS cable — allowing an EV to gain approximately 400 km of range in just five minutes (Cortina 2025).

BYD's Flash Charging technology represents an incremental innovation, as it significantly improves charging speed and efficiency using existing lithium-ion technologies, high-voltage electronics, and enhanced BMS algorithms while retaining the same underlying battery chemistry. The deployment of megawatt-class chargers in Europe therefore aligns with a market-penetration strategy, consistent with Chen and Chen's (2023, 9) innovation matrix.

The charging speed — unprecedented at scale in the European context and more than twice as fast as Tesla's Superchargers — could help BYD establish itself as an industry leader on the continent. The network will be open to all brands. Even electric vehicles equipped with older batteries are expected to benefit from a 20–30% reduction in charging time compared to current solutions, thanks to advanced technological optimisation. The initial rollout will focus on major high-traffic, long-distance corridors, with BYD planning to install chargers both at its dealership locations and through partnerships with local infrastructure providers in key European markets, including Germany, Spain, Belgium, and France (Guibout 2025).

2.2.4. Hyundai

2.2.4.1. Midstream

Based on the comparative model table, Hyundai's innovation strategy focuses on architectural and incremental innovations around an 800-V high-performance platform combined with high-nickel NCM batteries. Hyundai leads in European market charging speeds (up to 1,150 km/h), WLTP efficiency, and performance acceleration due to its voltage architecture and thermal management systems (see Table 4 in Appendix B).

Hyundai relies on high-energy-density NCM batteries, which provide long driving range and strong performance in cold climates — an advantage for countries with lower temperatures. However, one of the main drawbacks of NCM batteries is their sensitivity to frequent full or deep discharges. Regularly charging them to 100% or allowing them to drop below a 10% state of charge may accelerate battery degradation, so they are typically operated between 20% and 80% capacity (Parrott 2024).

The company does not produce its own batteries but collaborates with other major Korean companies such as LG, SK On, and Samsung, which supply it with batteries, OLED display panels, and semiconductors (Lambrecht 2023). This cooperation has recently intensified, with the companies agreeing to jointly establish a new R&D centre aimed at strengthening South Korea's future competitiveness (Kan 2025).

Hyundai also demonstrates architectural innovation through its dedicated E-GMP platform (Chen and Chen 2023, 9). The platform's patented multi-voltage charging system supports both 400 V and 800 V fast charging without requiring additional hardware, as it utilises the motor and inverter as an integrated boost converter. Furthermore, Hyundai's Integrated Charging Control Unit (ICCU) unites onboard charging and DC-DC conversion functions, enabling Vehicle-to-Load (V2L) capability — allowing the vehicle to supply power to external devices or even charge another electric car (Hyundai Motor Group 2020).

Beyond its BEV-focused developments, Hyundai follows a distinct technological path through its long-term investment in another zero-emission NEV technology — fuel-cell electric vehicles (FCEVs) (HMC 2020a). Within the Chen and Chen (2023, 9) framework, this approach represents a form of radical innovation. Hyundai remains one of the few global automakers maintaining mass production of hydrogen passenger vehicles, positioning its new model NEXO as evidence of its global hydrogen mobility leadership (HMC 2025b). The greatest advantage of this model is that it can be refuelled in just five minutes and has a driving range of up to 826 km, while remaining environmentally friendly (HME n.d.e).

The technology is still not widely adopted in Europe. According to the European Hydrogen Observatory (2025), the total number of registered FCEVs in Europe by 2024 was 6,509. Experts also warn of a declining demand for FCEVs, particularly in the private vehicle segment. The main challenges for the European market include an extremely limited number of refuelling stations, high vehicle prices, and the high cost of hydrogen — especially green hydrogen. However, fleets, public transport, and logistics companies are seen as more promising segments for hydrogen adoption (eCarsTrade 2025). Hyundai is also advancing in this direction, with FCEVs already included in its portfolio of trucks and buses (HMC n.d.a).

2.2.4.2. Downstream

Hyundai Motor Group does not develop or operate a proprietary charging network in Europe. Instead, the company contributes to the expansion of high-power charging infrastructure through alliances with other companies. Hyundai is a key shareholder in the IONITY consortium, which builds 350-kW stations along pan-European transport corridors, and invests in its continued rollout together with BMW Group, Mercedes-Benz Group, Ford, Volkswagen Group (including Audi and Porsche), Kia, and BlackRock (IONITY n.d). Participation in IONITY also generates direct cost advantages for drivers of shareholder-brand vehicles. Brands offer discounted IONITY tariffs through their proprietary charging services, which can reduce fast charging prices by 40–60% compared to the standard retail rate (Hyundai Motor Europe n.d.c).

2.2.5. Comparative Assessment of BYD and Hyundai

The analysis shows that in the midstream stage, BYD benefits from full vertical integration and strong cost leadership through its in-house LFP Blade Battery, which offers exceptional thermal safety, long cycle life, and independence from nickel and cobalt, although it still lags behind Hyundai in charging performance. Hyundai, by contrast, relies on high-nickel NCM batteries supplied by Korea's major battery manufacturers and achieves market-leading charging speeds and strong cold-weather performance through its 800-V E-GMP platform.

In the first half of 2025, Hyundai and BYD showed similar performance in the European BEV segment, ranking 10th and 12th with 46,380 and 41,270 units sold, respectively (Bekker 2025c). However, by September 2025, BYD stood out with its PHEV model, the BYD Seal U, reaching third place on the European NEV sales podium (Pontes 2025).

In addition to BEVs and PHEVs, both companies are pursuing technology diversification through investments in radical innovation: for BYD, this involves sodium-ion batteries, while for Hyundai it focuses on hydrogen fuel-cell (FCEV) technology. Both remain far from mass deployment in Europe. BYD's sodium-ion batteries are not yet commercially available, and Hyundai's FCEVs have achieved limited success in the European private-vehicle market, although they show promising potential in commercial and logistics applications.

On the downstream level, BYD is preparing for a major breakthrough by implementing its own ultra-fast charging technology in Europe, although the network is still under construction and not yet operational. In comparison, Hyundai already benefits from its participation in the IONITY charging alliance, but it does not possess proprietary in-house charging technology.

2.3. Policy and Material Access

2.3.1. EU Purchase Incentives and Subsidy Landscape

As discussed in Section 1.2.5 of the literature review, national governments have provided significant benefits to automakers, which were particularly crucial in China. While these incentives offered a substantial boost during the initial development phase, their impact on the European market — the focus of this section — is only indirect.

As for Europe, financial support for NEVs remains highly fragmented and is largely shaped by Member States' measures rather than by a harmonised EU-level subsidy framework. ACEA reports that every EU Member State provides some form of tax benefit for NEV owners, while tax benefits for manufacturers are offered by 19 Member States. However, direct purchase incentives are being phased out in an increasing number of countries, with eight Member States no longer providing them. Support for charging-infrastructure deployment also remains uneven, with such measures available in only about half of the EU Member States. Overall, this shift reflects a gradual move away from purchase subsidies toward tax-based and structural incentives, signalling the continued maturation of the European NEV market. Moreover, the majority of these initiatives are provided regardless of the car's country of origin (ACEA 2025a). The only quasi-discriminatory mechanism is France's environmental scoring system, introduced in late 2024, which is formally origin-neutral but effectively disadvantages many China-produced EVs while favouring models assembled in Europe with lower-carbon battery supply chains (Agence de la transition écologique 2025).

Alongside consumer and car manufacturing incentives, the EU increasingly prioritises industrial R&D and localisation support. European Parliamentary Research Service (EPRS) highlights the importance of and support for the EV battery cell manufacturing in Europe, including battery materials research, cathode and anode innovation, sustainable recycling technologies, and gigafactory development (2025, 6-7). At present, the EU accounts for only 7% of global battery manufacturing, and just 15% of the battery production within the EU is carried out by firms headquartered in Europe (ACEA 2025b). Around 75% of European battery manufacturing capacity is controlled by Korean companies such as LG Energy Solution, Samsung SDI, and SK On (EPRS 2025, 7). Independent analyses confirm concerns that, despite the urgent need, a significant share of the European battery-manufacturing projects announced for 2030 faces delays or a risk of cancellation (Wicke, Weymann, and Neef 2025).

2.3.2. Access to Critical Raw Materials

The batteries such as LFP and NCM, which are currently the most widely used in the NEV industry, are all types of lithium-ion batteries. The most critical materials for their production include graphite for anodes and, depending on the specific chemistry, lithium, iron, and phosphorus for LFP, and lithium, nickel, manganese, and cobalt for NCM (EPRS 2025, 4). Battery cells account for up to 40% of the total value of an average electric vehicle (ACEA 2025b). Therefore, access to critical raw materials (CRMs) remains one of the defining structural constraints in the global NEV industry.

Extraction and processing are marked by extreme geographic concentration along the entire value chain. Lithium is mined primarily in Australia, China, and Chile. The largest share of global nickel reserves is located in Indonesia, while cobalt resources are concentrated in the Democratic Republic of Congo. China, in turn, accounts for almost all of the world's graphite production. The picture becomes even more asymmetric in the materials processing stage. Across lithium refining, nickel sulphate production, cobalt chemical processing, and spherical graphite preparation, China controls the overwhelming majority of global processing capacity, often exceeding 70–90% depending on the material. Over 80% of worldwide battery cell production capacity is concentrated in China (EPRS 2025, 4; International Council on Clean Transportation (ICCT) 2025a). This means that even when mining is geographically diversified, battery-grade materials almost always pass through China before reaching cell manufacturers. CRM access shapes not only production cost structures but also regulatory compliance capabilities and long-term competitiveness in all major NEV markets.

2.3.3. EU Tariffs, FTAs and Trade Remedies

Market access for NEVs in Europe is strongly conditioned by the EU's common external tariff and a growing layer of trade-defence measures. According to EU Regulation R1821/16 for passenger cars (HS 8703, which includes NEVs), the EU applies a standard 10% import duty to third-country producers. This baseline can be reduced or eliminated through free trade agreements (FTAs) (European Commission 2025b).

As a result of the anti-subsidy investigation into imports of new BEVs from China, the European Commission concluded that Chinese BEV imports benefit from unfair government subsidies and threaten the economic viability of the EU industry. On 29 October 2024, a new regulation was adopted imposing definitive countervailing duties on imports of BEVs intended for passenger transport originating from China. Chinese BEV imports are now subject to countervailing duties (CVDs) ranging from 17% to 45%, in addition to the standard 10% import duty (European Commission 2024).

Some non-Chinese brands have also been affected by these tariffs on models manufactured in China. For example, Tesla received a CVD rate of 7.8%, while BMW was assigned 20.7%. Both companies have joined the complaints against the European Commission's decision (Brzozowski 2025).

In April 2025, the WTO (World Trade Organization) established a dispute panel at China's request to review the EU's countervailing duties on Chinese battery-electric vehicles. China argues that the duties violate WTO subsidy rules, while the EU defends them as legitimate trade-remedy measures. The dispute remains ongoing with no panel decision yet (WTO 2025).

In the same month, the European Commission also signalled that it could accept replacing the CVDs with minimum-import-price commitments tailored to specific firms and vehicle categories, whereas China has pushed for a single industry-wide deal, likely intended to protect the state-owned SAIC. Yet the parties have not reached an agreement (Tagliapietra, Trasi, and Sebastian 2025).

Under the EU–South Korea Free Trade Agreement, the EU's 10% import tariff on passenger cars was removed. As a result, Korea-built vehicles that comply with the agreement's rules of origin now enter the EU at a 0% customs duty, giving Korean manufacturers full tariff-free access to the European market (European Union and Republic of Korea, 2011).

2.3.4. BYD

2.3.4.1. Upstream

BYD benefits from a structurally favourable upstream position due to its deep integration into China's dominant battery material and processing ecosystem. China controls the majority of global midstream refining for lithium and cobalt, a substantial share of nickel chemicals, and nearly all spherical graphite production, which ensures that BYD has reliable access to battery-grade materials at competitive cost levels (EPRS 2025, 4).

BYD's long-term partnerships with domestic Chinese suppliers (Tang 2025), combined with its in-house Blade Battery (LFP) technology and growing investment in sodium-ion batteries, further reduce dependence on high-cost, globally constrained materials like cobalt and nickel (BYD n.d.c). Its upstream security is strengthened by China's position as a leading processor of lithium and graphite (EPRS 2025, 4). As a result, BYD operates with lower exposure to global CRM price fluctuations and export-control risk compared with many European and Korean firms, which rely on diversified but weaker supply chains (see Tables 3 and 4 in Appendix B).

2.3.4.2. Downstream

In the downstream European market, BYD simultaneously benefits from consumer incentives and faces significant trade policy barriers.

Like all foreign manufacturers, BYD's vehicles are fully eligible for origin-neutral European purchase incentives and tax benefits, allowing consumers to claim subsidies in countries with relatively generous schemes such as Italy, Spain, Greece, Belgium, Austria, and Croatia (ACEA 2025a).

However, despite the start of its localisation strategy, including plans to build plants outside China (BYD Europe n.d.a), BYD's Europe-bound vehicles are still primarily assembled in China, placing the company at a structural disadvantage relative to Korean and European competitors. China-built BEVs face the standard 10% EU import tariff and, since October 2024, additional definitive countervailing duties arising from the EU anti-subsidy investigation into Chinese BEVs. Due to its cooperation with the investigation, BYD received the lowest tariff among the affected Chinese manufacturers, set at 17% (European Commission 2024).

In order to circumvent the CVDs, BYD has increased its exports of PHEV models to Europe, as only BEVs fall under the EU anti-subsidy measures (Westerheide 2025). This means that PHEVs are subject only to the standard 10% import tariff and not the additional 17% duty, which keeps these models highly competitive. This trend is clearly reflected in the September ranking, where BYD's Seal U PHEV reached third place among NEVs sold in Europe (Pontes 2025).

2.3.5. Hyundai

2.3.5.1. Upstream

Hyundai's upstream position is shaped primarily by its integration with South Korea's globally significant battery ecosystem, rather than direct control of mineral resources. Unlike Chinese manufacturers that increasingly secure mining stakes or long-term offtake agreements, Hyundai relies on partnerships with Korean cell suppliers — SK On, LG Energy Solution, and Samsung SDI — whose global networks provide access to lithium and nickel sourced from countries like Australia, Chile, and Indonesia (GIZ 2022, 31; Lambrecht 2023; LG Energy Solution 2021; Shin 2023). Despite this geographic diversification, the inputs used by these Korean battery manufacturers remain closely tied to China, which dominates the refining and conversion stages — accounting for more than 70% of global precursor cathode active material (PCAM) production and over 80% of graphite processing (IEA 2025c). This results in higher procurement costs and greater sensitivity to global CRM price volatility compared with vertically integrated Chinese competitors.

2.3.5.2. Downstream

Hyundai's downstream position in Europe is strengthened by the EU–South Korea Free Trade Agreement, under which the EU's standard import duty on passenger cars is eliminated. As a result, Hyundai vehicles enter the EU at a zero tariff rate, provided they meet the rules of origin (European Union and Republic of Korea 2011). This advantage allows the company to offer its EVs and PHEVs without border tariffs while remaining fully eligible for national consumer subsidies (ACEA 2025b).

2.3.6. Comparative Assessment of BYD and Hyundai

Overall, BYD and Hyundai occupy contrasting positions in upstream and downstream access. BYD benefits from tight integration into China's dominant battery-materials ecosystem, giving it secure and competitively priced access to lithium, nickel, cobalt, and graphite, and reducing its exposure to CRM price volatility. Hyundai's upstream access, by contrast, is mediated through Korean cell suppliers with diversified international sourcing but continued dependence on Chinese refining — especially for graphite and precursor cathode materials — leaving Hyundai structurally more vulnerable than BYD in raw-material security.

Downstream, however, the balance reverses. Hyundai enjoys a significantly more favourable position in Europe thanks to the EU–South Korea FTA, which grants tariff-free entry for qualifying Korea-built vehicles, alongside its European manufacturing base that preserves full subsidy eligibility. BYD, despite benefiting from origin-neutral consumer incentives, faces the combined burden of the EU's standard 10% import tariff and the EU's countervailing duties on China-built BEVs, pushing it to rely more heavily on PHEVs.

In sum, BYD holds the upstream advantage, while Hyundai benefits from superior downstream market access.

2.4. Risk Management, Resilience and Firm Governance

2.4.1. European Risk Context for NEV Manufacturers

In the European market, NEV supply chains are exposed to a wide spectrum of risks that affect upstream access, midstream production continuity, and downstream compliance. Following Section 1.3.2.4, the risks were grouped into six categories — geopolitical, regulatory, operational, financial, environmental, and ethical risks — each of which is highly relevant to firms expanding into or operating within Europe.

Geopolitical risks for NEV manufacturers are characterised by vulnerabilities that can directly disrupt upstream access and influence consumer purchasing decisions. For example, political statements made by Tesla's CEO, Elon Musk, led to a 49% decline in Tesla's European sales in April 2025 compared with the previous year (Inagaki and Li 2025). Political tensions between the United States and China — marked by an ongoing tariff war (Taylor 2025) — influence third-party decisions regarding the extent to which they are willing to cooperate with either side or diversify their partnerships. Due to cybersecurity risks and concerns within the EU about China's political influence, potential restrictions on the use of Chinese NEVs, including possible bans, are being discussed (Stec and Gunter 2025). These dynamics push the EU toward closer cooperation with China's main counterparts in East Asia — South Korea and

Japan (Tagliapietra, Trasi, and Sebastian 2025). By controlling a substantial share of CRMs, China also possesses significant leverage to shape the global NEV market. Under new Chinese regulations, exporters of rare earths and magnets may not ship materials without an approved licence and supporting documentation verifying end use. The approval process is slow: according to the European Association of Automotive Suppliers, Chinese authorities approved only 25% of submitted export-licence applications over the course of a month. This situation poses a serious risk of supply chain disruption for European automakers (IEA 2025c; Liu and Gan 2025).

Regulatory risks can arise independently of geopolitical risks. The European market is highly regulated, with strict compliance requirements and transparency obligations, as discussed in Section 2.1.1 on the EU legislative framework. Companies operating in the EU must comply with the relevant regulations — including the CSRD (2022/2464), the CSDDD (Directive (EU) 2024/1760), the EU Battery Regulation (2023/1542), and CBAM (Regulation (EU) 2023/956). Since many of these frameworks are still evolving, potential future changes must also be factored into strategic planning (European Commission 2025a; European Union 2019, 2022, 2023a, 2023b, 2023c, 2024a; European Commission 2023c). Anti-subsidy regulations (European Commission 2024) and member state–level national rules (ACEA 2025b) also fall under this category of regulatory risk.

Operational risks occur primarily due to the dependence of companies operating outside Europe on long-distance maritime logistics and vulnerable transport corridors. For example, Red Sea disruptions have already forced global rerouting and sharply increased transit times for shipments to Europe. For companies that depend on timely battery-pack and vehicle flows into Europe, chokepoint disruptions translate into higher inventory costs, delayed deliveries, and vulnerability to production stoppages (Haralambides 2024, 376). European supply chains also remain highly exposed to operational disruptions in Asian ports. Asian port congestion has repeatedly translated into sharp, lagged increases in China–Europe freight rates, showing that upstream bottlenecks in the manufacturing region are the primary driver of logistics cost volatility for NEV exporters (Michail and Melas 2025, 5). Operational risks are not limited to logistics bottlenecks or cross-border supply constraints; they also arise within production facilities themselves. Safety concerns related to high-voltage battery systems and the risk of thermal runaway are among the key challenges in the NEV industry (Backinger 2025). Risks of fires, delays, and large-scale recalls must also be considered during both NEV manufacturing and the construction of NEV production plants (Buzio 2022; Marsh 2022).

Financial risks are closely interconnected with other risk categories, as regulatory changes, tariffs and operational disruptions translate directly into higher costs and margin volatility. At the same time, NEV manufacturers operating in Europe face several distinct financial risks that are independent of these dynamics. These include exposure to euro exchange-rate fluctuations (European Central Bank 2020), structurally high European labour costs (Eurostat 2025), and elevated industrial energy prices (European Commission 2025c; European Round Table for Industry 2024, 10), all of which raise fixed expenditures and reduce profitability. In addition, NEV producers encounter substantial capital-expenditure risks associated with high construction and permitting costs in Europe (Transport & Environment 2024), as well as growing foreign-investment risks linked to the EU's tightening FDI-screening mechanisms (Tagliapietra, Trasi, and Sebastian 2025), which can delay or constrain new plant investments. *Environmental* and *ethical risks* are associated with sustainability and green supply chain management and are addressed in Section 2.1 on Sustainability and Corporate Social Responsibility.

2.4.2. Midstream Risk Management and Resilience Framework

In line with the analytical framework, the analysis of BYD and Hyundai focuses on the midstream of the NEV supply chain — battery production, pack integration, and vehicle assembly — where firms exercise the greatest strategic control over supplier structures, production-network design, localisation, digital visibility and governance. Upstream and downstream activities are referenced only where they clarify midstream exposure or midstream recovery capability. Following Pettit, Fiksel, and Croxton (2010, 4–6), the framework integrates both risk management, understood as the identification and mitigation of known hazards, and resilience, defined as the ability to anticipate, absorb, and recover from disruptions. The assessment applies five levers of midstream resilience: supplier diversification and the trade-off between vertical integration and multi-sourcing; network design and localisation; digital visibility and traceability; incident-response and recovery capability; and governance as the organisational backbone (Lou, Islam, and Billington 2023, 30). Each lever mitigates different elements of the European risk environment outlined in Section 2.4.1, including geopolitical, regulatory, operational, financial, environmental, and ethical risks.

2.4.3. BYD

BYD's midstream configuration shapes the firm's overall risk management and resilience profile in the European market. A defining characteristic of BYD's structure is the combination of high vertical integration and a broad, coordinated supplier ecosystem, which together mitigate multiple categories of European risk (Ruid 2024). Internally, BYD produces battery cells, battery packs, motors, power electronics and automotive semiconductors (Zhang and Li 2024, 84), reducing exposure to geopolitical and operational risks associated with concentrated foreign inputs and global component-supply volatility. Chinese research conceptualises BYD as a "chain-master enterprise" (链主企业 *liànzhŭ qǐyè*) that shapes technological development, supplier coordination and digital integration across the NEV ecosystem, making the company the structural centre of industry-wide resilience rather than upstream miners or downstream distributors. It also emphasises that breakthroughs in "key core technologies" and substantial R&D capacity significantly stabilise BYD's midstream operations by reducing external dependency (Wang, Li, and Zhang 2024, 157). This structure also mitigates financial risks, given its reduced sensitivity to upstream price fluctuations and improved coordination across internal production stages.

At the same time, BYD maintains an extensive and diversified supplier network that enhances both risk mitigation and resilience. The firm supplies batteries and powertrain components to global automakers (Miyata and Kawakami 2022; Ruid 2024) and has expanded cooperation with European suppliers, engaging more than 170 Italian and EU manufacturers in 2025 through supplier-development events (BYD 2025c). Such diversification reduces single-supplier dependence and improves the firm's ability to substitute inputs during disruptions — mitigating operational, regulatory and geopolitical risks linked to long-distance transport routes and supply concentration.

Upstream diversification further strengthens BYD's midstream stability. BYD has strategically secured access to lithium by obtaining mining rights in Brazil. Production is expected to begin only after approximately 8 to 15 years, which illustrates the company's long-term strategic planning and its commitment to further reinforcing its vertical-integration model (Rice 2025). In parallel, BYD also expanded domestic upstream control by purchasing a 5% stake in Chengxin Lithium, one of the largest lithium producers in China, for CNY 3 billion, securing preferential access to processed lithium following a period of severe price fluctuation (Benchmark Minerals 2022). These upstream hedging strategies mitigate geopolitical risks associated with dependency on Chinese refining bottlenecks and financial risks stemming from global commodity volatility. Because these upstream measures directly stabilise battery feedstock availability, their resilience effects are realised at the midstream, supporting predictable and reliable input flows for Europe-bound production.

Production-network design serves as another central lever of BYD's midstream resilience. BYD's multi-plant domestic network provides redundancy but exposes European operations to operational and geopolitical risks associated with maritime chokepoints, Red Sea disruptions and Asia–Europe freight-rate volatility (as discussed in Section 2.4.1). European localisation can help mitigate not only operational but also regulatory risks, as vehicles manufactured outside China would no longer fall under the anti-subsidy measures (European Commission 2024). BYD's localisation efforts align with this trend. In addition to its already successfully operating electric-bus plant in Komárom, Hungary (Zhang 2025), the company is building two further facilities to support its European expansion: one in Hungary (BYD 2023) and another in Türkiye (Atay 2024). According to the latest reports, both plants are expected to begin operations in 2026 (Mobility Portal 2025). BYD's executive vice-president Stella Li also mentioned in an interview that the company is considering plans for a third plant in Europe (Reuters 2025a). Although nothing has been confirmed, Spain has been mentioned as one possible location (Mobility Portal 2025). Overall, BYD's European localisation strategy reflects not only an effort to embed production within the EU's compliance environment but also a commitment to long-term resilience by adding new capacity nodes and reducing concentration risk.

Digital transformation and full-chain information integration constitute a core part of BYD's ecosystem leadership. Chinese research identifies BYD's digital platforms — covering information-system strategy, data-resource integration, and digitalised R&D and manufacturing processes — as central mechanisms enhancing supply chain coordination and risk resilience (Wang, Li, and Zhang 2024, 156). These systems mitigate operational risks through predictive analytics and real-time monitoring, while enhancing resilience through rapid re-planning and production reallocation. Digital traceability also enables compliance with EU regulatory requirements under the EU Battery Regulation and CSRD, mitigating regulatory, environmental and ethical risks related to lifecycle carbon documentation and due diligence obligations (European Union 2022, European Union 2023a). BYD's long-standing ESG disclosure record provides a useful foundation for EU compliance, though Chinese ESG studies note persistent challenges such as selective disclosure (Wang 2024b), indicating the need for deeper multi-tier verification to meet EU due diligence expectations.

BYD's emergency-response and recovery capabilities significantly enhanced its resilience during the COVID-19 shock. The company maintained markedly higher short-term stability than comparable firms, owing to its comprehensive incident-response planning, rapid assessment and deployment mechanisms, and advanced internal management systems. Event-study evidence shows that BYD experienced smaller negative impacts during the initial lockdown period and subsequently entered a rapid recovery phase, with long-term abnormal returns far surpassing those of the comparison firm, reflecting its stronger capacity to withstand

and rebound from supply chain disruptions (Fu and Wu 2023, 103–104). These capabilities mitigate operational and financial risks linked to production interruptions or delay-related losses. However, BYD's responsiveness remains untested under EU recall procedures and regulatory scrutiny, which introduces additional regulatory risks.

Governance forms a central pillar of BYD's resilience and risk management system. The firm has issued CSR and ESG reports since 2010, progressively expanding disclosure to cover environmental management, social responsibility and governance mechanisms such as compliance, anti-corruption and board-level oversight (Fu and Wu 2023, 103–104; Wang 2024b, 1–2). Chinese studies find that these governance practices enhance transparency, reduce information asymmetry, improve access to financing and strengthen internal risk-control capacity (Fu and Wu 2023, 104–105; Zhang and Li 2024, 2–3; Zhang, Yao, and Suo 2025, 4–5). However, Wang Danfeng (2024b, 9-12) highlights selective disclosure and under-reporting of environmental incidents, identifying elements of "greenwashing" that may obscure environmental or regulatory risks.

Governance challenges also extend to supplier financial stability. Chinese reporting shows that BYD's internal settlement system, Dilian（递链 *dìliàn*）, reached an accumulated volume of around CNY 400 billion by mid-2023 and placed liquidity pressure on smaller suppliers (Wang 2025). Dilian operated as a closed-loop electronic IOU mechanism in which BYD issued digital payment vouchers instead of cash, allowing these notes to circulate down the supply chain or be discounted with financial institutions; while this improved BYD's working-capital position, it shifted financing costs and liquidity risk to lower-tier suppliers and enabled uncontrolled secondary circulation (Chen 2025; Wang 2025). In response to tighter regulatory oversight and industry calls for fair payment practices, BYD pledged to comply with the 60-day settlement norm set out in the official Initiative on Regulating Supplier-Accounts Payment Practices of Automobile Manufacturers by China Association of Automobile Manufacturers (CAAM) (CAAM 2025) and began phasing out the Dilian system (Chen 2025). These adjustments indicate an evolving understanding that supply chain resilience depends not only on internal integration but also on financially healthy and low-risk Tier 1 and Tier 2 suppliers, and that effective governance must anticipate and respond to emerging regulatory requirements in order to prevent compliance-driven disruptions and stabilise long-term supplier relations.

Overall, BYD's midstream structure — characterised by high vertical integration, diversified supply partnerships, upstream hedging, localisation, digital visibility and strong governance — mitigates all six categories of European risk while supporting the firm's ability to anticipate, absorb and recover from disruptions. Nonetheless, BYD's long-term resilience in Europe will depend on expanding local production beyond a single site, strengthening multi-tier transparency and aligning governance with evolving EU due diligence and auditability requirements.

2.4.4. Hyundai

Hyundai's midstream risk management and governance configuration is characterised by a hybrid system built on long-term strategic partnerships with Korea's major battery manufacturers (Kan 2025; Lambrecht 2023) and a highly localised regional assembly footprint (HMC n.d.c). This configuration provides considerable stability under European market conditions, while also exposing the firm to structural vulnerabilities linked to upstream material dependencies and deep-tier traceability requirements.

Hyundai Motor Company's supply structure strategy relies on specialised external partnerships with SK On, LG Energy Solution, and Samsung SDI (Kan 2025). It does not operate a fully vertically integrated supply chain. Instead, its production system is characterised by what scholars describe as quasi-vertical integration, a hybrid structure that coordinates both affiliated and non-affiliated suppliers through hierarchical, long-term, and highly codified relationships (Kim, Jeong, and Jo 2021, 73). As Kim, Jeong, and Jo show, Hyundai incorporated external suppliers into a captive subcontracting system from the 1980s onward and later consolidated this structure through the rise of Hyundai Mobis as the dominant modular parts supplier (64–70). The result is a multi-tiered, strongly Hyundai-controlled supplier hierarchy, domestically and in overseas plants, even though many firms remain legally independent (70, 75–77). Therefore, Hyundai's supplier structure is network-based and quasi-vertical, not genuinely vertically integrated. In the European context, this model presents mixed implications for risk management. On one hand, Hyundai's strong control over multi-tier suppliers supports quality consistency and coordinated responses across its network. On the other hand, the absence of true upstream ownership means Hyundai remains highly exposed to external risks such as EU regulatory shifts, carbon-compliance requirements and potential disruptions among independent battery-material suppliers. Because key NEV components are sourced through external partners rather than integrated production, Hyundai faces greater vulnerability to geopolitical shocks and cost volatility in Europe.

Korean research institutions emphasise that the country's battery sector remains profoundly dependent on Chinese upstream processing. Korea Institute for Industrial Economics and Trade (KIET) reports that Korean EV-battery makers import 80–90% of their processed critical mineral inputs from China, particularly the precursors required for cathode and anode production (KIET 2024, 1). Additional data from the Korea Institute of Geoscience and Mineral

Resources (KIGAM) and the Korea Mine Rehabilitation and Mineral Resources Corporation (KOMIR) show Korea's reliance on Chinese raw-material inputs continued to rise in 2023: imports of 37 key minerals from China reached USD 7.03 billion, up from USD 2.13 billion in 2018, while 91 percent of magnesium was sourced from China. Complementary customs statistics show similarly high dependence for battery materials such as graphite and lithium hydroxide, underscoring that upstream exposure remains a structural constraint for Korea's battery ecosystem (Yu and Yoon 2025). Taken together, these findings demonstrate that Korea's battery ecosystem — despite its global competitiveness in cell manufacturing — remains structurally exposed to disruptions in Chinese refining, export conditions, or geopolitical instability.

Hyundai's European manufacturing footprint is one of its strongest resilience levers. In the first three quarters of 2024, Hyundai sold 620,737 vehicles in Europe, around 80% of which were produced at its long-established plants in Türkiye and Czechia (HME n.d.d). These facilities form a mature, regionally embedded production base: the Nosovice plant in Czechia, operating since 2008, is powered by 100% renewable electricity, while the Izmit plant in Türkiye has been in continuous operation for more than two decades. Both plants produce a mix of internal combustion engine (ICE) vehicles and electric or electrified models, enabling Hyundai to flexibly adjust its product allocation in response to regulatory, demand, and supply chain shifts in the European market. This stable regional capacity allows Hyundai to mitigate logistics bottlenecks, reduce exposure to trade disruptions, and maintain supply continuity even under high geopolitical uncertainty.

Hyundai also benefits from the European manufacturing presence of Korean battery suppliers. SK Innovation is investing in its third European battery plant in Iváncsa, Hungary (SK Innovation 2021). LG Energy Solution operates a major gigafactory in Wrocław, Poland, with an annual capacity of 86 GWh (Colthorpe 2025). Samsung SDI likewise runs an established automotive-battery plant in Hungary, producing around eight million cells per month (Samsung E&A n.d). These facilities shorten midstream supply lines for Hyundai's European NEV production, even though upstream dependence on China-processed critical minerals remains unresolved.

As for digitalisation, Hyundai claims that smart factories and software-defined manufacturing are central to its future production model. At the Hyundai Motor Group Innovation Center Singapore (HMGICS), the group presents a "smart urban mobility hub" that uses digital-twin technology, AI and highly automated flexible production systems to monitor and simulate factory operations in real time. Hyundai also notes that implementing digital twins requires dedicated infrastructure, including an IoT platform that secures and links real-time data across factory equipment (HMG 2023). Building on this direction, Hyundai and Unity announced in 2022 their plan to establish a digital-twin "meta-factory" to enhance manufacturing flexibility and operational visibility (HMC 2022). As of 2025, however, there is no verifiable evidence in industry reports or the media that this facility operates at scale or delivers measurable supply chain benefits.

Hyundai's more recent digitalisation efforts are consolidated under the E-FOREST initiative, which positions the company's strategy within a broader shift toward Software-Defined Factories (SDFs). At E-FOREST TECH DAY 2024, Hyundai and Kia outlined a manufacturing vision integrating AI-enabled automation, autonomous mobile robots, flexible parts-assembly systems, digital-twin–ready infrastructure and human–machine collaboration technologies. E-FOREST thus functions as Hyundai's umbrella smart-factory brand, aiming to unify digital tools, robotics, logistics automation and modular manufacturing under a single operational framework (HMC 2024b).

These initiatives clearly strengthen internal manufacturing visibility (equipment, processes, quality, logistics within and between plants). However, Hyundai has not published comparable information on deep-tier supply chain traceability for battery raw materials. Based on currently available sources, its digitalisation strategy improves plant-level and midstream visibility but does not yet demonstrate full transparency over upstream critical-mineral sourcing.

Hyundai maintains coordinated incident-response and recovery systems based on flexible global manufacturing networks that enable temporary volume shifts and adaptive scheduling. These systems are designed to support continuity during disruptions and help mitigate operational and financial risks. The semiconductor shortage of 2021 highlighted the advantages of Hyundai's centralised crisis coordination, with the company recovering faster than many competitors (Lee 2021). Together, these episodes suggest that Hyundai can flexibly reallocate production and coordinate closely with suppliers under stress, even though the company does not publicly disclose a formal incident-response system or comparative data on recovery speed.

Hyundai's sustainability reporting framework demonstrates a reasonably strong formal governance structure: its 2024 and 2025 Sustainability Reports follow GRI, apply double materiality analysis and expand the scope of disclosed risks, impacts and critical minerals (HMC 2024a; HMC 2025a). These elements indicate a structured and maturing approach to governance and EU-oriented compliance. However, the practical depth of this governance remains limited. Disclosures are still largely qualitative, upstream visibility beyond Tier 1 suppliers is weak, and no CSRD-compliant digital tagging or external assurance of value-chain data is yet provided. Thus, Hyundai's governance architecture shows credible progress and institutional readiness, but remains incomplete, particularly regarding deeper-tier traceability and verification required under CSRD, ESRS and the EU Battery Regulation.

Hyundai Motor Company's midstream structure — based on diversified supplier partnerships, deep European localisation, expanding digital oversight and strong governance — effectively mitigates operational, regulatory, ethical and financial risks in the European context. However, remaining upstream dependencies on China and limited deep-tier traceability leave the firm exposed to geopolitical and financial risks. Long-term resilience will depend on expanding supply chain diversification, improving lifecycle-traceability systems and deepening integration with Europe's battery ecosystem.

2.4.5. Comparative Assessment of BYD and Hyundai

BYD and Hyundai employ fundamentally different midstream risk management and governance strategies, resulting in contrasting resilience profiles in the European context.

BYD, as a vertically integrated "chain-master enterprise", internalises batteries, power electronics, semiconductors, and motors, which strengthens coordination and reduces exposure to supplier-level volatility. Its upstream hedging and diversified supplier ecosystem add further stability. However, BYD remains far less mature in localisation: apart from its Komárom bus plant, all major European passenger-vehicle facilities are still in planning or early construction phases, meaning its European presence is not yet comparable to Hyundai's. BYD's digital integration and emergency-response capabilities appear strong, though its governance framework faces limitations such as selective disclosure, incomplete supplier verification, and unresolved multi-tier transparency gaps under emerging EU due diligence rules.

Hyundai, by contrast, operates a quasi-vertical, network-based supplier model built on long-term partnerships with Korea's battery makers. This structure ensures coordinated quality control but leaves the company structurally exposed to Korea's heavy dependence on China-processed critical minerals. Hyundai's resilience is strengthened by a well-established and long-operational European manufacturing footprint in Türkiye and Czechia, complemented by nearby battery cell plants operated by SK On, LG Energy Solution, and Samsung SDI. Its digitalisation initiatives — HMGICS, the meta-factory concept and the E-FOREST SDF framework — enhance plant-level visibility but do not provide deep-tier traceability. Hyundai's semiconductor-crisis response demonstrated adaptive scheduling and tight supplier coordination, yet upstream risk exposure remains significant.

Regarding governance, both firms show structured ESG frameworks and year-on-year improvements, but neither currently meets the full transparency, quantification and value-chain verification expected under CSRD, ESRS or the EU Battery Regulation. BYD benefits from tighter internal integration, while Hyundai offers more mature European localisation, but both still face gaps in multi-tier traceability and upstream assurance. Overall, BYD exhibits stronger internal control and upstream risk protection, whereas Hyundai provides more stable European operational capacity — but neither has yet achieved full EU-compliant due diligence maturity.

2.5. Brand and Quality Management

2.5.1. European Consumer Attitudes and Reputation Environment in the NEV Market

The European market is quite heterogeneous in terms of electrification. As of 2025, the most advanced markets are Norway, with a combined BEV–PHEV share of new registrations reaching 97%, followed by Denmark at 67%, Sweden at 61%, and the Netherlands at 55%. Within the EU context, Denmark, Sweden, and the Netherlands therefore lead in NEV adoption, followed by Belgium with 41%, Austria with 31%, and Germany with 28%. All other countries remain below the European average, but compared with 2024, Poland, Spain, and Czechia have shown significant year-on-year growth of 95%, 94%, and 53%, respectively (ICCT 2025b, 5). However, surveys conducted across European countries with varying levels of NEV market maturity show that substantial misconceptions and concerns continue to persist. These relate to cost, driving range, battery degradation, charging convenience, and resale value, and they remain widespread regardless of a country's level of NEV adoption. The high share of negative or neutral responses to NEV-related myths in countries such as the Netherlands and Denmark indicates that even in markets with high BEV penetration, many consumers still lack clear information or confidence regarding NEV performance (Westerhof et al. 2023, 3–4).

At the same time, recent findings indicate that 42% of the 8,000 respondents surveyed in Europe are willing to purchase an NEV this year, and nearly 60% expect to do so by 2030. However, this research was conducted by the Chinese brand Zeekr together with the British media agency Markettiers, and the sample is drawn largely from mature Northern European NEV markets. As a result, the findings lack broader representativeness and may overestimate overall European willingness to adopt NEVs (CleanTechnica 2025).

In general, the automotive industry holds one of the strongest reputations among major sectors in Europe, ranking second in the 2023 Global RepTrak index. The sector received a score of 73.8, indicating that Europeans consider the automotive industry highly reputable overall. Because buyers place substantial weight on reputation when choosing vehicles, this high reputational benchmark makes it considerably more difficult for new entrants to establish credibility. According to the same Global RepTrak ranking, the automotive brands with the highest reputation in Europe are Michelin (78.5), BMW Group (77.7), Mercedes-Benz (77.0), and Ferrari (76.9). By contrast, Tesla is already rated as an average brand with a score of only 63. The report also notes that Chinese NEV brands suffer from low awareness, a conclusion based on Google search metrics: BMW, Audi, and Volkswagen overwhelmingly dominate the European market by this measure (Petersen 2024). Research by Adevinta, a major online classifieds group in Europe, shows that 45% of Europeans consider brand reputation the most important factor when looking for a new car, and 32% of customers report that they tend to purchase vehicles from the same brand (Adevinta 2024).

However, these conclusions relate to the automotive industry as a whole and not specifically to the NEV segment. With regard to NEVs, Adevinta (2024) reports that 28% of surveyed consumers are willing to choose a new or unfamiliar brand when considering an NEV rather than an ICE vehicle. The main factors underlying this openness are battery range, cited by 39% of respondents as a decisive criterion, followed by lower price (35%) and shorter delivery times (26%), which make unfamiliar brands more attractive to potential buyers. This tendency creates greater opportunities for new and unfamiliar brands — including foreign entrants — to gain market share. For example, the new findings mirror earlier patterns, with Volkswagen and BMW again emerging as the most trusted brands: 41% and 40% of respondents respectively selected them as the most reliable among the ten options provided. Tesla received 27%, while emerging NEV brands such as Polestar, MG, and BYD were chosen by only 6%, 4%, and 4%, irrespective of their country of origin. However, when the same respondents were asked to choose an NEV manufacturer from the same set of companies, Tesla's ranking rose to 48%, whereas Volkswagen and BMW fell to 26% (Adevinta 2024).

Zeekr and Markettiers report that European openness toward Chinese NEV brands is increasing, with 38% of respondents indicating greater willingness to consider a Chinese NEV compared with a year earlier. This shift is particularly pronounced among current NEV owners (53%), suggesting that consumers with firsthand NEV experience are more aware of — and more receptive to — China's technological leadership in batteries and charging systems. According to the same research, even in more conservative markets such as Switzerland, most consumers agree that Chinese NEVs now match Western competitors in terms of innovation (CleanTechnica 2025).

Similar findings are reported in other sources, which show that 29% of UK consumers and 43% of Spanish consumers are willing to buy Chinese NEVs. For 30% of respondents, the key factor is "better value for money", while 10% cite "better technology". On the other hand, "political matters" are mentioned as a negative factor by 37%, concerns about "build quality" by 36%, and "lack of familiarity with the brands" by 28% (Petersen 2024).

Since the European EV market is characterised simultaneously by high reputation thresholds and growing openness to new entrants, downstream quality and service systems become decisive differentiators. To understand how firms can convert technological capability into customer trust, the following empirical analysis evaluates BYD and Hyundai's Brand & Quality Management, focusing on after-sales coverage, recall handling, CQI maturity, customer experience management, and brand equity within the EU context.

2.5.2. BYD

BYD is a relatively new brand for European consumers. Its full-scale European market expansion was confirmed only in 2022 (BYD Europe 2022). This means that the first challenge to be addressed in the European automotive market — where reputation plays a crucial role, as discussed earlier — is building brand awareness. And indeed, recent research shows a positive trend in this direction. According to a YouGov survey, only 14% of German consumers were aware of BYD in 2022 (Petersen 2024). New findings from the same data-analytics company indicate that by 2025, 38% of the general German population knew of BYD, and awareness reached 46% among Germans who are considering purchasing a NEV. BYD also holds top-tier awareness among new NEV brands in several other major markets, including the UK and Italy (Soller 2025). This suggests that the company's brand-building strategy is proving effective. For example, BYD became the first Chinese automotive company to sponsor the UEFA EURO 2024 football championship, taking over the position previously held by Volkswagen (Euromonitor International 2024). BYD is also increasing its visibility at other European events, such as the Donauinselfest music festival in Vienna, Austria, as part of its broader marketing strategy (OTS 2025).

The next challenge is the generally negative perception of Chinese cars, driven by political concerns and doubts about product quality (Petersen 2024). BYD addresses this challenge not only by promoting its technological achievements but also by adopting the slogan "BYDs built in Europe for Europe" as part of its localisation strategy. Plans for the first model, the Dolphin Surf, to be manufactured at the Hungarian plant were announced at IAA Mobility 2025 in Munich (BYD 2025b). The strong market performance of the BYD Seal U PHEV in Europe further confirms the positive development of BYD's reputation (Pontes 2025). Moreover, BYD is rapidly expanding a traditional dealer-and-service network instead of relying on direct sales. At the same global mobility community gathering in Munich, the company presented plans to be present in 32 European countries with more than 1,000 sales points by the end of 2025 and over 2,000 by 2026, largely by partnering with established distributors such as Inchcape, which already represents premium brands like BMW, and Ford across multiple markets (Juurikas 2025). Such a move helps to secure customer trust by partnering with well-established dealer groups.

From a CQI perspective, BYD demonstrated in 2024–2025 its ability to diagnose production-process issues, implement technical fixes, and manage large-scale recalls, as evidenced by a major recall of more than 115,000 vehicles in China (Reuters 2025b). However, such incidents also reveal the risks associated with very rapid volume growth, which can outpace process robustness and temporarily undermine perceived reliability. There have been no widely reported major safety recalls for BYD in the EU to date, but it is currently too early to draw firm conclusions, given the company's early stage of establishment in the European market and its still relatively low registration volumes.

Notably, all tested BYD models available in Europe have received the maximum five-star Euro NCAP safety rating, including the compact BYD Dolphin Surf — an achievement that is difficult to attain and not common among most competitors in this segment (BYD 2025a; see Table 3 in Appendix B). This strong safety performance can significantly support the brand's reputation in the European market.

In terms of customer-facing quality, BYD is putting noticeable effort into giving European buyers the same peace of mind they expect from long-established brands. New BYD models in Europe come with at least two years of BYD Assistance, a 24/7 pan-European roadside-support service. Customers can keep this protection for longer simply by having their car serviced at an authorised dealer, which ties regular maintenance to ongoing roadside cover in a straightforward and customer-friendly way (BYD Europe n.d.c). BYD has also recently started a Certified Pre-Owned (CPO) programme in Europe. Every used car in this programme is checked thoroughly and comes with at least one year of warranty, the remaining eight-year/200,000 km battery warranty, two years of roadside assistance and two years of data for connected services. BYD also uses its own system to measure how healthy the battery is and guarantees at least 90% battery health for every CPO car. This is meant to give buyers more confidence, especially about battery ageing and the value of used NEVs (BYD Europe 2025). These features integrate aftermarket data into quality processes and create a structured CQI interface between used-car markets and production.

Alongside these after-sales programmes, BYD is also investing in the digital dimension of the ownership experience. The company already offers a smartphone app with remote-control and vehicle-status features in its main markets, and early versions are now appearing in Europe —

though the rollout is still patchy and not yet consistent across countries (BYD Europe n.d.c). Based on user reviews, the BYD App suggests that BYD's digital ecosystem is still at an early and incomplete stage. Many reviewers describe the app as basic, lacking key NEV functions such as charging control, trip or energy-consumption data, and multi-user access. Several also report missing or removed features and limited usability (Google Play n.d.a). Independent owner feedback from European BYD customers also highlights problems with software and digital services, particularly emphasising the stark difference between the advanced Chinese versions and the unexpectedly limited and sometimes unreliable European software. At the same time, many owners praise BYD's warranty provisions and fast after-sales service. However, owner feedback varies substantially at the individual level. Despite the overall recognition of strong hardware value and solid build quality, political sentiments related to "Chinese" products — including concerns about cybersecurity and the protection of European jobs — remain widespread (Reddit 2024a, 2024b). It should be noted that this information is drawn from open online sources and reflects only a very small sample of early adopters; therefore, it serves merely as indicative background for future research, as studies on BYD's performance in the European market are still limited due to the early stage of its presence and the lack of long-term usage data.

2.5.3. Hyundai

Hyundai Motor Company entered the European passenger-car markets long before the current NEV wave, beginning exports of the Pony to Belgium and the Netherlands in 1978. Its European presence was further strengthened in 1994 with the establishment of a dedicated R&D centre in Germany, responsible for monitoring regional technology trends and developing models tailored to European customers (HME n.d.b). A major step in localisation already came in 2006, when Hyundai decided to build its first and still only EU manufacturing plant in Nošovice, Czechia, as a roughly EUR 1 billion greenfield investment with an annual capacity of about 300,000 vehicles (Eurofound 2006). The Nošovice plant has produced cars since 2008, now turning out up to 1,400 vehicles per day and employing more than 3,000 people, with wider regional employment effects of nearly 12,000 jobs (CzechInvest n.d). Hyundai reports that around 80% of its European sales are sourced from its factories in the Czechia and Türkiye (HME n.d.d). Together, these findings show that Hyundai is a long-established, highly localised player in Europe, supporting the claim that it enjoys greater brand familiarity and trust than more recent entrants. This claim is also supported by sales statistics: the Hyundai–Kia group ranked fourth in European sales in August 2025 (Bekker 2025a).

Another important point is that Hyundai Motor Group is transitioning from the traditional ICE to the NEVs. Based on JATO registration data for August 2025, Hyundai–Kia achieve an estimated NEV share of around 29% when applying the strict definition of NEVs that includes only BEVs, PHEVs and FCEVs. Hyundai–Kia therefore positions itself among the more advanced mainstream manufacturers in Europe in terms of electrification, combining a meaningful BEV portfolio with continued volume in conventional and hybrid vehicles. Although its NEV penetration remains below that of fully electrified newcomers, Hyundai–Kia's diversified powertrain mix indicates steady progress in the transition toward higher shares of zero-emission vehicles within the EU market (Bekker 2025a). It is difficult to obtain clean, publicly available, brand-level powertrain data for Hyundai alone in the European market, as most statistical sources report at group or pool level and do not isolate the Hyundai brand from Hyundai Motor Group.

Hyundai's IONIQ strategy is a classic example of using a sub-brand to separate a future-oriented NEV identity from the parent brand while still leveraging Hyundai's existing reputation and dealer network. Originating as "Project IONIQ" and the 2016 IONIQ model with hybrid, plug-in hybrid and battery-electric variants, Hyundai elevated IONIQ to a dedicated NEV sub-brand in 2020, announcing a family of BEVs (IONIQ 5, 6, 7) as the core of its Strategy 2025 electrification plan (HMC 2020a; HME 2020). This move allows Hyundai to construct a coherent NEV identity and design language under the IONIQ label, while maintaining scale advantages through Hyundai's existing dealer and service network.

Hyundai faces no issues regarding public awareness in Europe. YouGov reports that 94% of the UK population is familiar with the brand, and 45% hold a positive perception of it (YouGov 2025). However, general brand awareness does not necessarily reflect how consumers perceive Hyundai within the NEV segment. More NEV-specific insights come from markets with advanced adoption. In the Dutch NEV market — one of Europe's most mature — Hyundai demonstrates strong and growing brand awareness. With 31% unaided recall and 77% aided recognition, Hyundai ranks among the most recognisable NEV brands after Tesla and Volkswagen, indicating that it has successfully entered mainstream consumer consideration. Perception attributes show Hyundai is valued for its "value for money", range, practicality and modern design, aligning well with Dutch buyers' emphasis on sustainability, efficiency and reliability (Mark & Spark Solutions 2025).

Hyundai periodically faces safety recalls, including several high-profile cases involving NEVs such as the IONIQ 5 and IONIQ 6. In 2024, more than 208,000 Hyundai, Kia and Genesis NEVs were recalled in the United States due to an ICCU fault causing potential loss of drive power (Higgins 2024). In Europe, Hyundai manages such issues through established recall portals and dealer networks, ensuring transparent communication and prompt service (Hyundai Motor Deutschland n.d.). Although this aligns with industry norms, NEV-related recalls can still create reputational risks, particularly when they affect consumer confidence in new technologies. Research indicates that recalls may weaken trust and reduce resale values in safety-critical cases (Griffin, Koerber, and Thomsen 2020). For Hyundai, these incidents have not significantly damaged overall awareness or favourability in Europe, but they represent a structural vulnerability as the company scales its NEV portfolio.

Euro NCAP provides safety assessments for selected electric vehicles, though not all Hyundai NEV variants currently have published ratings. Among Hyundai's NEVs tested, the Hyundai Inster and Hyundai Kona received a four-star safety rating, placing them below the five-star benchmarks achieved by some competitors but still within an acceptable performance range for its segment (Euro NCAP n.d).

Hyundai's dealer strategy in Europe is characterised by consolidation, modernisation, and NEV integration, rather than a shift toward the direct-sales, dealer-free model adopted by some new entrants. At the European level, Hyundai has committed to expanding and strengthening its retail organisation as part of its long-term "Hyundai Way" growth plan, emphasising a more unified customer experience across all markets (HMC 2024). In 2023, Hyundai Motor Europe announced a comprehensive update of dealer and repairer contracts and standards across the EU, aiming to harmonise brand presentation, digital tools, and data-sharing rules, and to create what it calls an "industry-leading omnichannel experience" that connects online journeys with physical showrooms (HME 2023). In parallel, Hyundai is equipping European dealerships for the NEV transition. This includes the roll-out of charging infrastructure, technician training, and energy-service partnerships. For example, in Germany Hyundai collaborated with EnBW to implement charging solutions across authorised dealerships, positioning them as local e-mobility hubs rather than traditional sales points (pv Europe 2016). These initiatives show that Hyundai's strategy is not one of radical disintermediation, but of NEV-focused upgrading: preserving the traditional dealer network while transforming it to support electric mobility, improve service quality, and ensure consistent brand representation throughout the EU.

Hyundai's own description of the Bluelink App promises a fairly comprehensive remote-control and connectivity package for all models equipped with the Bluelink navigation system, with some extra functions for NEVs. According to the European Bluelink page, drivers are supposed to be able to "connect to your Hyundai from anywhere", including checking whether the car is locked, monitoring alarm events, viewing vehicle "health" (diagnostic report on systems such as tyres, brakes, airbags) and seeing live status data such as charge level and distance-to-empty. The app is also marketed as an extension of the in-car navigation: users can search for destinations at home and send them to the car, continue "last-mile" navigation on foot after parking, and locate their parked vehicle on a map. For electric Hyundai vehicles, Bluelink adds NEV-specific promises: remote climate pre-conditioning, range overview, and full control over charging schedule and charging limits to optimise battery life and electricity tariffs (HME n.d.a). Google Play reviews indicate that user satisfaction with Hyundai's Bluelink app is mixed but not overwhelmingly negative. The app holds an overall rating of 4.2 out of 5 based on more than 18,000 reviews, suggesting that many users find the core functionality acceptable or useful. However, written reviews reveal persistent weaknesses: users frequently report slow or unreliable connections, delayed vehicle-status updates, and inconsistent performance of NEV-specific features such as charging schedules and remote climate control. These issues create a noticeable gap between Hyundai's promised digital experience and the actual user experience, especially for IONIQ drivers who rely heavily on software integration. Overall, the rating indicates moderate satisfaction, but qualitative feedback highlights stability problems that weaken Hyundai's downstream brand perception in the NEV segment (Google Play n.d.b).

Because Europe is not a homogeneous market — dealer density, inventory levels, national logistics systems and regulatory conditions vary widely — both delivery times and after-sales service quality are difficult to estimate consistently across the EU, and no comparative cross-country studies are currently available. Nevertheless, one structural advantage for Hyundai is that in many European markets it offers a five-year, unlimited-mileage new-vehicle warranty, together with an eight-year or 160,000 km high-voltage battery warranty, which provides customers with a comparatively high level of security and reduces perceived ownership risk (HME n.d.g).

Overall, Hyundai is one of the strongest non-European OEMs in the EU NEV market. Its long-standing presence, high brand trust, extensive service network, mature CQI processes, competitive warranty packages and strong safety results provide it with a solid foundation. The introduction of the Hyundai Inster strengthens the company's prospects in the rapidly growing European affordable-NEV segment. Remaining challenges lie primarily in sustaining reliability under NEV volume expansion and improving the coherence and sophistication of its digital ecosystem. Nonetheless, Hyundai's downstream systems place the company in a far stronger competitive position than most new NEV entrants and allow it to translate product quality into long-term consumer trust.

2.5.4. Comparative assesment of BYD and Hyundai

A direct comparison of downstream brand factors remains complex, as many aspects — such as long-term after-sales satisfaction or digital ecosystem maturity — cannot yet be measured systematically for either BYD or Hyundai in Europe. What can be stated with confidence, however, is that Hyundai benefits from a far longer European presence, which has allowed it to build a dense and professionalised dealer network, established service routines, and a high level of brand familiarity. These strengths give Hyundai structural advantages in customer trust and downstream quality assurance. At the same time, Hyundai's long legacy also creates a degree of brand path dependency, making a rapid NEV breakthrough more difficult because consumer associations are still partly shaped by decades of combustion-engine positioning.

BYD, by contrast, enters Europe from a weaker starting point: limited familiarity, political sensitivities surrounding Chinese manufacturing, and a still-developing service infrastructure. Yet precisely because BYD is a newcomer, it also possesses significant brand-building potential. Its rapid awareness growth, strong Euro NCAP results, and fast expansion of dealer partnerships suggest that BYD can rapidly build its European identity. In other words, BYD is less encumbered by legacy perceptions and can position itself more freely as a technologically advanced NEV brand, while Hyundai must work within its established brand context even as it accelerates electrification.

3. Analytical Part

3.1. Research Question and Methodology

The goal of this section is to analyse and synthesise the empirical findings of the study. The objective of this master's thesis is to answer the following research question: How do East Asian new energy vehicle producers — BYD and Hyundai — use supply chain management strategies to address the challenges of expanding into the EU market?

To achieve this goal, the criteria were defined on the basis of the literature review. One of the main methodological challenges was to avoid analytical overlap, as many factors shaping NEV market expansion are closely interconnected. To ensure a clear and consistent structure, the analysis was therefore organised into distinct criteria: (i) Sustainability and Corporate Social Responsibility, (ii) Innovation and Competitiveness, (iii) Policy and Material Access, (iv) Risk Management, Resilience and Firm Governance, and (v) Brand and Quality Management.

The literature review framed supply chain management as the central analytical perspective of the study. Accordingly, supply chain management was used to structure the empirical analysis across upstream, midstream, and downstream dimensions. Each empirical section begins with an examination of the specific European market conditions relevant to the respective criterion. This is followed by an analysis of how BYD and Hyundai apply supply chain management strategies to address these conditions in the context of EU market expansion.

The study adopts a qualitative comparative case study design. BYD and Hyundai Motor Company were selected as case studies because they represent two leading East Asian NEV manufacturers with fundamentally different supply chain configurations, degrees of vertical integration, and market-entry strategies in Europe. At the same time, both firms are actively expanding their presence in the EU market and face similar regulatory, logistical, and competitive pressures, making them suitable for systematic comparison.

The empirical analysis is based primarily on secondary data. Sources include corporate sustainability and annual reports, official company communications, EU policy and regulatory documents, industry and market reports, and academic publications. Where appropriate, third-party assessments, independent research institutions and reputable industry media are used to triangulate firm-level claims and reduce reporting bias. Due to the limited availability of long-term European data for newer market entrants, particularly BYD, the analysis focuses on observable strategies, disclosed practices and early performance indicators rather than on long-term outcome measures.

Overall, this methodological approach ensures coherence between the theoretical framework and the empirical analysis, enables structured comparison across firms, and reflects the constraints on data availability in a rapidly evolving market environment.

3.2. Analysis of Research

3.2.1. Summarised Findings

The following table presents a comparative synthesis of the key structural challenges characterising the European NEV market and the corresponding firm-level responses of BYD and Hyundai. The second column summarises the main exogenous constraints of the European environment, including regulatory, infrastructural, market-related, and geopolitical factors that shape market entry and expansion. The remaining columns analyse how each firm addresses these constraints through distinct supply chain management strategies across upstream, midstream, and downstream dimensions.

By structuring the analysis in this way, the table reflects the core supply chain logic underlying this thesis: external conditions create constraints and incentives, while firm-specific supply chain configurations determine strategic responses and competitive outcomes. The table does not introduce new empirical evidence but synthesises and contrasts the findings presented in the preceding empirical sections.

Table 2 Analytical Comparison of BYD and Hyundai Across Supply Chain Dimensions

Criteria and Dimension		The Challenges of the European Market	BYD	Hyundai
Sustainability & CSR	Upstream	• Highly regulated environment with strict sustainability and reporting requirements (CSRD, ESRS, EU Battery Regulation, CO_2 emission standards, CBAM, CSDDD). • Requirement for auditable ESG disclosures and externally verifiable sustainability data. • Obligation to ensure full value-chain traceability, including multi-tier visibility for environmental and human-rights risks. • High expectations for human-rights protection across all upstream and midstream operations. • Strong environmental protection standards, including lifecycle carbon transparency, recycling obligations, and responsible sourcing of critical raw materials. • Growing scrutiny of greenwashing and selective disclosure risks.	BYD benefits from strong upstream control: its vertical integration and LFP-based chemistry together reduce dependence on high-risk materials like cobalt and nickel and make internal traceability easier. At the same time, transparency across deeper supplier tiers is still limited. External ESG assessments are not yet fully aligned with EU expectations, human rights risks remain insufficiently mitigated, and the company is still working toward full compliance with EU due diligence and auditability requirements.	Hyundai has established a structured ESG governance system and is gradually expanding its responsible minerals programme to cover more critical materials. However, upstream visibility remains limited beyond Tier 1 suppliers, and reporting on key minerals is still not fully comprehensive. Human-rights risks in lower tiers have not yet been sufficiently addressed, and Hyundai is still in the process of aligning its due diligence and auditability practices with EU expectations.
	Midstream		Vertical integration also gives BYD solid control over its manufacturing processes, emissions and component traceability. Because the company focuses on fully electric and low-emission models, meeting EU fleet-average CO_2 standards is relatively straightforward. In terms of recycling readiness, BYD operates battery recycling facilities and has processed over 10,000 tons of power batteries. Nevertheless, past environmental incidents at several BYD plants and gaps in how these cases were reported point to weaknesses in environmental governance. Recent labour rights issues connected to contractors reveal similar challenges in oversight, while ESRS alignment, digital reporting and external assurance mechanisms are still in development.	Hyundai's European manufacturing base helps the company reduce emissions and supports progress toward ESG reporting standards. However, meeting EU fleet-average CO_2 requirements remain difficult because the company still relies heavily on ICE vehicles. Sustainability reporting is detailed but remains largely qualitative, supplier data are not included in external assurance processes, and recent labour governance issues suggest that midstream due diligence practices are not yet applied consistently across regions. Regarding recycling, Hyundai has established a group-wide circular economy framework for NEV batteries; however, implementation remains phased, with limited disclosure on recycling volumes and no external verification, and full EU compliance is still under development.
Innovation & Competitiveness	Midstream	• Highly competitive NEV market dominated by strong incumbents such as Volkswagen Group, BMW, Mercedes-Benz, Tesla and other established brands. • Strong performance expectations: long range, fast charging, efficient batteries, advanced software. • Uneven and insufficient charging infrastructure across Europe, increasing pressure on vehicle-level efficiency and charging integration. • The market is unified at the regulatory level but not	BYD's biggest strength still lies in its battery technology. Since the company produces its own batteries, it has been able to turn the Blade Battery into a real competitive advantage. The redesign of the LFP cell structure makes the battery safer, longer lasting and more stable in cold weather, while also avoiding materials like cobalt and nickel. This gives BYD a strong value-for-money position in Europe and helps explain the success of models like the BYD Seal U in the PHEV segment. The main drawback is that BYD's fast charging performance is weaker than that of Korean or European rivals, which matters in a market where	Hyundai's approach looks quite different from BYD's. The company builds much of its competitiveness around its 800-V E-GMP platform, which allows very fast charging, good efficiency and strong performance in cold climates. This makes Hyundai one of the fastest-charging brands in the European market. Instead of making its own batteries, Hyundai uses high-energy-density NCM packs from Korean suppliers, which support long ranges but also need more careful charging habits to avoid faster wear. Hyundai also continues to invest in hydrogen technology. Even though FCEVs are still niche in Europe, Hyundai sees

		homogeneous: electrification levels, purchasing power, and charging availability differ significantly between EU Member States. • Intense price–performance competition. • The market in a mature but not yet saturated diffusion stage, favouring incremental and architectural innovation over radical technologies.	charging speed is becoming increasingly important. BYD is trying to close this gap with the next generation of the Blade Battery and with early work on sodium-ion technology, but these improvements are still in progress.	long-term potential in commercial and heavy-duty transport and keeps developing the technology for future opportunities.
	Downstream		On the downstream side, BYD's position is likely to strengthen as it rolls out its Flash Charging network in Europe from 2026. The idea is to make charging faster and easier, especially in places where high-power stations are still hard to find. These new megawatt-class chargers, open to all brands and capable of delivering up to 1,000 kW, could strengthen BYD's competitive position by combining its affordable and reliable cars with significantly better charging options. This move fits well with BYD's wider strategy of not only improving its vehicles but also building the services and infrastructure that support them.	Unlike BYD, Hyundai does not build its own charging network. Instead, it relies on partnerships and is a key member of the IONITY alliance. Through this, Hyundai helps expand Europe's 350-kW charging network and offers lower tariffs to its customers, which improves the ownership experience without the company needing its own infrastructure. This strategy fits well with Hyundai's strong vehicle technology, even if it means the company does not have a proprietary solution comparable to BYD's upcoming Flash Charging network.
Policy & Material Access	Upstream	• Highly concentrated CRM supply (lithium, cobalt, nickel, graphite), with most refining located in China. • Strong European dependence on foreign processing, limiting control over battery-grade materials and pricing. • EU push for battery localisation (cells, recycling, R&D), but progress remains uneven and many projects face delays. • Strict sourcing and traceability requirements increase compliance complexity for globally integrated manufacturers.	BYD benefits from a secure upstream position because it is deeply embedded in China's dominant battery-materials ecosystem. Since China controls most global refining of lithium, cobalt, nickel chemicals and almost all spherical graphite, BYD has reliable access to battery-grade inputs at comparatively stable prices. Long-standing partnerships with Chinese suppliers, together with BYD's in-house LFP Blade Battery and its growing investment in sodium-ion technology, reduce the company's exposure to expensive and supply-constrained materials like cobalt and nickel. As a result, BYD faces significantly lower vulnerability to global raw-material volatility than European or Korean manufacturers, whose supply chains are more geographically dispersed and less secure.	Hyundai's upstream position is strongly shaped by its integration with South Korea's well-developed battery industry. The company relies on major partners such as SK On, LG Energy Solution, and Samsung SDI, whose extensive global supply networks provide access to key minerals — including lithium and nickel — from countries such as Australia, Chile, and Indonesia. This structure offers Hyundai a reasonable degree of diversification. However, it does not fully insulate the company from the sector's broader dependence on China. Most refining and processing of battery-grade materials still takes place in China, which leaves Hyundai exposed to higher procurement costs and fluctuations in global CRM prices. In summary, while Hyundai benefits from strong technological partnerships, it lacks the upstream security that vertically integrated Chinese manufacturers enjoy.
	Downstream	• Fragmented EU subsidy landscape, with many Member States phasing out purchase incentives and shifting to tax-based support. • EU trade-defence measures sharply raise market-entry	In Europe's downstream market, BYD operates under a mixed set of advantages and constraints. On the one hand, BYD's models fully qualify for origin-neutral consumer incentives and tax benefits, which helps maintain competitive pricing in countries that still offer supportive	In the European downstream market, Hyundai operates from a notably favourable position. Under the EU–South Korea Free Trade Agreement, Hyundai vehicles that meet rules-of-origin requirements enter the EU without the standard 10% import tariff. This gives the

		costs for China-built BEVs (10% duty + CVDs). • FTA asymmetry favours Korean manufacturers, whose vehicles enter the EU tariff-free under the EU–Korea FTA. • EU–China WTO dispute adds uncertainty for long-term pricing and market planning. • Policy shift toward rewarding localisation and low-carbon supply chains, reducing competitiveness of imported models.	schemes. On the other hand, almost all BYD vehicles sold in Europe are imported from China, which places the company at a clear disadvantage compared with Korean and European brands. China-built BEVs are subject to the standard 10% import duty plus the EU's countervailing duty introduced in 2024; BYD received the lowest rate (17%), but the added cost is still significant. To mitigate this, BYD has increased exports of its PHEV models, which fall outside the scope of the EU anti-subsidy measures and therefore avoid the additional tariff. This strategy is visible in the market: the Seal U PHEV reached third place in European NEV sales in September 2025. Overall, localisation plans exist, but until European production begins, BYD will continue to face structural cost barriers in the EU market.	company a clear price advantage over manufacturers exporting from China, who face both the standard 10% import duty and, for BEVs, additional countervailing tariffs introduced in 2024. At the same time, Hyundai's NEVs remain fully eligible for national purchase incentives and tax benefits across EU member states. Taken together, these conditions allow Hyundai to compete more effectively on price and reduce the trade-related barriers that weigh on non-FTA producers.
Risk Management, Resilience & Firm Governance	Midstream	• Geopolitical Risks: EU–China tensions, export controls and political uncertainty that affect supply and market access. • Regulatory Risks: Strict and evolving EU rules (CSRD, CSDDD, Battery Regulation, CBAM) requiring high transparency and traceability. • Operational Risks: Logistics disruptions, long shipping distances, port congestion, and recall risks. • Financial Risks: High European labour and energy costs, exchange-rate exposure, and expensive localisation conditions. • Environmental Risks: Strong lifecycle-carbon and recycling requirements increase compliance pressure. • Ethical Risks: High expectations for human-rights due diligence and risk of reputational damage from supplier misconduct.	BYD's midstream resilience and risk management are supported by high vertical integration, which reduces exposure to supply shocks, component shortages and shipping disruptions. Its broad supplier network and long-term moves to secure lithium and other materials add an extra layer of protection, even if some of these initiatives are still in early or strategic stages. European localisation is also becoming a central part of BYD's approach: the new plants in Hungary and Türkiye are expected to start operating soon and should ease both logistical pressure and exposure to EU regulatory measures once they come online. The company also benefits from strong digital systems and well-tested emergency-response capabilities, which has helped BYD recover quickly during earlier disruptions. At the same time, several governance challenges remain. Issues such as selective ESG disclosure, limited insight into deeper supplier tiers and past liquidity pressure on smaller suppliers show that BYD will still need to strengthen its transparency and due diligence practices to fully meet EU expectations.	Hyundai's midstream resilience relies on long-standing partnerships with Korea's major battery makers rather than full vertical integration. This gives the company strong coordination across its supplier network but also leaves it dependent on external partners whose critical minerals still largely come from China. As a result, Hyundai remains vulnerable to upstream geopolitical and price risks. In Europe, Hyundai benefits from a well-established local manufacturing base in Czechia and Türkiye, supported by nearby Korean battery plants. This setup shortens supply lines and helps the company maintain stability during global disruptions. Digitalisation efforts, such as the E-FOREST smart-factory programme, improve visibility inside plants, though full traceability of raw materials is still limited. Hyundai has also demonstrated effective crisis response in earlier supply shocks. Its governance framework is developing in line with EU expectations, but deeper verification and multi-tier transparency will be needed to fully meet new EU due diligence requirements.
Brand & Quality Management	Downstream	• Highly heterogeneous NEV adoption across Europe, with strong Northern European markets but slower uptake in Central and Eastern Europe, shaping very different expectations and levels of familiarity with NEV brands. • Persistent misconceptions about NEV cost, range, and	BYD is still a relatively new brand in Europe, but awareness has grown quickly, supported by major sponsorships and partnerships with established dealer groups. Negative perceptions of Chinese cars remain a challenge, yet BYD's localisation strategy and strong Euro NCAP safety scores help build credibility. The company is expanding a	Hyundai benefits from long-standing brand familiarity and strong trust levels in Europe, supported by decades of localisation and an extensive dealer and service network. The company has successfully positioned its IONIQ sub-brand within the mainstream NEV segment, especially in mature markets where awareness and

		battery life influence purchase decisions even in mature markets. • High reputation barriers: established European brands dominate trust rankings, making entry difficult for newcomers. • Openness to new brands is growing within the NEV segment, especially when price, range or delivery times are attractive. • Chinese brands face low awareness and mixed perceptions, though acceptance is rising among experienced NEV users. • Strong emphasis on after-sales service, software quality and recall handling as key factors in building credibility.	traditional dealer and service network and has introduced European roadside assistance and a Certified Pre-Owned programme to strengthen customer trust. Early feedback highlights solid hardware quality but points to weaknesses in software and the BYD App, which is less mature than its Chinese counterpart. Overall, BYD’s downstream position is improving, but digital maturity and lingering political perceptions continue to influence how the brand is received.	consideration are high. Hyundai maintains established processes for quality control and recall handling, though recent NEV-related recalls show that reliability challenges can still occur as volumes grow. Safety performance remains solid, with most tested models receiving competitive Euro NCAP ratings, even if not always matching top-tier scores. Strong warranty packages further reduce perceived ownership risk, while the main area needing improvement is Hyundai’s digital ecosystem, as user feedback highlights stability issues in the Bluelink App. Overall, Hyundai’s mature downstream systems and strong reputation give it a significantly more secure position in Europe than newer entrants.

3.2.2. Sustainability and Corporate Social Responsibility

Sustainability lies at the core of NEV adoption. Electrification only fulfils its purpose if it is aligned with renewable energy use, environmental protection, and labour standards across every tier of the supply chain. This is why the EU has introduced strict regulatory requirements and pays significant attention to the NEV industry, which represents a key component of the EU Green Deal as a strategic roadmap to environmental protection goals (European Commission 2019).

However, it should be noted that European environmental protection legislation is quite new, having been adopted starting in 2019, and most regulations are still in a transition phase. The EU Battery Regulation (Regulation (EU) 2023/1542) is already in force but only with limited components: the digital battery passport will be required from February 2027 and recycled content minimums from August 2031 (European Union 2023a). The Corporate Sustainability Reporting Directive (CSRD, Directive (EU) 2022/2464) is already binding but must be transposed into national law by all member states by 26 July 2026, and companies will be subject to supervision starting in 2027 (European Union 2022). The full operation of CBAM (Carbon Border Adjustment Mechanism, Regulation (EU) 2023/956) begins on 1 January 2026 (European Union 2023b). The Corporate Sustainability Due Diligence Directive (Directive (EU) 2024/1760) is still in the implementation phase (European Union 2024a). Only the CO_2 Emission Performance Standards for New Cars and Vans (Regulation (EU) 2019/631) have been fully in force since 2019 (European Union 2019). Moreover, greenwashing laws are still under discussion in the European Parliament (European Parliament 2025). The concern is that excessive regulation may not improve environmental protection but may instead have the opposite effect, potentially discouraging companies from adopting environmentally friendly production practices due to the complexity of the approval and compliance processes.

Thus, the process of legislative development in the EU that affects the NEV industry is still ongoing, and many changes may occur within the industry. Current ESG reporting is also in a transition phase. This means that companies have some time to adapt to the requirements until their final implementation. In general, flexibility is required in order to continuously adjust to possible new legislative changes. For firms headquartered outside the European Union, such as BYD and Hyundai, compliance can be more challenging and may necessitate additional administrative and regulatory capacity; however, there is still time for adaptation.

However, Hyundai's Sustainability Report 2025 represents a further step toward fulfilling EU requirements. At the time of writing this master's thesis, BYD's Sustainability Report 2025 was not yet available, which makes a fully comprehensive comparison impossible.

Moreover, one of the major limitations, despite legislative initiatives, is that the majority of the information remains self-reported. Even international organisations such as Amnesty International, Greenpeace, and Human Rights Watch can only infer companies' reporting willingness and the level of auditing and compliance with international norms, while their access to underlying data is also limited.

In the analytical framework, plant-level disclosures were identified as an assessment tool; however, in practice, such disclosures remain very restricted. For example, the 35% green electricity usage target for 2025 mentioned in BYD's Sustainability Report remains largely theoretical without detailed information on its implementation at specific plants (BYD Company Limited 2024, 44). The information provided by companies usually focuses on positive achievements, such as BYD's zero-carbon headquarters in Shenzhen, while performance indicators at the plant level are generally not disclosed (BYD n.d.c). Hyundai reports its participation in the global decarbonisation initiative RE100 (HMC 2024a, 24), which can be considered a more credible commitment than purely internal measures. The company also discloses information on several additional plants; however, the data remain selective and do not provide precise quantitative figures (HMC 2024a, 23).

Many indicators used to support a positive reputation are difficult to evaluate without deep industry knowledge. For example, BYD reports the establishment of two recycling facilities that have processed over 10,000 tons of power batteries, presenting this as a positive achievement (BYD Company Limited 2024, 62). However, to properly assess this claim, information on the total volume of batteries and the treatment of those not recycled would also be required. According to current studies, the efficiency of battery recycling is still not fully proven, as it remains financially burdensome (Ekatpure 2023, 2), and progress in this area is not yet sufficiently stable to draw firm conclusions about whether the widespread use of LFP and NCM batteries in NEVs can be considered environmentally safe.

Similarly, this applies to supply chain due diligence. Companies tend to emphasise areas involving comparatively “safer” critical materials, while often omitting those segments where challenges and risks are more pronounced. For example, BYD discloses audit coverage for Tier 1 suppliers of “3TG” minerals (tantalum, tin, and tungsten) but omits detailed information on suppliers of cobalt, lithium, nickel, and natural graphite. Disclosure regarding Tier 2 and Tier 3 suppliers is also limited (BYD Company Limited 2024, 132). Hyundai is also currently able to provide traceability only at the Tier 1 supplier level, while efforts to extend traceability to lower-tier suppliers are still ongoing (HMC 2024a, 66). Moreover, the company engages in selective disclosure. While the Sustainability Report devotes an entire chapter to inspection efforts related to cobalt and copper mining in the Democratic Republic of Congo, it contains no discussion of nickel sourcing (HMC 2024a, 70). This imbalance suggests that environmental and social efforts related to nickel mining may be less comprehensive or less developed than in other areas; however, the 2025 report introduces plans to address this area in the future (HMC 2025a, 78). The differences are explained by the different types of batteries used, which is why BYD and Hyundai rely on different core critical materials (see Tables 3 and 4 in Appendix B).

Independent third-party assessments provide a more objective benchmark — and here a notable contrast emerges. Both BYD and Hyundai have been accused by various NGOs of insufficient compliance with environmental and human rights standards. In its 2024 evaluation of 13 NEV manufacturers, Amnesty International ranked BYD last and Hyundai third from the bottom. The result is much worse than that of European counterparts (Amnesty International 2024b, 45). S&P Global recognises Hyundai’s sustainability practices as being within the top 1% of the global automobile industry, assigning it a score of 70 out of 100 as of 2024 (S&P Global 2025a). This represents a slight decline from 75 out of 100 in 2023, which was reported during the research phase of this paper (HMC 2024, 11; S&P Global 2024). Nevertheless, the overall score remains high. BYD’s performance is also comparatively solid, with a score of 59 out of 100 (S&P Global 2025b). At the same time, Mercedes-Benz and Tesla — both ranked highest by Amnesty International (Amnesty International 2024b) — receive significantly lower ESG scores from S&P Global, at 45 and 28 respectively (S&P Global 2025c; S&P Global 2025d). The divergence between S&P Global and Amnesty International arises because they measure different dimensions of corporate sustainability: S&P evaluates broad ESG governance and disclosure systems, where Hyundai excels, while Amnesty International focuses narrowly on human-rights due diligence in mineral supply chains, where Tesla and Mercedes exhibit relatively stronger transparency. This pattern also indicates that BYD's and Hyundai's competitors still exhibit comparatively low levels of ESG disclosure and governance-system maturity, as reflected in their weaker performance in S&P Global's ESG assessment. The emerging EU regulatory framework is likely to pose significant challenges for the rival companies as well.

Thus, the future expansion of BYD and Hyundai in the European market depends not only on successful alignment with European legislation but also on broader shifts in industry perceptions regarding sustainability and social responsibility issues. The latest report by Transport & Environment may already trigger such changes, as it reveals that plug-in hybrids — long considered a suitable transitional alternative to internal combustion engine vehicles — are significantly more polluting than previously assumed, with real-world emissions close to those of petrol cars. This finding suggests that PHEVs, as one category of NEVs, have been substantially overrated as a transition technology and that EU regulatory frameworks relied on fundamentally flawed testing assumptions (Transport & Environment 2025, 14-15).

3.2.3. Innovation and Competitiveness

This section of findings relates more strongly to technological metrics, which is why it is more robust and less speculative than the previous one. The main conclusion is relatively straightforward: stronger technological performance at a lower price is highly valued and enhances competitiveness. Nevertheless, several points still require consideration.

Firstly, real-world performance can differ significantly from metrics reported on paper. For example, the WLTP range represents the distance a NEV can travel on a single charge under the WLTP testing cycle, which is a standardised laboratory procedure used in the EU and many other markets to estimate energy consumption and emissions (European Commission 2025a). However, real-world performance can vary substantially depending on factors such as temperature, speed, driving style, and the use of climate control. The same applies to other metrics, particularly expected battery life cycles. In general, NEVs have not been on the market long enough to allow for firm conclusions regarding whether promised performance metrics remain reliable in the long term. Especially in the case of new entrants, the promise of exceptionally high performance metrics at very low prices can raise concerns about their credibility. Companies with a longer presence in the NEV market are better positioned to rely on real-world operational evidence. For example, BYD vehicles have been deployed in large-scale fleets in China for over a decade, which provides a more reliable basis for assessing the long-term durability and longevity of reported performance metrics. By contrast, Hyundai, as a manufacturer historically focused on internal combustion engine vehicles, began its transition to NEVs significantly later, which reduces the relative availability of long-term real-world data and weakens the robustness of its long-run performance assessments. A clear example of how new findings can contradict manufacturers' claims was discussed earlier in the case of PHEVs, which were found to be significantly more costly and environmentally harmful than initially claimed (Transport & Environment 2025, 14–15). The risk of similar discrepancies remains high in a rapidly expanding but still insufficiently mature NEV industry.

Secondly, the various studies show that fast charging is consistently associated with accelerated lithium-ion battery ageing due to increased electrochemical and thermal stress, although the magnitude of degradation depends on charging rate, battery chemistry, and battery management systems (Bhagavathy et al. 2021; Bruj and Calborean 2025; Leijon 2025).. Battery-related concerns are important not only for consumers but also for policymakers assessing the overall sustainability of NEVs. Bhagavathy et al. (2021, 2) provide an explicit comparison of degradation patterns in NCM batteries — predominantly used by Hyundai — and LFP batteries, which are mainly used by BYD, empirically demonstrating that LFP chemistry is more robust under fast charging conditions than NCM. Leijon (2025, 11) also emphasises the role of battery chemistry, noting that NCM batteries are particularly sensitive to issues associated with fast charging. Similarly, the study by Bruj and Calborean (2025, 16), which focuses exclusively on NCM batteries, confirms accelerated battery ageing caused by frequent fast charging.

Overall, this does not represent a definitive limitation. Leijon (2025, 10) outlines several mitigation strategies to reduce battery ageing under fast charging conditions. Nevertheless, fast charging remains a critical issue that must be taken into account. At present, fast charging — and especially planned ultra-fast charging — solutions are not optimal for many NEV models currently available on the market. Consequently, BYD's planned ultra-charging network in Europe faces inherent limitations, but it may also create opportunities for BYD if the company succeeds in further improving its LFP Blade Battery technology to reliably withstand extremely high charging rates without accelerating degradation. However, it remains too early to assess how such systems will perform under real-world conditions.

In any case, this area represents a key field for technological innovation and may lead to significant competitive shifts in the NEV market, favouring manufacturers that achieve the most effective battery–charging integration.

Finally, the growing dependence on software introduces an additional challenge related to innovation in the NEV industry. Core vehicle functions — such as driving modes, charging management, and heating — are increasingly controlled by software. When this software is unstable, slow, or prone to bugs, a vehicle's functional usability may deteriorate even if its mechanical components remain fully operational. This phenomenon is often compared to a "smartphone effect", whereby a device becomes frustrating or impractical to use when system performance degrades — an experience that traditional car users do not typically associate with automobiles (Consumer Reports 2022, 5).

The analytical framework also proposed comparing not only vehicle-level innovations but also manufacturing efficiency. However, a systematic comparison proved impractical due to highly uneven disclosure practices. Plant-level performance data are rarely reported in a consistent or comparable manner, making it almost impossible to assess manufacturing efficiency across firms on a reliable basis. For this reason, manufacturing efficiency was not included as a separate analytical dimension in the empirical analysis.

3.2.4. Policy and Material Access

This section shows that competitiveness in the NEV industry is shaped not only by technological innovation, but increasingly by policy decisions, geopolitical developments, and access to critical raw materials. These factors shape long-term outcomes more than short-term market conditions.

Geopolitics plays a central role in access to battery materials. The supply of lithium, cobalt, nickel, and graphite is highly concentrated. China controls a large share of global refining and processing (EPRS 2025, 4). Because of this, access to battery-grade materials is no longer only an economic issue. It is also a strategic and political one. The European Union remains dependent on external suppliers, while at the same time it introduces stricter rules on sourcing, traceability, and sustainability. This combination increases pressure on manufacturers that rely on global supply chains. In this context, localisation in Europe appears to be the safest long-term option, even though it is not the most cost-efficient one. This issue is discussed in more detail in the Risk Management section.

In order to reduce dependence on the third-country battery production, the European Union supports projects about the local battery production, but the expectations that Europe will become self-sufficient in battery production remain uncertain (Wicke, Weymann, and Neef 2025). Upstream processing still takes place outside Europe. This means that Chinese and Korean manufacturers are likely to keep an advantage in battery materials, processing know-how, and supply chain integration in the medium term. European policy may reduce this gap over time, but it is unlikely to remove it in the near future.

These conditions affect BYD and Hyundai in different ways. BYD benefits from close integration with China's battery ecosystem and from its in-house battery production. This reduces exposure to raw-material price swings. At the same time, it increases exposure to European trade measures and geopolitical tensions. Hyundai relies on a more diversified supplier base and benefits from the EU–South Korea Free Trade Agreement, which lowers tariff risks. However, Hyundai still depends on battery materials processed in China, which limits supply chain independence.

Overall, policy frameworks and access to critical materials shape competitiveness in a structural manner. Geopolitical tensions are increasingly difficult to predict in today's turbulent environment. While the European Union possesses strong regulatory leverage that allows it to exert significant influence over foreign firms, the EU's own regulatory trajectory — particularly the commitment to a full transition toward electric mobility — also places it in a position of dependence on critical raw materials and battery production. As a result, the relationship between the EU and external NEV producers is best characterised as one of mutual interdependence, requiring continuous diplomacy and negotiation. Firms that are able to manage political risk, secure stable access to materials, and comply with evolving regulatory requirements are therefore better positioned to compete successfully in the European NEV market.

3.2.5. Risk Management, Resilience and Firm Governance

This section builds on the previous analysis and offers a short commentary on the risk management patterns identified in Table 2, Analytical Comparison of BYD and Hyundai Across Supply Chain Dimensions. It focuses on how NEV manufacturers manage risk and build resilience across their supply chains in response to geopolitical, regulatory, operational, financial, environmental, and ethical challenges.

BYD and Hyundai are both pursuing strategic localisation in Europe to mitigate multiple types of risk by aligning their operations with European legislation. However, Hyundai's localisation efforts are far more mature, supported by well-established manufacturing facilities, whereas BYD is only at an early stage of this process, with production in Hungary and Türkiye expected to begin in 2026. In light of the recent unfavourable findings on PHEV emissions — with PHEVs currently accounting for a significant share of BYD's European sales — establishing European manufacturing capacity becomes particularly important, both to enhance regulatory alignment and to circumvent anti-subsidy measures.

Despite similar localisation goals, the two companies differ significantly in their governance models. BYD is characterised by strong vertical integration. The company produces key components in-house and keeps close control over its battery supply chain. This reduces exposure to external supply shocks, shipping delays, and short-term material shortages.

However, vertical integration also has its limitations. It is cost-intensive because of high R&D spending and constant pressure to stay ahead in every aspect of technology. Smart partnerships can help to share these burdens. Without them, vertical integration can weaken financial flexibility, increase operational risks, and slow adaptation to changing market demand. A more closed supply chain structure may also lead to inefficiencies in upstream procurement. BYD appears to be aware of these issues and has started to move toward a slightly more open supply chain model (Yu 2024, 94).

Hyundai follows a different risk management approach. Instead of full vertical integration, the company relies on long-standing partnerships with major Korean battery suppliers. Several of these partners have established production capacity in Europe, which shortens supply chains and improves operational stability in the European market. This multi-partnership model supports coordination, flexibility, and risk sharing, and reduces dependence on any single supplier. At the same time, Hyundai remains exposed to upstream risks linked to external partners and the concentration of battery-material processing in China. In addition, Hyundai's participation in the IONITY charging network strengthens downstream resilience by improving access to high-power charging infrastructure while sharing investment and operational risk rather than bearing it alone.

Both companies still lack full traceability of raw materials. Deeper multi-tier verification will be required under the new EU due diligence rules. Digitalisation efforts and emergency-response practices can be observed in their relatively quick recovery from earlier disruptions, but these capabilities are difficult to assess without access to internal company mechanisms. As a result, conclusions about long-term resilience should be interpreted with caution.

3.2.6. Brand and Quality Management

Research on NEV acceptance and brand perception in Europe is more extensive than might be expected for a relatively young market segment. The available empirical studies provide a sufficiently strong basis to draw informed conclusions about the role of branding in European automotive markets. This reflects the fact that brand perception has long played a central role in vehicle purchasing decisions in Europe, where established manufacturers have shaped consumer expectations of quality, safety, and reliability.

Within this context, Hyundai benefits from its long-standing presence in the European market. The brand is well known to consumers and is associated with established service networks and a predictable ownership experience. This familiarity reduces perceived risk and supports acceptance of Hyundai's NEV models, particularly among mainstream buyers.

BYD, by contrast, remains a relatively new entrant in the European passenger-car market, but consumer awareness has increased rapidly. Unlike manufacturers that entered electrification gradually, BYD is positioned as a dedicated NEV producer. This clear specialisation supports an innovation-oriented brand image and signals technical focus in electric mobility, which can strengthen credibility among early adopters and more experienced NEV users.

Moreover, BYD has achieved strong Euro NCAP safety ratings across all tested models, which helps build confidence among European consumers. Consistently high safety scores provide a clear and credible quality signal, which is particularly important for a relatively new brand entering mature automotive markets. Hyundai's Euro NCAP results are also solid and confirm a generally high level of vehicle safety. However, in the compact segment, Hyundai's ratings tend to be slightly weaker than the ratings of BYD's comparable models, which may influence relative safety perceptions in this highly competitive category.

Both brands offer relatively extensive warranty packages, but evaluating after-sales service remains very difficult. There are no reliable comparative studies available. Observations based on customer reviews point to weaknesses in software-related issues; however, this approach is academically highly superficial, which means that any conclusions drawn from it remain limited.

Recall systems, particularly in Europe, are also difficult to assess comprehensively. BYD has faced few recall cases in Europe so far, but the overall sales volume remains too low to allow for robust conclusions. Hyundai, by contrast, has an established European recall infrastructure, which suggests a more mature and potentially more reliable response capability.

Hyundai also benefits from its long-established position in Europe. As a solid and well-known brand that is consistently ranked among the top ten manufacturers by European sales, and one that is not associated with strong negative political sentiment, Hyundai has more reputational margin for error. Occasional mistakes are unlikely to be fatal for the brand. BYD, by contrast, faces a much narrower margin. As a new Chinese entrant to the European market, it must act with far greater caution, as even minor failures — whether related to quality, software, or compliance — can have a disproportionate negative impact on its reputation. At the same time, the situation also works in the opposite direction. For Hyundai, it is more difficult to move beyond the perception of being "solid but just okay", as established brands often struggle to create strong shifts in consumer perception. BYD, by contrast, still has room for more dramatic change: as a new entrant in a rapidly evolving industry, it has greater potential to reshape its image and reposition itself, precisely because the NEV market remains highly dynamic and unsettled.

3.2.7. Synthesis of Analytical Findings

This section synthesises the main analytical findings of the research and assesses the extent to which they correspond to the initial expectations outlined in the research design. It does not serve as a final conclusion, but rather as a structured reflection on the outcomes of the analytical framework and their alignment with the expected results.

With regard to sustainability and corporate social responsibility, it was initially expected that BYD would demonstrate relatively strong recycling initiatives due to its high level of vertical integration, while simultaneously facing challenges related to upstream traceability, third-party audits, and labour-standard verification among external suppliers. Overall, these expectations were largely confirmed. BYD does indeed demonstrate tangible recycling initiatives, although it remains difficult to assess the future impact of these actions, and the traceability of mining sites and upstream suppliers remains limited. Hyundai, by contrast, was expected to show stronger alignment with EU disclosure requirements and ESG audit frameworks due to its established partnership structures within the Korean industrial ecosystem. Recycling initiatives were expected to progress more slowly. In general, this assessment also proved accurate, although Hyundai's level of compliance with emerging EU sustainability frameworks appears, in some areas, to be less advanced than initially anticipated. Nevertheless, both firms retain significant scope for improvement as regulatory frameworks continue to mature.

From an innovation perspective, the expectations were largely met. Both companies demonstrate distinct technological strengths, while neither pursues an aggressive strategy of offering disruptive 'premium breakthroughs' at unusually low prices, as observed among some newer market entrants. Instead, both firms follow relatively moderate innovation strategies aimed at conveying technological reliability and corporate solidity. BYD's battery systems underperform in terms of charging speed and driving range, but offer high safety levels and long service life. Hyundai's battery systems, by contrast, enable faster charging and longer range, but tend to degrade more quickly and fall behind BYD's Blade Battery in terms of safety performance. An unexpected development was BYD's ambitious plans to deploy ultra-fast charging infrastructure in Europe, which could represent a significant strategic breakthrough if successfully implemented.

The findings related to policy frameworks and material access fully correspond to initial expectations, particularly with regard to the concentration of critical raw materials in China, the impact of anti-subsidy measures, and the role of free trade agreements. These factors demonstrably influence production structures, distribution strategies, and overall supply chain reliability. Developments in this area remain largely unpredictable, as they depend on geopolitical dynamics, diplomatic relations, and strategic efforts to secure long-term access to materials under stable conditions. Accordingly, this thesis reflects the situation at the time of writing and deliberately avoids speculative assumptions about future developments.

Risk management and resilience considerations effectively integrate the findings of the preceding analytical dimensions by examining how firms seek to mitigate structural vulnerabilities. Here, expectations were fully confirmed. BYD is actively pursuing European localisation strategies, although these processes are still at an early stage. Hyundai, in contrast, already benefits from established European production facilities and dense partnership networks, including collaborations with other Korean firms operating within Europe. A noteworthy additional finding was BYD's increasing cooperation with European suppliers, particularly Italian firms, indicating a more diversified localisation approach than initially anticipated.

Regarding brand reputation and market perception, BYD's recognition in Europe has grown at a surprisingly rapid pace. Challenges related to after-sales service are being addressed primarily through the expansion of strong dealer networks. As expected, Hyundai benefits from a well-established service infrastructure and competitive warranty conditions. A particularly interesting finding concerns customer dissatisfaction with software systems at both firms. This is notable given the common perception of Asian high-tech companies as software-driven innovators. BYD faces significant challenges in adapting its software ecosystems to European user expectations, while Hyundai's difficulties stem largely from transitioning legacy software architectures originally developed for internal combustion vehicles to NEV-specific platforms.

Overall, despite facing some comparable challenges as East Asian entrants into the European market, BYD and Hyundai follow fundamentally different strategic pathways shaped by their governance structures, industrial backgrounds, access to critical materials, and exposure to European trade remedies. The most significant shared factor is their strong commitment to European localisation and brand positioning through "Made in Europe" strategies, aimed at increasing acceptance and legitimacy among European consumers.

3.3. Research Relevance

The findings of this research are relevant to several groups of stakeholders. First, they are relevant for EU policymakers whose objective is to design more effective sustainability-, environmental-, and socially oriented regulations. This research contributes to a better understanding of how current regulatory frameworks affect the strategies and initiatives of third-country NEV manufacturers, as well as how these developments influence the internal economic environment of the EU. In this context, the analysis may support efforts to balance environmental and social protection goals with the need to maintain economic stability, competitiveness, and healthy market conditions within the European Union.

Second, the case study firms, BYD and Hyundai, may benefit from the detailed analysis of their supply chain strategies in Europe by gaining an external academic perspective on areas requiring further improvement. The findings are equally relevant for other NEV manufacturers entering the European market, as they provide insights into common entry barriers and illustrate alternative strategic approaches to supply chain management within the EU regulatory environment.

Suppliers and logistics partners, particularly potential European partners, may also benefit from the research by assessing the reliability and strategic orientation of potential partnerships. The same applies to dealers, investors, and financial institutions, for whom an understanding of supply chain resilience and regulatory exposure is essential for risk evaluation and long-term decision-making.

Consumers and fleet operators in the EU may use the findings to assess the strategic models adopted by these manufacturers, as well as the challenges faced by new market entrants, and to evaluate how these firms respond to environmental, social, and quality-related expectations.

Finally, and arguably most importantly, the research is relevant to academia. The analysis identifies multiple avenues for future research, including the assessment of NEV adoption effectiveness in Europe, the implementation and long-term impact of European regulatory frameworks, the prospects of sodium-ion and fuel-cell electric vehicle technologies in the European market, and the still under-researched field of after-sales customer satisfaction and its influence on purchasing decisions. As the NEV industry remains relatively young, there is substantial potential for further research across economic, technological, social, and political dimensions.

3.4. Research Limitations

This research was conducted within the framework of a master's thesis for the programme "Economy and Society of East Asia" at the University of Vienna. As a result, the study is subject to several inherent limitations, including restricted access to certain materials, time constraints, and formal limitations related to scope and length, making it impossible to address all potentially relevant aspects of the topic.

One of the primary challenges encountered in this research was the interpretation of measurement frameworks used across different statistical sources, as well as the need to clearly distinguish between data referring exclusively to the EU and data covering the EU together with the UK and EEA countries, which are often collectively labelled as "Europe". Although the main objective of this thesis is to analyse the EU market — where EU regulations apply directly — statistical data for the UK or for combined EU–UK–EEA regions were occasionally used when EU-only data were not available. This inconsistency may affect the comparability of certain findings and, consequently, the overall interpretation of the results.

A similar limitation arises from the differentiation between Hyundai Motor Group, which includes Hyundai, Kia, and other sub-brands, and Hyundai Motor Company as a single brand. While some data sources clearly distinguish between individual brands within the group, others report performance indicators at the group level by aggregating results across multiple brands. In this thesis, efforts were made to maintain a clear distinction between brands, particularly because Hyundai and Kia offer substantially different vehicle portfolios and branding strategies. However, in cases where disaggregated data were not available, combined group-level statistics were used. These instances are explicitly indicated in the analysis.

Although the EU constitutes a legally integrated single market, it remains highly heterogeneous in practice, with significant differences across Member States in terms of consumer preferences, income levels, charging infrastructure availability, regulatory enforcement, and market maturity for NEVs. The differences across all 27 Member States are too complex to be fully captured within the scope of this research.

In addition, this research does not analyse marketing events, advertising campaigns, or country-specific promotional strategies. Marketing practices in the European Union automotive market vary significantly across Member States due to differences in consumer culture, media landscapes, regulatory constraints, and market maturity for NEVs. A systematic comparison of marketing activities would therefore require a separate analytical framework and country-level data that go beyond the scope of this thesis. Instead, branding is analysed primarily through structural factors such as brand awareness, reputation, safety ratings, warranty policies, and after-sales systems, which are more closely linked to supply chain management and are more comparable across the EU context.

The information related to rival companies presented in this research is intended solely to provide a contextual overview, and these firms were not analysed in detail. Moreover, as a student researcher, access to certain proprietary or high-cost data sources was limited. For example, attempts to obtain detailed battery market reports from SNE Research were unsuccessful, as these materials are available only to business customers and require subscription fees amounting to several thousand euros. This restricted access may limit the depth of comparative analysis in certain areas.

Finally, several issues related to the research topic were not analysed in depth due to time and scope limitations. This study focuses primarily on competition within the NEV industry and therefore does not comprehensively address competition between NEVs and internal combustion engine (ICE) vehicles. Moreover, certain aspects, such as gender diversity within manufacturers' governance structures or the protection of customer data and privacy, were not examined. A detailed financial analysis was also beyond the scope of this research.

3.5. Conclusion

This thesis examined how East Asian new energy vehicle manufacturers, specifically BYD and Hyundai, use supply chain management strategies when expanding into the European Union market. The analysis focused on sustainability, innovation, access to materials, regulation, risk management, and downstream market factors in order to understand how different corporate structures perform under EU market conditions.

The results show that BYD and Hyundai follow very different paths into the European market. BYD relies on strong vertical integration and internal control over key technologies. It has begun localisation in Europe, but this process is still at an early stage. At the same time, BYD shows long-term ambition, not only in vehicle production but also through planned investments in European charging infrastructure. While vertical integration supports coordination and governance control, BYD still faces challenges related to upstream transparency, regulatory adaptation, and alignment with European market expectations.

Hyundai follows a different path. As an older and well-established firm in Europe, it benefits from long-standing European production sites, supplier networks, and partnerships. This structure supports regulatory stability and market trust, but it also adds complexity and slows the transition from internal combustion platforms to NEV-focused systems. These differences also shape brand positioning. BYD benefits from a clear NEV identity, while Hyundai relies on trust built over many years in the European market.

In response to the research question, the findings show that there is no single supply chain strategy that guarantees success in the EU market. Each firm enters the market with different starting conditions. Overall, successful expansion depends on how well companies adapt their structures and strategies to European conditions. Governance models, localisation efforts, risk management, and regulatory compliance all play an important role. Both BYD and Hyundai adjust their supply chains to the EU context, especially through localisation and sustainability measures. However, their outcomes differ due to their industrial background, access to critical materials, experience with EU institutions, and broader geopolitical relations, which remain difficult to predict.

The analysis also shows that innovation, sustainability, regulation, and branding are closely connected. Innovation not only improves performance and cost efficiency, but also helps reduce sustainability risks by extending battery lifetimes and improving recyclability. Sustainability efforts also influence how brands are perceived in Europe. Transparent sourcing, recycling initiatives, and compliance with EU rules shape trust among consumers, dealers, and public institutions. Choices between battery technologies, such as LFP and NCM, affect not only charging speed and driving range, but also safety, battery lifespan, environmental impact, and labour-related risks.

The findings indicate that earlier concerns regarding the rapid and inevitable dominance of Chinese NEV manufacturers in Europe—which informed the introduction of trade defence measures—are no longer prevalent under current market conditions. Cost advantages alone are no longer sufficient. Regulation, political dynamics, and institutional factors now play a much stronger role. As a result, future market outcomes may change significantly as regulatory frameworks evolve. In the long term, only firms with strong resilience and the ability to adapt to regulatory and market changes are likely to maintain stable positions.

Overall, the European market cannot be treated as a single homogeneous space. It is a system of interconnected national markets with different preferences, levels of infrastructure, and regulatory practices. Technology choices, sustainability goals, regulation, supply chain structures, and brand perception influence each other across this system. Firms that fail to address these challenges together face clear limits in such a competitive environment. By comparing BYD and Hyundai, this thesis shows how East Asian manufacturers adapt their supply chains to the European context. The findings are relevant for policymakers, industry actors, and researchers working on sustainable mobility and supply chain governance in the European Union.

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Appendix A – Abstract

English Version

This thesis examines how leading East Asian new energy vehicle (NEV) manufacturers adapt their supply chain management strategies when expanding into the European Union market. Focusing on BYD from China and Hyundai Motor Company from South Korea, the research analyses how differing corporate structures, governance models, and strategic priorities influence their ability to comply with EU regulatory frameworks and compete in a highly regulated environment.

The study applies a comparative analytical framework covering sustainability and corporate social responsibility, innovation and technological performance, policy and material access, risk management and supply chain resilience, as well as downstream market factors such as brand perception and consumer acceptance. By combining academic literature, policy documents, and corporate disclosures, the thesis assesses how these dimensions interact within each company's supply chain configuration.

The findings suggest that BYD and Hyundai pursue fundamentally different expansion strategies. BYD relies on a high degree of vertical integration and internal control over key technologies, which provides cost and coordination advantages but also raises challenges related to transparency and regulatory alignment. Hyundai, by contrast, follows a more decentralised and partnership-based supply chain model that supports regulatory compliance but may limit flexibility and speed of adaptation. Overall, the analysis demonstrates that supply chain structure plays a decisive role in shaping NEV manufacturers' competitiveness in the EU market these days.

German Version

Diese Masterarbeit untersucht, wie führende ostasiatische Hersteller von New Energy Vehicles (NEVs) ihre Lieferkettenstrategien anpassen, um in den Markt der Europäischen Union zu expandieren. Im Mittelpunkt stehen BYD aus China und die Hyundai Motor Company aus Südkorea. Analysiert wird, wie unterschiedliche Unternehmensstrukturen, Governance-Modelle und strategische Prioritäten ihre Fähigkeit beeinflussen, EU-Regulierungen einzuhalten und sich in einem stark regulierten Marktumfeld zu behaupten.

Die Arbeit verwendet einen vergleichenden analytischen Rahmen, der Nachhaltigkeit und Corporate Social Responsibility, Innovation und technologische Leistungsfähigkeit, politische Rahmenbedingungen und Materialzugang, Risikomanagement und Lieferkettenresilienz sowie nachgelagerte Marktfaktoren wie Markenwahrnehmung und Konsumentenakzeptanz umfasst. Auf Basis wissenschaftlicher Literatur, politischer Dokumente und unternehmensbezogener Berichte wird untersucht, wie diese Dimensionen innerhalb der jeweiligen Lieferkettenkonfiguration zusammenwirken.

Die Ergebnisse zeigen, dass BYD und Hyundai grundlegend unterschiedliche Expansionsstrategien verfolgen. BYD setzt auf einen hohen Grad vertikaler Integration und interne Kontrolle über Schlüsseltechnologien, was Kosten- und Koordinationsvorteile bietet, jedoch auch Herausforderungen hinsichtlich Transparenz und regulatorischer Anpassung mit sich bringt. Hyundai hingegen verfolgt ein stärker dezentralisiertes und partnerschaftsbasiertes Lieferkettenmodell, das die regulatorische Konformität und Marktlegitimität unterstützt, jedoch die Flexibilität und Anpassungsgeschwindigkeit begrenzen kann. Insgesamt verdeutlicht die Analyse, dass die Struktur der Lieferkette eine maßgeblich zentrale Rolle für die Wettbewerbsfähigkeit von NEV-Herstellern im EU-Markt spielt.

Appendix B

Table 3 Comparative Specifications and Market Positioning of BYD Models and Key Rivals in Germany

BYD Model (and segment)	Starting Price (Germany, €)	WLTP Range (km)	Battery (Type, kWh)	Cargo Vol. (L)	0-100* (sec)	Charge Speed (km/h)	Safety (Euro NCAP)	Rival Price (Germany, €)	Rival WLTP Range*	Rival Battery	Rival Cargo Vol.	Rival 0-100*	Charge Spead (km/h)	Safety (Euro NCAP)
BYD Dolphin Surf (B-Compact)	22990-30990	220-310	BYD BLADE 400 V 30-43,2	308 (max. 1307)	12,1-9,1	260	5 stars	Hyundai Inster Standard – 23900	327	NCM 400 V 39 kWh	280 (max. 1059)	11,7	360	4 stars
								Renault 5 E-Tech 40kWh 120hp – 27900	303	NCM 400 V 42 kWh	326 (max. 1000)	9	340	4 stars
								Fiat 500e Hatchback 42 kWh – 34990	331	NMC 400 V 42 kWh	185 (max. 550)	9	390	4 stars
BYD Atto 2 (B-Compact)	31990	312	BYD BLADE 400 V 51,1	400 (max. 1340)	7,9	260	Not available	Skoda Erloq 50 – 33900	350	NCM 400 V 52 kWh	470 (max. 1580)	9	500	Not available
								Leapmotor B10 67.1 kWh – 32400	435	LFP CATL	430 (max. 1700)	8	580	Not available
BYD DOLPHIN (C-Compact)	34,640	427	BYD BLADE 400 V 62	345 (max. 1310)	7	400	5 stars	MG MG4 Electric 64 kWh – 39990	435	NCM 400 V 64 kWh	363 (max. 1177)	7,9	630	5 stars
								Volkswagen ID.3 Pure – 33330	357	NCM 400 V 55 kWh	385 (max. 1267)	8,2	520	5 stars
BYD ATTO 3 (C-Compact)	38990	420	BYD BLADE 400 V 62	440 (max. 1338)	7,3	390	5 stars	Kia EV3 Standard Range – 35990	414	NCM 400 V 58,3 kWh	460 (max. 1251)	7,5	450	5 stars
								Peugeot e-2008 54 kWh – 40550	397	NCM811 400 V 54 kWh	434 (max. 1467)	9,1	480	Not available
								Changan Deepal S05 RWD – 38990	485	LFP 400 V 68,8 kWh	492 (max. 1250)	7,5	700	Not available
BYD SEAL U (D-Large)	41990-44990	420-500	BYD BLADE 400 V 73-89	552 (max. 1440)	9,6-9,3	340-390	5 stars	Tesla Model 3 RWD – 40970	520	CATL LFP64 400 V 64 kWh	594 (max. 977)	6,1	770	5 stars
								Hyundai Kona Electric 65 kWh – 47190	514	NMC 400 V 65 kWh	466 (max. 1300)	7,8	480	4 stars
BYD SEAL (D-Large)	46990-52990	460-520	BYD BLADE 800 V 63-84	400 (max. 1440)	7,5-3,8	420-510	5 stars	Tesla Model Y RWD – 45970 (discounted)	500	CATL LFP64 400V 64 kWh	854 (max. 2138)	5,9	650	Not available
								Hyundai IONIQ 5 84 kWh RWD – 51650	515	NCM 800V 84 kWh	520 (max. 1580)	7,5	1110	5 stars
BYD SEALION (D-Large)	47990-58990	482-502	BYD BLADE 800 V 82,5-91,3	578 (max. 1789)	6,7-4,5	550-770	5 stars	Mercedes-Benz CLA 250+ – 55859	792	NCM 800 V 90 kWh	405 (max. no data)	6,7	1530	Not available
								BMW iX1 xDrive30 – 55000	417	NMC 400V 66,5 kWh	490 (max. 1495)	5,6	530	Not available
BYD TANG (E-Executive)	69715	530	BYD BLADE 800 V 111	235 (max. 1655)	4,9	400	5 stars	XPENG G9 AWD Performance – 72600	540	LFP 800V 93,1 kWh	660 (max. 1576)	4,2	1620	Not available
								Audi Q6 SUV e-tron performance – 68800	641	NCM811 800V 100 kWh	526 (max. 1517)	6,6	930	5 stars

Source: Compiled by the author based on data from the EV Database (ev-database.org) (only available models for sale on 13 November 2025)

Table 4 Comparative Specifications and Market Positioning of Hyundai Models and Key Rivals in Germany

Hyundai Model (and segment)	Starting Price (Germany, €)	WLTP Range (km)	Battery (Type, kWh)	Cargo Vol. (L)	0-100* (sec)	Charge Speed (km/h)	Safety (Euro NCAP)	Rival Price (Germany, €)	Rival WLTP Range*	Rival Battery	Rival Cargo Vol.	Rival 0-100*	Charge Spead (km/h)	Safety (Euro NCAP)
Hyundai INSTER (A-Mini)	23900-25400	327-370	NCM 400 V 39-49	280-351 (max. 1059)	11,7-10,6	360-430	4 stars	BYD Dolphin Surf 30 kWh Active – 22990	220	BYD BLADE 400 V 30	308 (max. 1307)	12,1	260	5 stars
								Renault 5 E-Tech 40kWh 120hp – 27900	303	NCM 400 V 42 kWh	326 (max. 1000)	9	340	4 stars
								Citroën ë-C3 Comfort Range 44 kWh– 23300	326	LFP 400 V 44 kWh	310 (max. 1200)	11,5	330	Not available
Hyundai Kona Electric (B-Compact)	41990-47190	377-514	NMC 400 V 48-65 kWh	466 (max. 1300)	8,8-7,8	280-480	4 stars	Leapmotor B10 67.1 kWh – 32400	435	LFP CATL	430 (max. 1700)	8	580	Not available
								Tesla Model 3 RWD – 40970	520	CATL LFP64 400 V 64 kWh	594 (max. 977)	6,1	770	5 stars
								BYD SEAL U 71,8 kWh– 41990	420	BYD BLADE 400 V 73 kWh	552 (max. 1440)	9,6	340	5 stars
Hyundai IONIQ 5	43900-59400	440-495	NMC 800 V 63-84 kWh	520 (max. 1580)	8,5-5,3	800-1090	5 stars	Mercedes-Benz CLA 250+ – 55859	694	NCM 800 V 90 kWh	405 (max. no data)	6,7	1530	5 stars
								BYD SEAL 82.5 kWh RWD Design – 48990	570	BYD BLADE 800 V 84 kWh	400 (max. 1440)	5,9	560	5 stars
Hyundai IONIQ 6	43900-61000	429-513	NMC 800 V 53-77,4 kWh	401 (max. no data)	8,8-5,1	780-1150	5 stars	Tesla Model Y RWD – 45970 (discounted)	500	CATL LFP64 400V 64 kWh	854 (max. 2138)	5,9	650	Not available
								BYD SEALION 7 91.3 kWh AWD Excellence – 58990	502	BYD BLADE 800 V 91,3	578 (max. 1789))	4,5	550	5 stars
								Changan Deepal S05 RWD – 38990	485	LFP 400 V 68,8 kWh	492 (max. 1250)	7,5	700	Not available
Hyundai IONIQ 9	68500-86750	600-620	NMC 800 V 110,3	338 (max. 2419)	9,4-5,2	840-870	5 stars	BYD TANG Flagship – 69715	530	BYD BLADE 800 V 111 kWh	235 (max. 1655)	4,9	400	5 stars
								Audi Q6 SUV e-tron performance – 68800	641	NCM811 800V 100 kWh	526 (max. 1517)	6,6	930	5 stars
Hyundai IONIQ 5 N	74900	448	NMC 800 V 84	480 (max. 1540)	3,4	960	5 stars	Tesla Model Y Performance – 62970	580	NCM LG 5M 400V 82 kWh	854 (max. 2138)	3,8	660	Not available
								Polestar 4 Long Range Dual Motor	570	NCM811 400V 100 kWh	526 (max. 1536)	3,8	650	5 stars

Source: Compiled by the author based on data from the EV Database (ev-database.org) (only available models for sale on 13 November 2025)