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SECTORAL FINANCIAL ANALYSIS OF THE AUTOMOTIVE INDUSTRY: INSIGHTS INTO FINANCIAL AND OPERATIONAL DYNAMICS

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Abstract

This thesis examines the financial and operational performance of traditional automakers versus pure-play EV manufacturers amid the automotive industry's shift to electrification. Using advanced benchmarking and econometric analysis, it highlights key differences in growth, profitability, and macroeconomic sensitivities. Findings reveal EV firms' superior innovation capacity but higher volatility, contrasted with traditional OEMs' operational resilience. The study also uncovers electrification's impact on value chains and capital structures, offering actionable insights for navigating industry transformation. By integrating innovative methods, this research provides a framework for understanding the evolving dynamics of a sector poised for continued disruption and innovation.

Keywords (Automotive Industry, Sectoral Financial Analysis, EV-Manufacturers, Traditional Manufacturers)

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1 Introduction

The global automotive industry is undergoing a profound and urgent transformation. Long characterized by internal combustion engine (ICE) technologies, century-old production paradigms, and deeply entrenched value chains, the sector now faces a complex convergence of forces demanding strategic recalibration on an unprecedented scale. Mounting environmental pressures, resource constraints, and evolving policy frameworks are accelerating the adoption of electric vehicles (EVs) at a pace scarcely imaginable a decade ago. Ambitious emissions targets within the European Union, expanded EV tax incentives in the United States, and substantial investments in battery technology across Asia collectively underscore the industry's shift toward electrification. Simultaneously, recent supply chain disruptions, intensifying competition for critical minerals, and the reconfiguration of labor relations amidst increasing automation illustrate that systemic risks and market volatility have become persistent features, rather than episodic challenges.

In light of these sweeping changes, there is an urgent need not only to understand the technological evolution of automotive platforms, but also to critically assess the deeper patterns of industry-wide trends, systemic risks, and strategic responses that will determine the sector's future. This thesis seeks to provide a comprehensive and integrative assessment of these transformative currents, examining how established original equipment manufacturers (OEMs) and emerging EV-focused entrants alike navigate evolving market conditions. By mapping the drivers of change that are reshaping value chains, stakeholder alliances, and competitive dynamics, the analysis highlights the strategic priorities and adaptations essential for long-term viability. Significantly, the research situates financial and operational metrics at the core of its inquiry, using them as empirical lenses through which the economic and strategic health of leading firms can be evaluated amidst escalating uncertainty.

Methodologically, this study advances literature by employing innovative benchmarking techniques and rigorous statistical methods, specifically concentrating on large OEMs rather than suppliers or smaller dealership networks. Its contribution lies in generating actionable insights for a range of stakeholders as the sector confronts unparalleled upheaval. By engaging with strategic imperatives such as technological adoption, financial resilience, and market responsiveness, the thesis illuminates the critical factors shaping the industry's developmental trajectory. As electrification intensifies, the framework developed here provides a foundation for understanding the emerging automotive landscape and underscores the pivotal role of major OEMs in guiding future developments.

In bringing together multiple dimensions, sustainability imperatives, shifting consumer preferences, regulatory pressures, and the interplay between incumbent firms and newcomers, this study offers an integrated framework for interpreting the ongoing transformation of the automotive industry. Rather than advancing prescriptive conclusions at this early juncture, the subsequent chapters encourage a critical and open-minded engagement with the sector's evolving contours. Through this approach, the work aims to illuminate an era in which systemic challenges and dynamic financial and operational conditions converge, challenging conventional assumptions and marking a pivotal inflection point for one of the world's most influential industrial arenas.

1.1 The Automotive Sector at a Glance

In order to thoroughly investigate emerging trends within the contemporary automotive sector, this analysis commences with a comprehensive examination of the industry's supply chain, which is essential for understanding the intricate and evolving dynamics of the market. The automotive supply chain serves as a pivotal framework for evaluating how structural shifts, driven by electrification, technological innovation, and sustainability imperatives, are reshaping core operational dimensions (Humphrey & Memdovic, 2003; Wong, 2021). These transformations encompass supply chain efficiency, production methodologies, and market performance, underscoring the need for holistic exploration of both traditional and emergent supply chain paradigms.

1.2 The Traditional Automotive Supply Chain

The supply chain of the automotive industry reflects a complex and multilayered structure which is influenced by several actors. At the foundation, as illustrated in Figure 1. raw material suppliers provide essential inputs to form the building blocks such as steel, aluminum, copper and rare earth elements like lithium or cobalt (Humphrey & Memdovic, 2003). Tier-2 Suppliers manufacture specialized components, such as electronic circuits, sensors or mechanical sub-assemblies which are not necessarily exclusive to the automotive sector like the semiconductors from NVIDIA or Intel. Tier-1 Suppliers, which includes major firms like Bosch or Continental, are responsible for integrating parts and components from Tier-2 suppliers into complete systems such as braking modules, infotainment systems or electric drivetrains (Wong, 2021).

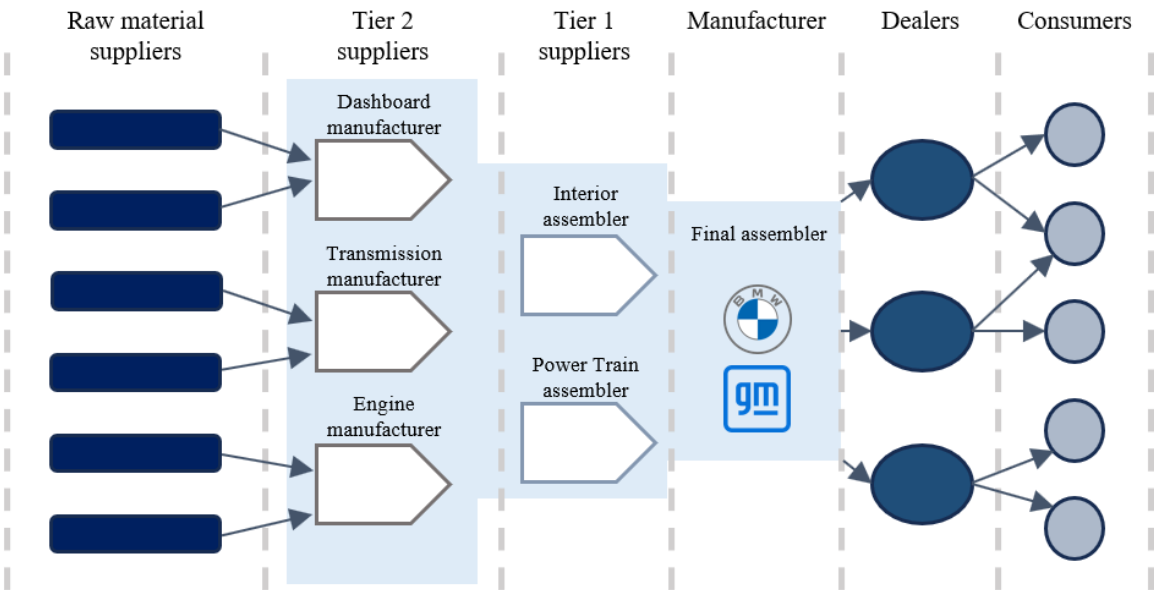

Figure 1: Traditional Supply Chain in the automotive sector

At the core of the value chain (Figure 1) are the OEMs, which assume responsibility for vehicle design, parts sourcing, and managing assembly operations. Once assembled, vehicles enter the distribution phase, traditionally dominated by dealerships that function as the primary consumer interface, managing both sales and after-sales services. However, this conventional model is evolving. Some manufacturers, such as Tesla, have adopted direct-to-consumer (D2C) sales strategies, bypassing traditional dealerships to enhance profitability and customer engagement (Asuncion & al., 2023).

1.3 Identified Trends Reshaping the Automotive Supply Chain

Trend to Electrification

The global automotive industry is undergoing a profound transformation, driven by accelerating environmental policies and shifting consumer preferences (IEA, Global EV Outlook 2023, 2023; Lutsey & Nicholas, 2019). Governments across Canada, the European Union, and the United States are actively reshaping regulations and incentives to favor cleaner powertrains. This transition is reinforced by sweeping legislation, such as the U.S. Inflation Reduction Act (IRA), the EU's Net Zero Industry Act, China's 14th Five-Year Plan, and India's production-linked incentive schemes (European Commission, 2023; White House, 2022). Together, these measures aim not only to reduce emissions but also to spur new business opportunities and employment along the EV supply chain. Only in 2023, automotive companies invested an impressive amount of USD 500bn in EV battery manufacturing, signaling a decisive shift in where and how value is created in the industry.

A key element of this transformation is the coexistence of seemingly opposing factors. Traditionally, ICE vehicles relied on mechanical complexity, roughly 1,400 components per engine, to create value downstream, primarily in assembly and engine-related activities (Helveston & Samaras, 2021). In contrast, EV powertrains use electric motors with as few as

200 components. On the surface, this reduced complexity might suggest that EVs would be simpler to produce. Yet the real story unfolds further upstream in the value chain. EVs depend on specialized and often scarce materials, such as lithium, cobalt, and nickel, as well as sophisticated battery cell manufacturing and semiconductor chip production (Larcher, 2015; Sovacool B. K., Griffiths, Kim, & Bazilian, 2020). These segments, mostly housed at the raw material extraction and Tier 1/Tier 2 supplier stages, have become the new strategic battlegrounds for the industry.

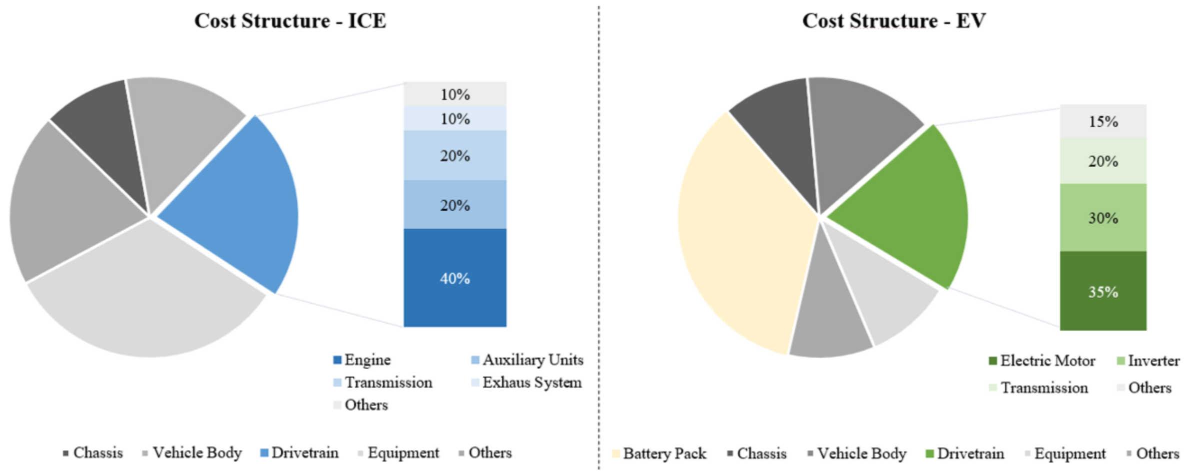

Figure 2: Cost Breakdown by Components: ICE vs EV vehicles

This shift in emphasis has profound implications. While ICE vehicles derived a significant portion of their value from engine manufacturing and final assembly, EVs concentrate their value creation upstream in advanced materials, component supply, and technological innovation (Ziemann, Grunwald, & Schebek, 2020; Kirchherr, Reike, & Hekkert, 2017). As highlighted in Figure 2, the advent of BEVs redistributes the industry's center of gravity, placing greater importance on those who can reliably provide essential raw materials and state-of-the-art battery cells and electric motors.

The result is a supplier network and sourcing strategy that must be reimagined. Automakers now find themselves racing not only to develop next-generation battery chemistries and more efficient electric drivetrains, but also to secure stable, ethically sourced raw materials. In this landscape, the traditional engine has ceded its throne to the lithium-ion battery, making expertise in chemistry, electronics, and upstream resource management as critical as traditional mechanical engineering skills once were (Larcher, 2015; Lutsey & Nicholas, 2019).

The ongoing shift toward EVs redefines the very nature of value and expertise in the automotive sector. By elevating upstream activities and placing battery technologies front and center, this transformation compels stakeholders to rethink everything from manufacturing processes to global supply chains, ensuring that the industry's future is as much about where its materials come from as how they are assembled.

Trends to Raw Material Dependencies

Central to this paradigm shift is the cost structure and technological evolution of EV batteries. Even as the price of critical raw materials, notably lithium carbonate, has surged, the cost of lithium-ion batteries has continued to decline (Figure 3). This paradoxical trend is explained by several interrelated factors. Ongoing advancements in battery cell chemistry, such as the increasing adoption of lithium iron phosphate (LFP) cathodes, have reduced reliance on cost-intensive materials like cobalt and nickel. At the same time, economies of scale, driven by rapid capacity expansion and improved production efficiencies, have curtailed overall battery costs (The Wall Street Journal, 2024). Thus, improvements in battery composition and manufacturing methodologies have more than offset the upward pressures exerted by raw material prices.

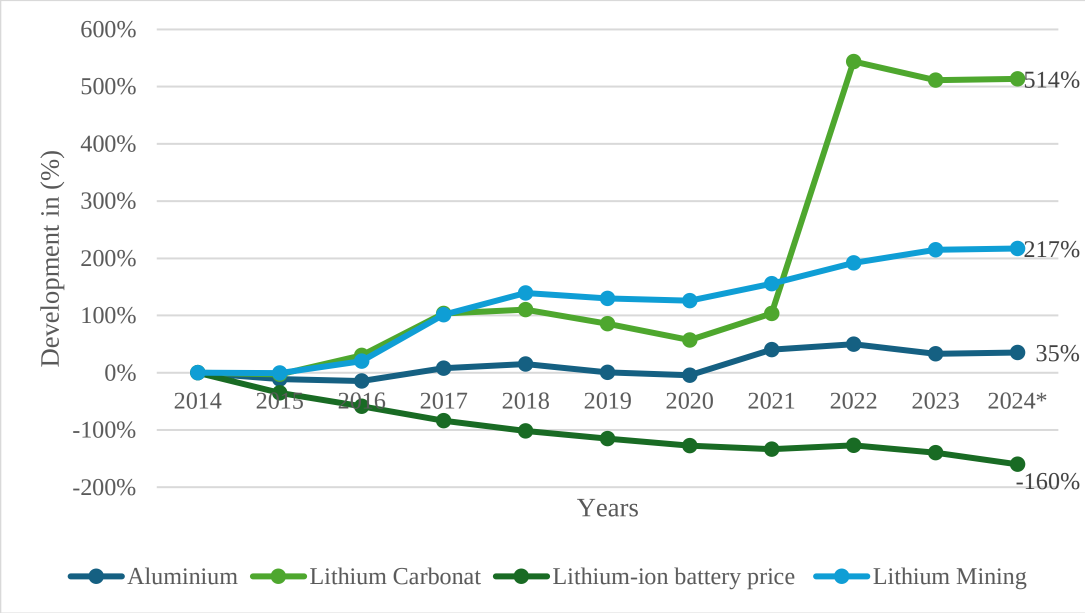

Figure 3: Selected Raw Material/Mining Developments

Yet, to understand the broader context of these technological gains and cost optimizations, it is crucial to examine the intensifying global competition for critical inputs. The industry's strategic pivot toward advanced battery technologies, which relies on minerals such as lithium, nickel, and cobalt, has deepened its dependency on complex and geographically concentrated supply chains (Sovacool B. K., Griffiths, S., & Bazilian, 2020). Notably, China continues to command a dominant position in mining, refining, and midstream processing capabilities for these raw materials, underscoring a structural vulnerability in global EV supply chains. This concentration not only poses concerns for long-term price stability and supply security, but it also prompts proactive policy interventions in major automotive markets, as they seek to diversify sources and reduce exposure to potential disruptions (Kirchherr, Reike, & Hekkert, 2017).

A more in-depth analysis of how fluctuations in raw material prices influence investor perceptions of the market is presented in Chapter 5, which examines the complex dynamics of raw material and price shocks. Additionally, it highlights how the interplay of technological innovation, economic incentives, and geopolitical factors shapes the trajectory of EV battery costs and the industry's future sourcing strategies.

Trends Toward Technological Advancements

The global automotive industry is undergoing a profound transformation as resource dependencies evolve, supply chains adapt, and the technological complexity of vehicles intensifies. OEMs increasingly rely on strategic partnerships with technology leaders to integrate advanced software, connectivity, and data-driven functionalities into their product offerings. In this new paradigm, market leadership and long-term industry trajectories are increasingly dictated not by mechanical refinements alone, but by the sophistication of software-defined features—ranging from real-time navigation to autonomous capabilities and integrated user experiences (Kirchherr, Reike, & Hekkert, 2017; Sovacool B. K., Griffiths, S., & Bazilian, 2020).

Recent disruptions underscore the importance of these alliances. The global semiconductor shortage, exacerbated by the COVID-19 pandemic, revealed how critical microchips and electronic components have become to modern automotive manufacturing. Efforts like the European Chips Act, which seeks to strengthen Europe’s electronics ecosystem through a €43 billion investment, aim to reduce external dependencies and enhance supply chain resilience (European Commission, 2023). Simultaneously, the emergence of autonomous vehicles has accelerated investments in artificial intelligence (AI) and machine learning. These technologies enable real-time decision-making, Vehicle-to-Everything communication, and advanced driver-assistance systems, compelling Tier-1 suppliers to expand their capabilities and collaborate more closely with OEMs (Bansal & Kockelman, 2017; Fagnant & Kockelman, 2015).

Such shifts are evident in the strategic alliances forming across the industry. Mercedes-Benz’s partnership with Google is illustrative, integrating Google Maps and Google Cloud’s AI to enhance navigation, maintenance, and overall vehicle performance. Legacy automakers (LAMs) like Volkswagen (VW) are similarly transitioning from a hardware-centric model to one emphasizing proprietary software platforms, digital services, and continuous updates, ensuring that future vehicles remain technologically current and compelling. Meanwhile, new entrants like Rivian demonstrate how embedding software-driven architectures and connected services from inception can position emerging firms as formidable competitors, challenging established players to evolve or risk obsolescence.

Beyond software integration, collaborations like BMW's joint venture with Great Wall Motors showcase how established automotive engineering expertise can blend with scalable manufacturing and EV capabilities to meet rapidly changing consumer expectations (Springer, 2022). Furthermore, advancements in battery technology, particularly solid-state batteries, promise to revolutionize the automotive value chain by delivering higher energy density, shorter charging times, and lower costs (Ziemann, Grunwald, & Schebek, 2020; Larcher, 2015). As these technologies mature, the ability of OEMs to partner effectively with technology leaders will become even more critical, ensuring that their offerings align with consumer demands for sustainability, connectivity, and sophisticated digital functionality.

Taken together, these trends highlight that forging robust technological alliances is no longer optional for LAMs like VW or Mercedes-Benz; it is a strategic imperative. By engaging with software experts, AI developers, and battery innovators, OEMs can anticipate shifts in market preferences, navigate regulatory changes, and solidify their position within the evolving automotive competition against pure-play EV manufacturer. In an era characterized by digitalization, electrification, and autonomous mobility, the integration of cutting-edge software and technological innovations stands at the core of sustainable competitiveness and industry-wide transformation.

Trends in Distribution and Consumer Preferences

As EV adoption spreads, the traditional dealership model is also evolving. D2C sales strategies, pioneered by Tesla, bypass traditional dealers to maintain control over pricing, margins, and consumer engagement. This innovation has pressured legacy OEMs to explore hybrid sales approaches, combining online sales platforms with existing dealer networks, to meet shifting customer expectations for convenience, transparency, and digital experiences.

Consumer preferences further reinforce these trends. Studies by Deloitte and Simon Kucher show that more than 60% of global consumers view EVs as the future, associating them with sustainability and advanced digital features like in-car navigation and smartphone integration. EV buyers, in particular, prioritize such technologies more than their ICE counterparts. Simultaneously, alternative ownership models, such as subscription-based services from BMW or Volvo, are gaining traction among younger, convenience-focused demographics. Although subscription models are growing rapidly (CAGR 31.8%), traditional ownership still dominates (Precedence Research, 2024). Vehicle type preferences remain regionally distinct, North America favors sports utility vehicles (SUVs), and light trucks, Asia leads in subcompacts and two-wheelers, and global tastes increasingly lean toward hybrid versatility. The bestselling vehicles of 2023, Tesla's Model Y, Toyota's Corolla, and Ford's F-Series, underscore the market's diverse but evolving demands (Statista, 2024).

1.4 Regional Dynamics and Market Fragmentation

Production Dynamics

Over the past decade, as illustrated in Figure 4, total passenger vehicle production grew from around 65m units in 2013 to 68m units in 2023, reflecting a CAGR of 0.4%. The dominant production regions are primarily established economies in Asia, followed by Europe and North America, while emerging markets such as India have also grown to a representative share.

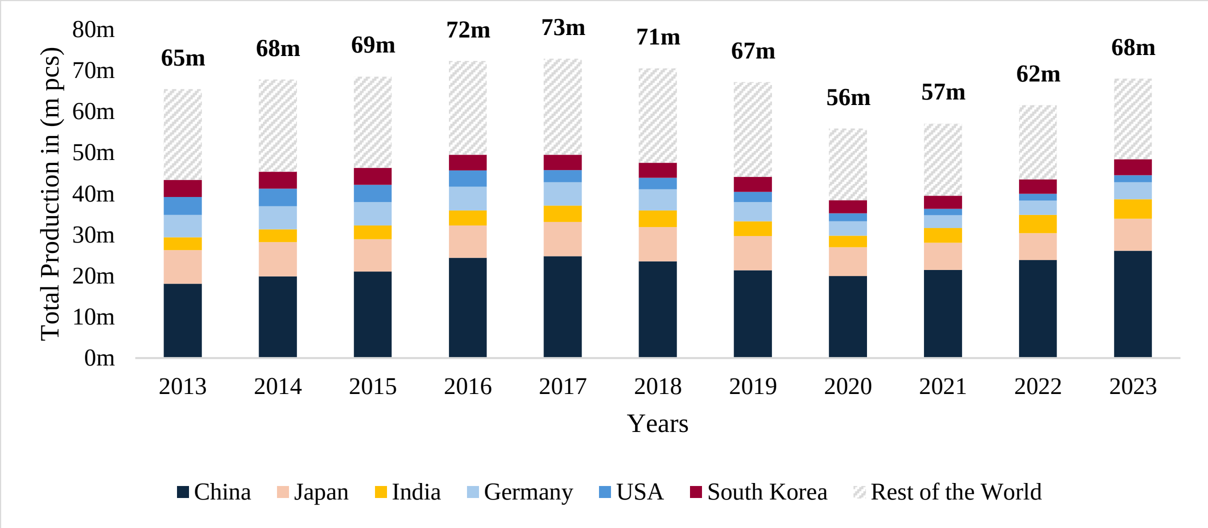

Figure 4: Global passenger car production by major regions 2013-2023 (in#)

Country-specific trends over the past decade show contrasting dynamics. Over the past decade, India has achieved a 4.2% CAGR in vehicle production, expanding its annual output from 3m to 5m vehicles in the last decade, marking the largest market share gain globally to 7% in 2023. China followed with a 3.7% CAGR, increasing its market share to 38% from (vs. 25% 10y ago), solidifying its position as the largest automotive producer. Meanwhile, key manufacturing nations like the United States (-8.8%), Germany (-2.8%), Japan (-0.5%), South Korea (-0.5%) have experienced notable declines in passenger car production. In the U.S., this trend is primarily fueled by shifting consumer preferences, with buyers increasingly favoring large SUVs, light trucks, and pickup trucks, while automakers prioritize their production due to the higher profit margins these vehicles offer (Wolfram et al., 2019). The decline in Germany's passenger car production was significantly influenced by declining ICE vehicle exports (-40%) between 2017 and 2023. While domestic production and exports of EVs increased significantly, this growth did not fully offset the decline in combustion engine vehicles (Deutsche Bundesbank, 2024).

Sales Dynamics

The global automotive industry reached a market value of approximately USD 3.6tn in 2023, an increase from USD 2.9tn in 2013. Despite this expansion in overall value, unit sales growth has remained notably subdued, with the market recording a 10-year CAGR of only 0.3%. This stands in stark contrast to the 2000 – 2010 period, when the industry achieved a CAGR of roughly 2.5% (OICA, 2024). Several factors have contributed to this slowdown, including a prolonged decline in ICE vehicle sales, persistent supply chain disruptions, and broader economic uncertainties stemming from the COVID-19 pandemic and the war in Ukraine. Within this context, global sales in 2023 amounted to approximately 67m passenger cars and 10m light-duty vehicles.

As supply chain issues eased, production returned to normal levels leading also to a year-on-year growth in vehicle sales of 5% in 2023. Nevertheless, the ICE market, historically the foundational market for the legacy OEMs, continues to experience a long-term decline over the past 10 years (CAGR -1.6%) causing their market share to lose ground in favor of the EV market. The EV market, in contrast, has grown at a remarkable CAGR of 53% over the same period, reaching approx. 18% market share in vehicle sales 2023. Currently, Plug-In-Hybrid-EVs (PHEV) command a higher sales volume (11.5m units) than BEVs (2.1m units). However, the trend underlines that BEVs are experiencing significantly faster growth, with a CAGR of 47% compared to the 19% CAGR of PHEVs. This signals that the momentum is shifting toward fully electric solutions, which may significantly transform vehicle manufacturing and the supply chain even further.

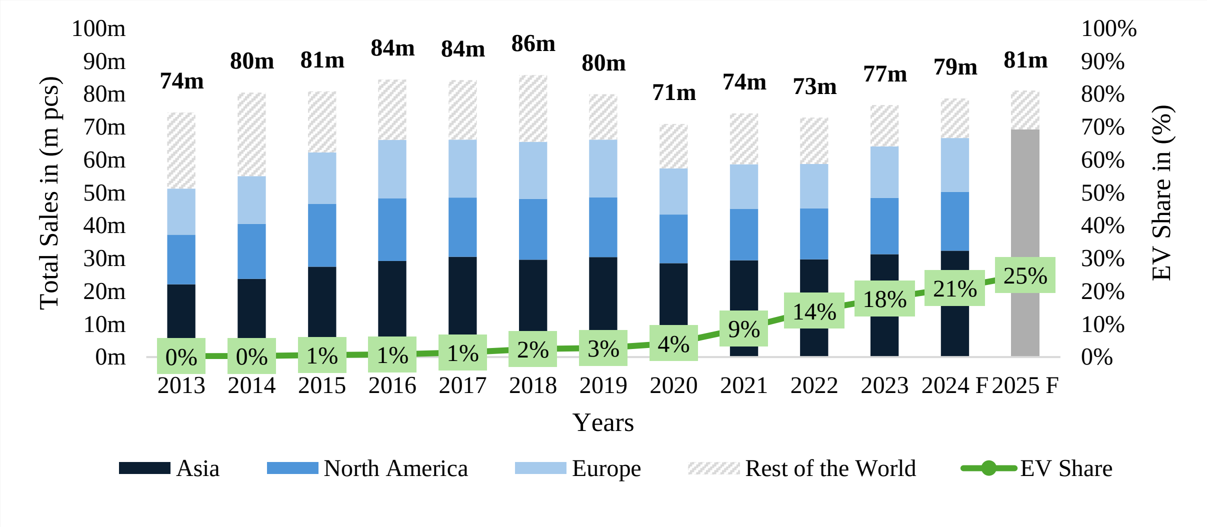

Figure 5: Global sales volumes by geography 2013-2025F (in#)[1]

Regionally, Asias substantial role as a major consumer market (capturing 41% overall and 59% of the EV market) is particularly significant for the sector, as displayed in Figure 5. While China (27%) is the largest provider, India (5%) and Japan (4.5%) are also essential for the sales market. China has been investing around USD 230bn since 2009 to support the EV market including infrastructure subsidies, tax exemptions and other incentives for customers and manufacturers. (Business Insider, 2024). This has led to a 59% EV market share, making them not only the largest consumer market, but also the greatest single contributor to global EV sales. Notably, the rise of India, with the market share growing substantially (4-year CAGR 9%) surpassing the one of Japan for the first time in 2022. The Indian government subsidy program FAME I+II[2] aimed to increase the affordability and to promote e-mobility which has helped to amplify attraction for those vehicles, making them the fastest growing EV market during the last five years. North America (mainly the U.S.) represents the second largest consumer market for automobiles with 22% market share for all cars sold in 2023, while only contributing 10% share in the EV market. Europe in comparison is particularly stronger in the sales for EVs (23%)

[1] The sales market includes both passenger cars and light-weight vehicles, as reliable ICE/EV sales data were only available for the consolidated market.
[2] Faster Adoption and Manufacturing of Hybrid and Electric Automobiles

while the total market share for car sales is around 20%, with Germany (4%) and France (3%) taking the lead.

At the cutting edge, Norway and Sweden (EV share 93% and 60%) demonstrate how comprehensive incentive frameworks like subsidy-policies and road tax reductions can achieve near-complete market penetration. New entrants like Turkey illustrate the power of innovative domestic players to alter established market hierarchies by growing with the strongest 5y CAGR of 211% due to a new model introduction of the domestic EV manufacturer TOGG.

Taken together, these interconnected regional developments depict a global automotive market in flux. Nations and manufacturers deploy tailored strategies to achieve unique policy, environmental, and economic goals. In this environment, the most successful automotive and EV markets will be those that can balance local consumer needs, infrastructure readiness, and forward-looking incentives. As more countries vie for leadership in electric mobility, the interplay of policy, innovation, and market responsiveness will ultimately determine which regions shape the future of transportation.

Brand Fragmentation and Selected Manufacturers

China, Japan, Germany, the United States, and South Korea exemplify the intricate interplay between national automotive markets and the strategic positioning of both domestic and foreign brands that is outlined in Table 1. China’s leading automotive firms BYD, Geely, SAIC, and Great Wall Motors have leveraged robust state support, strategic investments in electrification, and favorable regulatory measures to attain substantial gains in domestic market share. Since 2020, Chinese automakers have increased their collective market share by 21%, reflecting the efficacy of these policy incentives and technological advancements in EV production.

Table 1: Market share of domestic and foreign brands in major sales regions (%)

	Selected Major Markets 2023				
	In (m pcs)	*21m*	*15m*	*4m*	*3m*
		China	**US**	**Japan**	**Germany**
Share/Brands	**Chinese**	56%	0%	0%	1%
	US	8%	33%	1%	7%
	Japanese	17%	35%	94%	7%
	German	18%	8%	3%	62%
	Other	1%	24%	2%	23%
	Total	100%	100%	100%	100%

Japan, home to Toyota, the world's largest automaker, alongside Honda, Nissan, and Suzuki, exhibits a markedly insular market structure rooted in cultural preferences and a longstanding emphasis on hybrid technologies. This focus on hybrids, rather than BEVs, consolidates Japanese brands at the forefront of their national market, where the top five manufacturers command 80% of total vehicle sales.

Germany's automotive industry, anchored by VW, the second-largest global automaker, and esteemed luxury brands such as Mercedes-Benz, BMW, and Porsche, presents a more heterogeneous domestic landscape. Achieving a market share comparable to Japan's top five concentration requires the top fifteen manufacturers, signaling a more competitive environment. This more dispersed market structure reflects both the premium segment's strength in Germany and the openness of its domestic consumers to foreign automotive products. Similarly, the United States accommodates a multiplicity of brand origins. While domestic firms General Motors and Ford retain a significant presence, Japanese manufacturers, notably Toyota and Hyundai, have successfully integrated into this market by emphasizing reliability, SUVs, and pickup trucks. The virtual absence of Chinese brands in the U.S. market results primarily from prohibitive tariff regimes, which have escalated from 25% to 100%, effectively rendering Chinese imports cost ineffective. This comparative overview of leading automotive nations underscores how market structures, regulatory frameworks, cultural preferences, and technological trajectories collectively shape competitive dynamics.

To investigate these trends more systematically and to understand the evolving paradigms of global leadership in the automotive sector, it is instructive to examine a representative basket of major industry players. In Table 2, we outline the selection of key manufacturers, encompassing both LAMs and PP EV producers. This dual focus permits a nuanced understanding of the tension and convergence between traditional ICE-centric competencies and emergent capabilities in battery-electric drivetrains.

Table 2: Automotive Representative Company Basket (AutoRep-Basket)

Company	Country	Sales (Units)	Market Share	Market Cap (Bn)	Rank Sales	Rank Market Cap
Toyota	Japan	10.31	15%	223	1	2
Volkswagen	Germany	9.24	14%	42.5	2	8
Hyundai / KIA	South Korea	7.3	11%	39.8	3	10
Stellantis	Netherlands	6.39	10%	36.6	4	11
General Motors	USA	6.19	9%	65.9	5	4
Ford	USA	4.41	7%	44.9	6	7
Honda	Japan	4.19	6%	39.8	7	9
BYD	China	3.03	5%	105	8	3
BMW	Germany	2.56	4%	45.4	9	6
Mercedes-Benz	Germany	2.49	4%	59.1	10	5
Tesla	USA	1.81	3%	1004.1	11	1
Great Wall Motors	China	1.25	2%	26.6	12	13
Tata Motors	India	1.2	2%	34.9	13	12
NIO	China	0.16	0%	9.7	14	14
Total Basket		60.53	90%			
Other		6.47	10%			
Total Market (Passenger Cars)		67	100%			

The chosen basket representing approximately 90% of global vehicle sales, encompasses firms from Asia, Europe, and North America. By doing so, we capture variances in production scale, consumer behavior, and policy orientations across major markets. This approach enables a rigorous examination of how entrenched players and new entrants navigate disparate regulatory regimes, resource endowments, and market expectations. Through this lens, we can better elucidate the underlying economic, technological, and strategic imperatives that determine industry trajectories and discern the key factors that will drive competitive advantage in the global automotive sector's imminent and more electrified future.

2 Market View

To better understand the unique dynamics and performance of the automotive sector relative to the broader market, we created a custom automotive index comprising the returns of the 14 selected companies *(AutoRep-Basket)* between 2014-2024. This tailored index provides a focused framework for analyzing sector-specific trends and assessing its relative position, especially in comparison to the MSCI World as a proxy for the market return. To enrich this analysis, we constructed two variations of the index: one weighted by market capitalization named *Auto-Index(MW)* and the other equally weighted *Auto-Index(EW)*. This dual approach enables us to examine how influence shifts among sector participants and gain deeper insights into the sector's overall performance and evolving trends. Building on this foundation, we further analyze the dynamic relationships between the market-weighted index and key macroeconomic and financial indicators. This investigation aims to uncover how automotive market participants respond to shocks in critical economic variables, offering insights into industry performance, strategic resilience, and broader implications for navigating economic uncertainty.

2.1 Custom Index

Using the daily total returns of each stock over the past 10 years, we constructed both Indices as Performance Index. For a comprehensive overview of the methodology and detailed performance metrics, please refer to our Index Factsheet in Appendix 1. Our analysis reveals mainly three insights into the dynamics of the sector: superior returns at elevated risk, concentration risk driven by market structure, and heightened cyclical vulnerability.

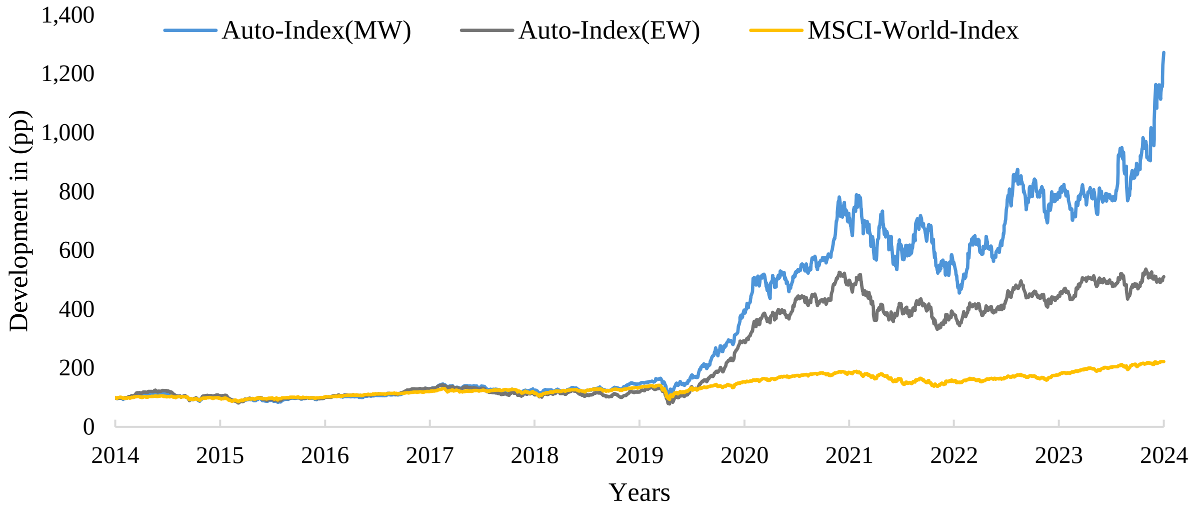

Figure 6: Automotive Representative Company Basket (AutoRep-Basket)

Our automotive index, particularly the *Auto-Index(MW),* delivered extraordinary returns, with a 10-year cumulative return of 1,172% compared to 410% for the equal weighted version and just 122% for the MSCI World Index. This outperformance is closely linked to the rise of the EV manufacturers, which have experienced elevated growth fueled by technological innovation, regulatory incentives for sustainability, and shifting consumer preferences. However, these returns come at a cost: both Auto Indices exhibit significantly higher volatility (5-year volatility: 33% MW, 25% EW) compared to the MSCI-World-Index (18%), reflecting, the sensitivity to macroeconomic cycles, supply chain disruptions, and raw material price shocks (e.g., lithium, cobalt). It also underscores the industry's exposure to capital-intensive operations, where minor shifts in global demand or political changes can lead to outsized financial impacts. For instance, after China reduced its EV subsidies in 2019, sales of EVs declined by 4%, leaving manufacturers with excess production capacity which also negatively impacted the stock prices (Feng, 2023).

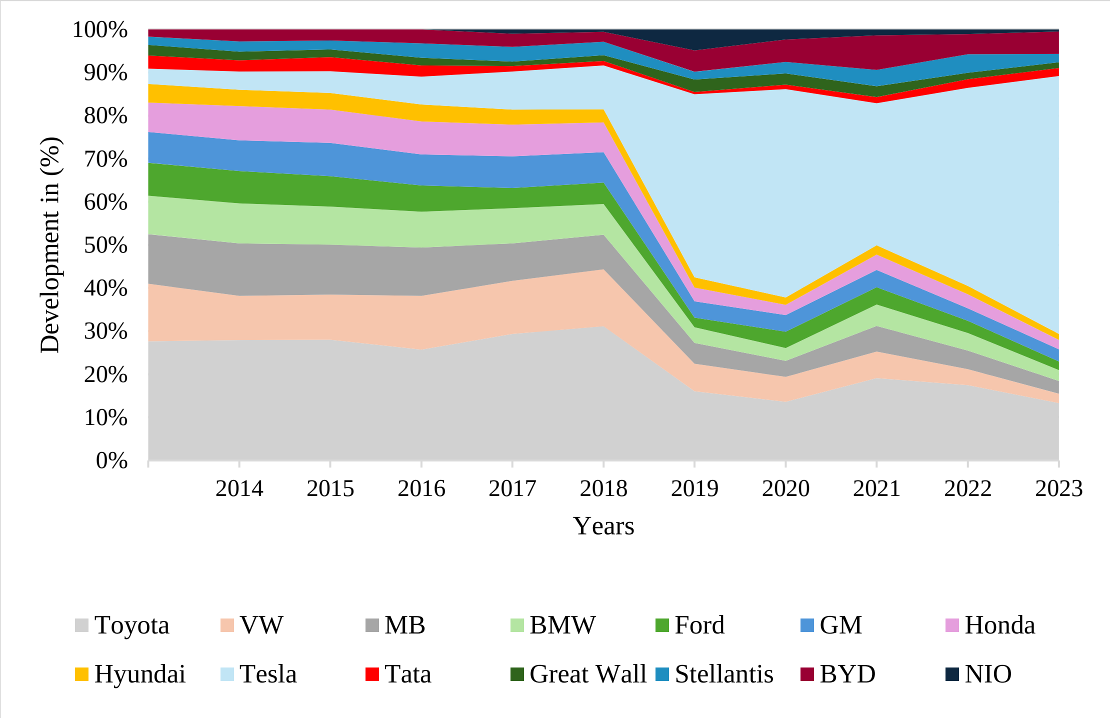

Figure 7: Yearly Distribution of the Auto-Index (MW) Components

To analyze the dynamics of the capital markets in recent years and to assess the shifting perception and capital allocation by investors, we took a closer look at the *Auto Index(MW)* which is displayed in Figure 7. From 2014 to around 2020, traditional automakers such as Toyota, VW, and GM occupied a significant share of the index. Toyota, in particular, maintained a stable and prominent position throughout this period due to its strong hybrid technology offerings and reliable performance. However, the decline in the relative weight of LAMs becomes apparent after 2020, coinciding with the accelerating global shift toward electrification and sustainability. The most striking trend is Tesla's rapid rise, as its share of the index surged dramatically after 2020. This reflects its rapid growth in market capitalization, fueled by technological innovation, first-mover advantage in the EV market, and robust investor confidence. This dominance has displaced traditional automakers significantly, influencing the overall performance significantly. BYD and other emerging EV players, such as NIO, have also gained traction, albeit at a slower pace. Companies like BYD are capturing a growing share of the market due to their ability to scale production efficiently and cater to both domestic and international demand for EVs. Overall, the transition from traditional ICE-focused manufacturers to EV-centric companies is evident in the composition of the index, driven by macroeconomic forces but also future investor expectations and confidence as demonstrated by Tesla's market capitalization.

2.2 Risk Perspective

Both Auto Indices have shown more connected downside risk compared to the MSCI World Index. With 1-month VaR of -2% (MW, EW) versus -1% (MSCI) and max drawdowns of -42% (MW) and -45% (EW), the data highlights the sector's cyclical vulnerability during periods of macroeconomic stress, such as during recessions or global trade disruptions. Through a regression analysis, we determined that the excess returns of the *Auto-Index(MW)* exhibited a beta of 1.21 relative to the MSCI World, while the more diversified exposure trough Auto Index (EW) showed a beta of 1.05. The higher beta reflects the increased influence of large, dominant companies in the *Auto-Index(MW)* such as Tesla, which tend to exhibit higher stock price volatility and greater market sensitivity as evidenced by a beta of 1.9 (please see Table 7 in Appendix 1). Similarly, NIO (1.7) and BYD (0.3) exhibit contrasting profiles, where NIO's higher beta indicates its speculative growth status, while BYD's lower beta suggests a more stable position despite being a major EV player. Traditional automakers like Toyota, Honda, and Great Wall Motor exhibit low beta values (0.4), indicating their relatively defensive characteristics compared to peers. These companies benefit from diversified portfolios that include ICE vehicles, hybrids, and steady revenue streams from established global markets. Conversely, automakers like GM, Ford, and Stellantis, with betas of 1.5, show higher volatility, reflecting their transitional phase as they pivot towards EV production amidst intense competition.

A closer examination of risk-adjusted returns reveals a notable shift in dynamics, with EV manufacturers significantly outperforming traditional automakers in this metric. As outlined in Figure 8, Tesla's dominance is evident, with the company leading both in market capitalization ($1.25tn) and in its five-year Sharpe ratio (1.16), followed by Chinese EV manufacturer BYD with 1.01. Other manufacturers such as Tata and Great Wall Motor, with Sharpe ratios of 0.79 and 0.85 respectively, highlighting the rising prominence of non-Western automotive players in the stock market. However, companies like NIO, with a Sharpe ratio of 0.47, lag slightly, reflecting the challenges of scaling operations in an increasingly competitive market.

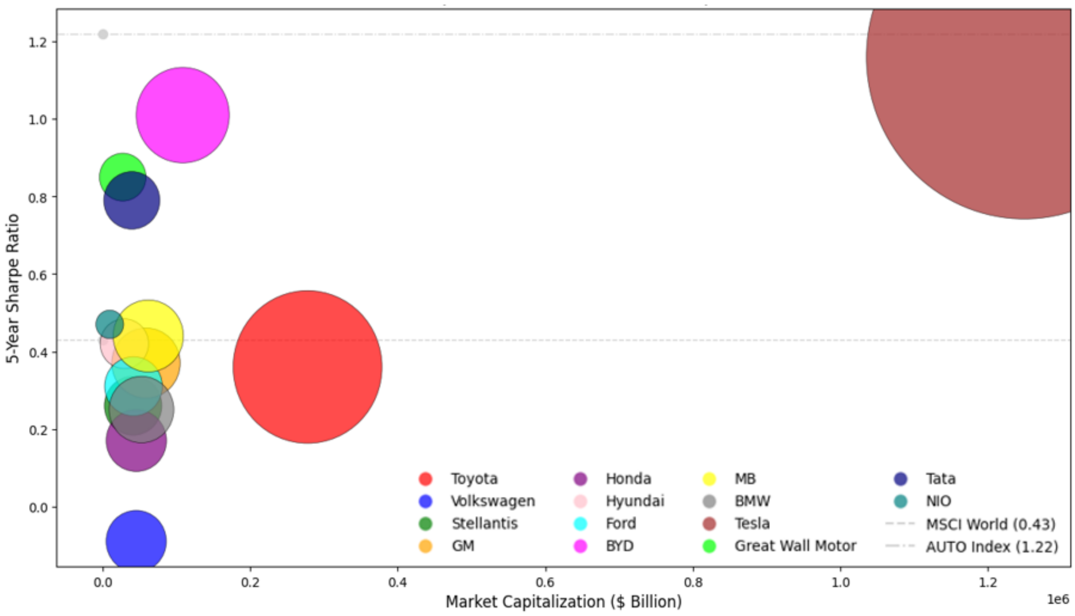

Figure 8: Market Capitalization vs 5-Year Sharpe Ratio

Toyota, despite having the highest market capitalization among LAMs at USD 277bn, has a relatively modest Sharpe ratio of 0.36. VW's negative Sharpe ratio (-0.09) is particularly concerning, suggesting strategic missteps in its EV initiatives and exposure to supply chain disruptions. Other legacy players like GM, Ford, and Honda exhibit moderate Sharpe ratios ranging from 0.17 to 0.37, indicating stable but unspectacular risk-adjusted performance. However, in the combined basket, the *Auto-Index(MW)* demonstrated the sector's superior risk-adjusted returns with a sharpe ratio of 1.23, especially compared the MSCI world with 0.43. An equal allocation of the selected stocks would have resulted in a Sharpe ratio of 0.91.

2.3 VAR Model

The vector autoregressive (VAR) model analyzes the interdependence between key macroeconomic factors and the automotive sector, treating all variables as mutually influential. It incorporates the *Auto-Index(MW)* alongside macroeconomic indicators such as industrial metal prices as proxies for input costs, oil prices, and exchange rates to capture global competitiveness. Additionally, bond returns are included as a measure of capital costs, while the VIX index represents market sentiment and uncertainty. The model evaluates dynamic relationships, providing insights into causal linkages via Granger causality and assessing the sector's response to macroeconomic shocks. Using impulse response functions (IRFs) that quantify the propagation of shocks over time, supporting risk assessment and strategic decision-making for industry stakeholders. A comprehensive model description is presented in Appendix 2. Model results are displayed in Table 3.

Table 3 – VAR(2) Results

		Index	Commodities	Oil	Currency	Interest	Volatility
Index	1st lag	0.098 ***	0.010	0.004	-0.002 **	0.004 **	-0.006
Commodities	1st lag	-0.124 ***	-0.009	0.044 ***	-0.001	-0.004	0.011
Oil	1st lag	0.080	0.089 **	-0.249 ***	-0.010 ***	-0.013	-0.039 **
Currency	1st lag	-0.117	0.348	0.045	-0.072 ***	-0.135 **	-0.238 *
Interest	1st lag	-0.087	0.642 ***	-0.038	-0.049 ***	0.078 ***	-0.093
Volatility	1st lag	-0.090 **	-0.196 ***	-0.005	0.021 ***	-0.033 ***	0.823 ***
Index	2nd lag	0.023	-0.001	-0.001	0.000	-0.001	0.004
Commodities	2nd lag	-0.033 *	-0.017	0.003	-0.001	0.005	0.022 **
Oil	2nd lag	0.036	0.013	-0.106 ***	-0.002	-0.006	-0.012
Currency	2nd lag	-0.885	-0.531 *	-0.220	0.004	0.020	0.215
Interest	2nd lag	-0.296	-0.250 *	-0.113 *	0.001	-0.008	-0.006
Volatility	2nd lag	0.092	0.194 ***	0.001	-0.020 ***	0.029 ***	0.149 ***
Constant		0.363	0.091	0.081	-0.010	0.064	0.508 ***
Observations		2,606	2,606	2,606	2,606	2,606	2,606
R^2		0.155	0.234	0.592	0.231	0.274	0.937
adj. R^2		0.143	0.130	0.554	0.182	0.224	0.936
F Statistic		3.20 ***	4.31 ***	13.58 ***	5.07 ***	5.94 ***	3192.62 ***

Note: .*, ** and *** denote that the null can be rejected at the 10%, 5% and 1% levels of significance, respectively.

Model Results and Interpretations

The IRFs depict how unexpected daily shocks in each variable impact the automotive index over a time of 8 days. Interpreting these short-run responses provides insights into how market participants react to evolving economic conditions and the subsequent implications for automotive industry performance.

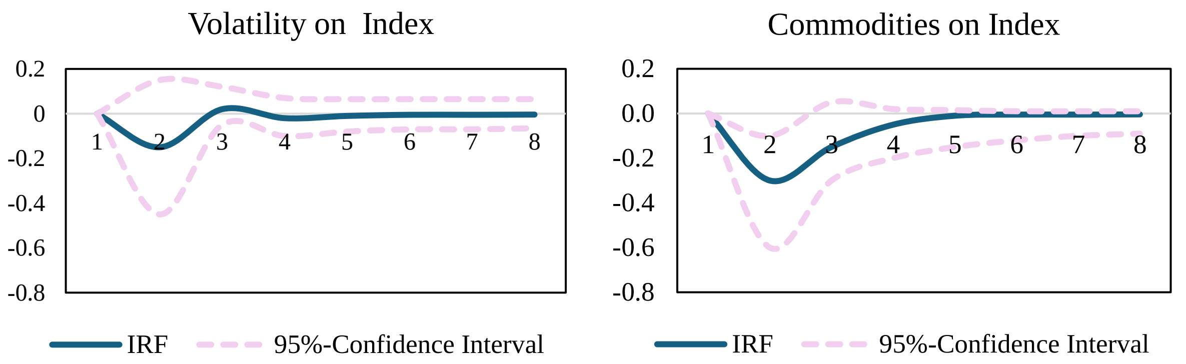

Figure 9 – IRFs of a Volatility shock (left) and a Commodity price shock (right) on the Index

Volatility Shocks

A one-standard-deviation increase in market volatility generates a sharp and immediate decline in the automotive index, reaching its lowest point around Day 2. As heightened uncertainty emerges, investors appear to downgrade earnings expectations, reducing valuations of capital-intensive, cyclical industries such as automotive manufacturing. By Day 4, the index begins to recover, suggesting that once investors reevaluate the risk environment, the immediate panic subsides, and valuations revert toward equilibrium levels. In practice, automotive firms may need to adopt robust risk management strategies and maintain liquidity buffers to endure these brief periods of market anxiety (Bloom, 2009).

Commodities Shocks (Industrial Metals)

A positive shock to commodity prices leads to an immediate and pronounced downturn in the automotive index, again most severe by Day 2. This reaction suggests that investors interpret rising input costs as a threat to profit margins and competitiveness, prompting a near-instant revaluation of stock prices. However, the index recovers toward zero by around Day 4, implying that while cost shocks are initially disruptive, the sector can adapt, possibly through procurement strategies, cost pass-through mechanisms, or adjustments in production processes. The rapid, albeit transient, impact underlines the necessity of flexible supply chain and cost management practices to mitigate raw material price shocks.

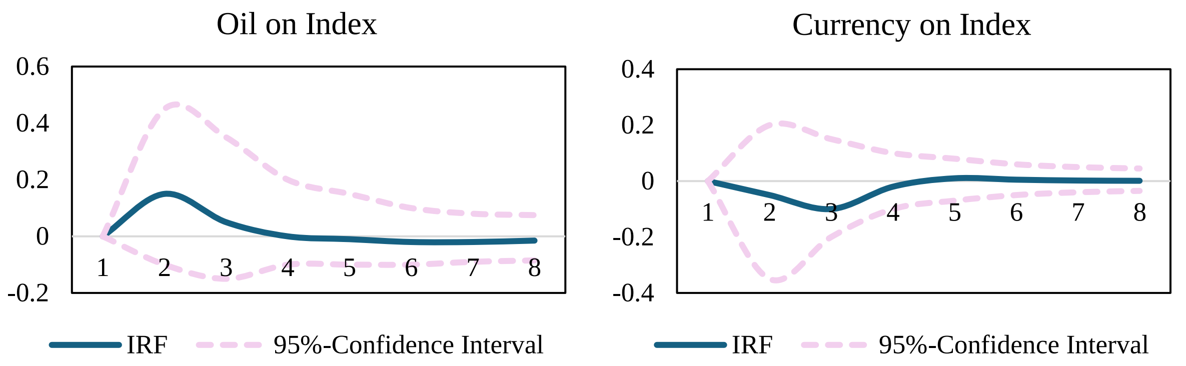

Figure 10 – IRFs of an Oil price shock (left) and a Currency price shock (right) on the Index

Oil Price Shocks

In contrast to commodities, a one-standard-deviation shock to oil prices elicits an initial positive response in the automotive index, peaking at Day 2 before gradually decaying to zero by Day 5. This early positive signal may arise from market participants associating oil price increases with overall economic expansion or higher transportation demand, thus initially benefiting automotive manufacturers. Additionally, the composition of the automotive index, particularly the substantial weight of EV-manufacturers, may amplify this effect. Higher oil prices could increase consumer demand for oil-independent transportation alternatives, such as EVs, thereby supporting equity valuations in the short term. Yet, as the shock dissipates, investors likely reassess the cost implications of sustained higher energy prices, tempering the initial optimism. The brevity of the effect suggests that while oil price movements can signal macroeconomic conditions, their direct influence on automotive equity valuations is short-lived and subject to rapid reappraisal (Hamilton, 2009).

Currency Exchange Rate Shocks

A shock to the exchange rate exerts a modest negative effect on the automotive index, stabilizing around zero by Day 4. With major companies in the index, such as Tesla, headquartered in the U.S., an appreciating dollar makes exports to key markets like China more expensive, reducing competitiveness. The initial decline reflects investor concerns over revenue pressures. However, the sector's global presence and use of hedging strategies enable firms to adapt quickly, limiting the medium-term impact. The rapid return to baseline highlights the industry's ability to manage currency volatility effectively (Goldberg & Campa, 2010).

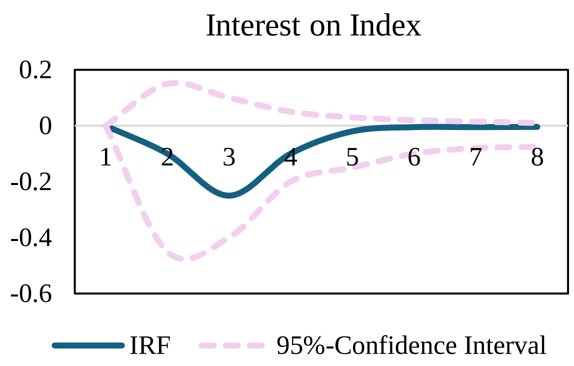

Figure 11 – IRF of an Interest rate shock on the Index

Interest Rate Shocks

A shock to interest rates prompts (Figure 11) a more oscillatory pattern. The Auto Index declines initially, reaching its most pronounced trough around Day 4, reflecting investors' concerns over tightening credit conditions, higher consumer financing costs, and potentially dampened vehicle demand. Over the following days, the effect moderates, suggesting that while rising rates pose a clear risk, by constraining both consumer purchasing power and corporate investment budgets, the sector's long-term growth prospects and adaptive strategies can offset the initial pessimism. This pattern highlights the importance of flexible financing solutions, efficient capital allocation, and robust balance sheet management to weather periods of monetary tightening (Bernanke & Blinder, 1992).

These IRF-based findings yield several key insights. First, the automotive sector is acutely sensitive to short-term volatility shocks, underscoring the importance of risk management and strategic planning. Second, immediate negative reactions to commodity cost increases highlight the value of resilient supply chains and flexible procurement strategies. Third, the transient positive response to oil price increases suggests that while higher energy costs may occasionally coincide with stronger demand signals, any initial optimism must be balanced against potential margin pressures. The limited and short-lived exchange rate effects emphasize the significance of hedging and geographic diversification. Finally, the short-run negative response to interest rate shocks underscores the sector's vulnerability to tighter credit conditions and the need to maintain operational flexibility. Taken together, the results suggest that automotive manufacturers must remain agile and strategic to mitigate the effects of daily macroeconomic fluctuations. By investing in financial hedges, supply chain resilience, and market diversification, as well as maintaining prudent financial structures, the industry can enhance its stability amidst a constantly evolving economic landscape.

3 Comprehensive Financial Benchmarking of the Global Automotive Sector

This chapter presents a holistic financial benchmarking of the global automotive peer group over multiple years. By examining dimensions such as capital structure, liquidity, efficiency, investments, ESG performance, growth, profitability, and market-based valuations all drawn from Bloomberg, the analysis provides a nuanced understanding of how LAMs and PP EV have navigated technological disruption, regulatory shifts, and evolving consumer preferences. To capture long-term structural trends rather than short-term volatility, this analysis employs annual data instead of quarterly observations. This approach reduces noise from cyclical model launches and seasonal sales strategies, both of which are common in the automotive industry (Myers, 1984; Titman & Wessels, 1988). To ensure robustness, standard statistical measures (mean, median, standard deviation, interquartile ranges) are employed for sector-level comparisons. Subsequently, average values for the observation window of 2018-2023 identify consistent top and bottom performers. While sensitivity to outliers is acknowledged, this systematic approach provides a meaningful benchmark. Nio, a relatively young firm still in its growth phase, is occasionally considered separately, as its nascent profitability profile and aggressive expansion differ markedly from more established players. Additional KPI benchmarks that are discussed but not displayed can be found in Appendix 3.

3.1 Capital Structure and Liquidity

Capital structure and liquidity decisions profoundly shape automotive firms' resilience. Over the 2018–2023 period, the sector showed a clear move toward more conservative financing and enhanced short-term solvency. Declining mean total debt-to-equity (%) and net debt-to-EBITDA ratio as shown in Figure 12, reflect intentional deleveraging.

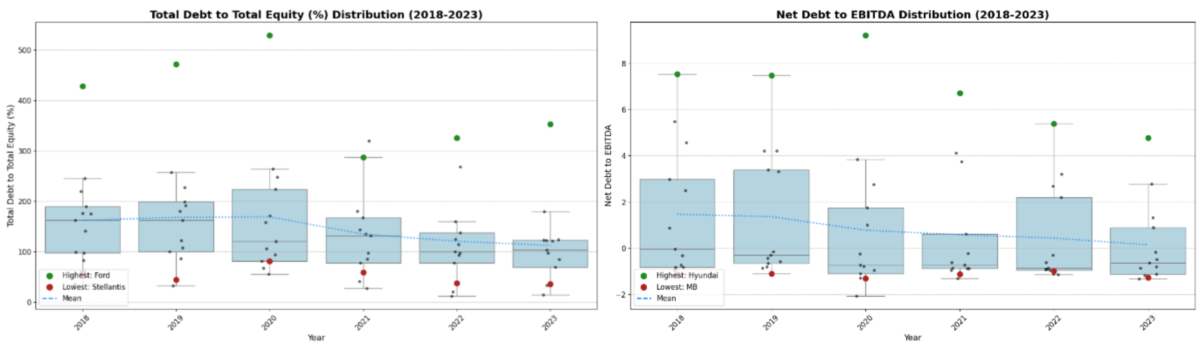

Figure 12 – Total debt to equity (%) and net debt to EBITDA development

This reduced leverage aligns with a strategic reorientation: firms appear increasingly focused on strengthening balance sheets to navigate technological transitions, such as the pivot to EVs, and to mitigate exposure to macroeconomic uncertainties (Titman & Wessels, 1988; McKinsey & Company, 2022). The concurrent improvement in current, quick, and cash ratios (Appendix 3) further demonstrates that firms are not only lowering debt but are also retaining greater liquidity buffers, potentially to finance R&D, manage supply chain volatility, and respond swiftly to market disruptions. Such developments reflect an industry cognizant of capital markets' heightened sensitivity to risk, with rising weighted-average-cost-of-capital (WACC) levels. As displayed in Figure 13, investors and lenders now demand higher returns for perceived uncertainties in automotive innovation and geopolitical tensions (Bloomberg, 2023; Myers, 1984). Interlinking these indicators reveals a sector aiming for enhanced financial resilience. Lower leverage ratios, mirroring improved earnings capacity, support stable or rising liquidity metrics, enabling firms to fund long-term strategic initiatives without excessive reliance on external credit. The modest decline in the defensive interval ratio after 2020, however, implies that as COVID-19-related shocks receded, companies adjusted their cash holdings and working capital structures to more typical operating conditions. This recalibration, in turn, may reflect confidence in future supply chain stability and the ability to internally fund innovation cycles, particularly in EV platform development and autonomous technologies (IEA, 2021).

Differences in individual company performance can be partly attributed to strategic positioning and operational execution. Firms with notably high liquidity (e.g., Tesla) or consistently lower debt burdens (e.g., Stellantis) appear better prepared to seize growth opportunities and absorb short-term shocks without resorting to costly external financing. Conversely, entities maintaining higher leverage or weaker liquidity profiles (e.g., Ford and BYD) may face constrained strategic flexibility and heightened vulnerability to capital market fluctuations. While BYD's high leverage is partly tied to its aggressive push into EVs, raising capital expenditures and expanding capacity, Ford's constraints stem from legacy cost structures [3]and slower adaptation to new propulsion technologies. While such outliers highlight the importance of balanced financial management, the overall sectoral trend is one of cautious deleveraging, liquidity strengthening, and strategic realignment toward stable, innovation-ready capital structures, foundations that are likely to shape competitive dynamics and investment flows in the coming years (Deloitte, 2023).

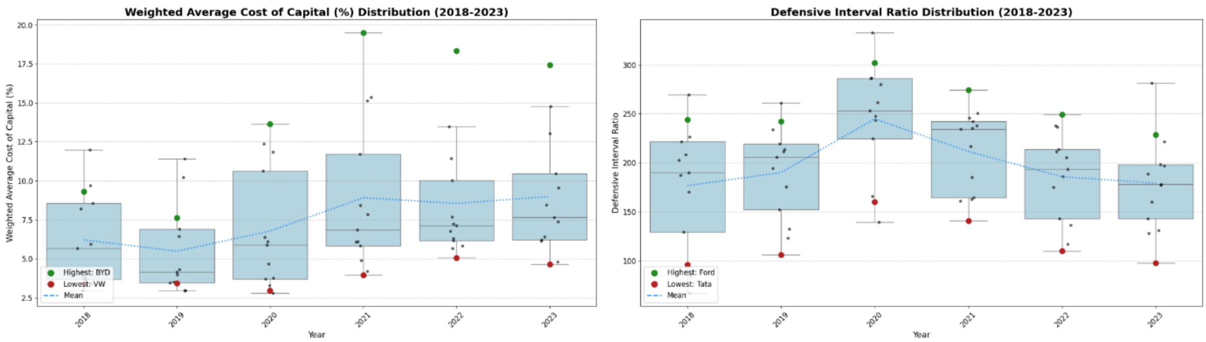

Figure 13 – WACC and DIR Development

3.2 Efficiency and Operational Metrics

Operational efficiency is vital in a capital-intensive industry with complex supply chains like automotive manufacturing. Over the last few years, firms have shown gradual improvements in asset turnover and working capital management. Asset turnover ratios strengthened after 2020, signaling that companies are using their manufacturing capacity and distribution networks more effectively despite global supply chain disruptions (Harvard Business Review, 2021; McKinsey & Company, 2022).

One clear development is the moderate improvement in asset utilization. The slight downward trend in inventory turnover displayed in Figure 14, juxtaposed with a rising asset turnover post-2020, suggests that while the speed of inventory movement has not uniformly kept pace,

[3] Legacy cost structures are expenses tied to outdated systems, practices, or obligations like pensions and older technologies.

companies are leveraging their overall asset bases more effectively. This reflects strategic reorganizations, such as more flexible production lines and better capacity management, to meet fluctuating demand and respond to supply chain constraints (Harvard Business Review, 2021). Simultaneously, stable or marginally improving working capital-to-sales ratios, coupled with declining days accounts receivable, point to enhanced liquidity management. Firms appear more disciplined in credit terms, likely reflecting both stronger negotiation power with customers and a heightened focus on cash preservation, crucial during a period characterized by semiconductor shortages and shifting trade policies.

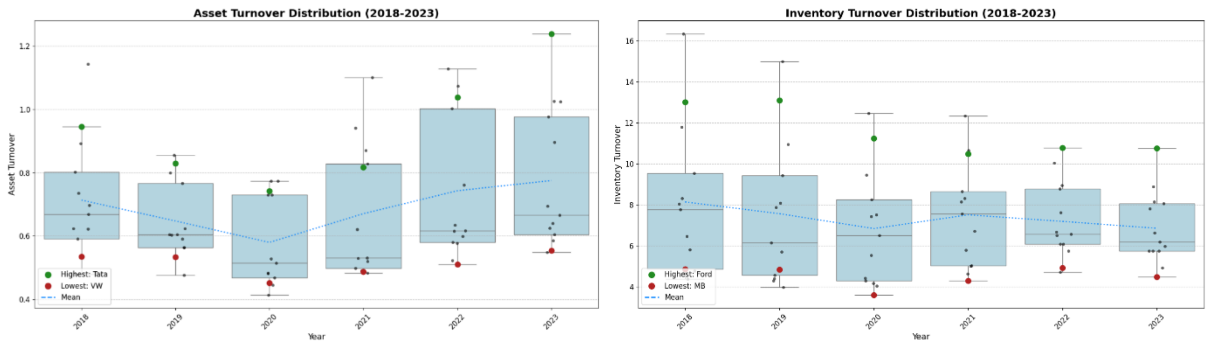

Figure 14 – Asset turnover and Inventory Turnover Development

The cash conversion cycle (CCC) shown in Figure 15 has remained relatively stable, with slight improvements after 2020. Together with balanced payable turnover days, this stability signals that companies have made strides in synchronizing the inflow of receivables and the outflow of payables, effectively reducing excess working capital tied up in operations. Where some firms, such as Stellantis, even achieve negative CCC, it indicates a rare competitive advantage: turning orders into cash faster than they must pay suppliers, thereby boosting short-term financial flexibility. This fine-tuning of operational processes, from procurement to distribution, is essential as manufacturers invest in new technologies and markets, seeking to maintain steady cash flow for R&D and strategic partnerships (IEA, 2021).

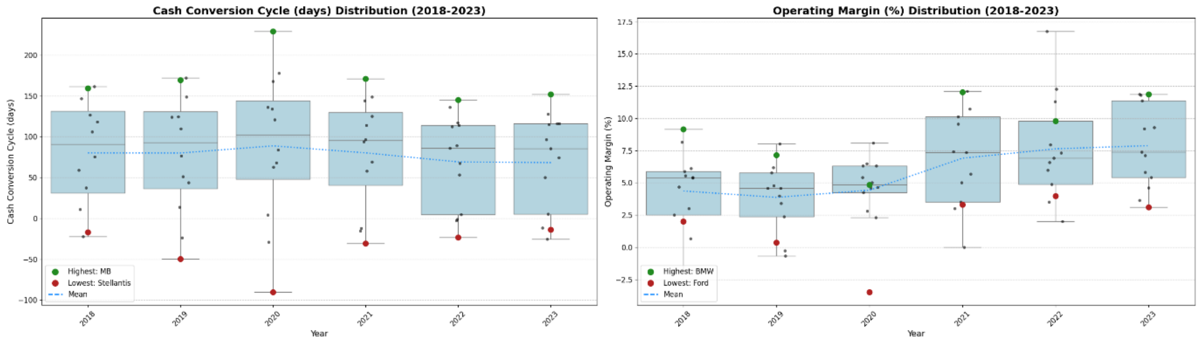

Figure 15 – CCC and Operating Margin Development

Rising operating margins (Figure 15) further reinforce the narrative of improved efficiency. The upward margin trend implies that not only are companies making better use of their assets and working capital, but they are also capturing greater value through either pricing strategies, brand positioning, or cost reductions. Premium manufacturers, exemplified by BMW, leverage brand equity and high-value models to sustain robust margins. Others, notably Ford, face persistent operational challenges, suggesting that different strategic choices, be it product mix, cost structure, or geographic focus, can markedly affect a firm's ability to translate efficiency gains into profitability (McKinsey & Company, 2022).

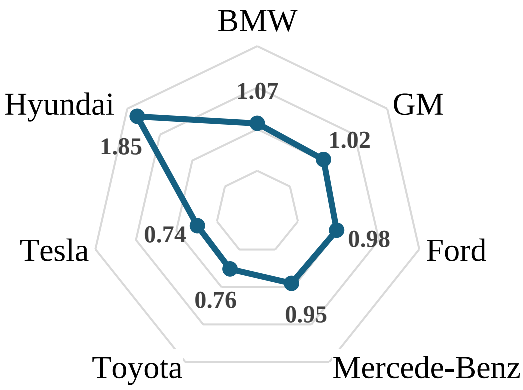

Figure 16 – Selected OEM's Revenue per Employee in USD millions as of 2023

Companies with higher revenue per employee (Figure 16), such as Hyundai, tend to benefit from streamlined production processes, and strong integration of supply chain and sales forecasting, allowing them to maximize output and pricing power per unit of labor. In contrast, firms like Toyota, despite their extensive global footprint, may struggle to match these efficiency levels due to more complex product lines or slower adaptation to advanced manufacturing techniques, resulting in lower revenue generation per employee. Companies consistently outperforming key metrics tend to align operational practices with strategic goals. For instance, companies with high inventory turnover or low days accounts receivable often show tighter integration of supply chain management and sales forecasting, contributing to faster asset cycling and stronger cash positions. Firms like Hyundai, with strong working capital ratios, are better positioned to fund innovation without undue reliance on external capital. By contrast, those lagging in metrics such as the CCC or operating margins may find themselves constrained when responding to market shocks or capital-intensive new product launches.

3.3 Cash Flow and Investments

The automotive sector's cash flow and investment patterns indicate a clear strategic pivot toward innovation-driven growth, underpinned by disciplined liquidity management. As R&D-to-sales and capex-to-sales ratios gradually increase (Figure 17), companies are channeling resources into EV platforms, advanced driver-assistance technologies, and upgraded manufacturing infrastructures. This shift reflects a recognition that continuous technological differentiation, bolstered by targeted infrastructure investments, is essential for long-term competitiveness in the face of changing consumer preferences, stricter environmental standards, and complex supply chain dynamics (McKinsey & Company, 2022).

Improvements in free cash flow margins and free cash flow to the firm (FCFF), displayed in Figure 18, underscores how effectively firms are balancing their forward-looking investments with prudent cost control (Bloomberg, 2023; Deloitte, 2023). As companies stabilize after initial disruptions, many are learning to integrate substantial R&D and capex commitments without eroding liquidity. These expenditures, once seen purely as costs, now serve as catalysts for future revenue streams and operational efficiencies, strengthening both the innovation pipeline and the financial backbone of the industry.

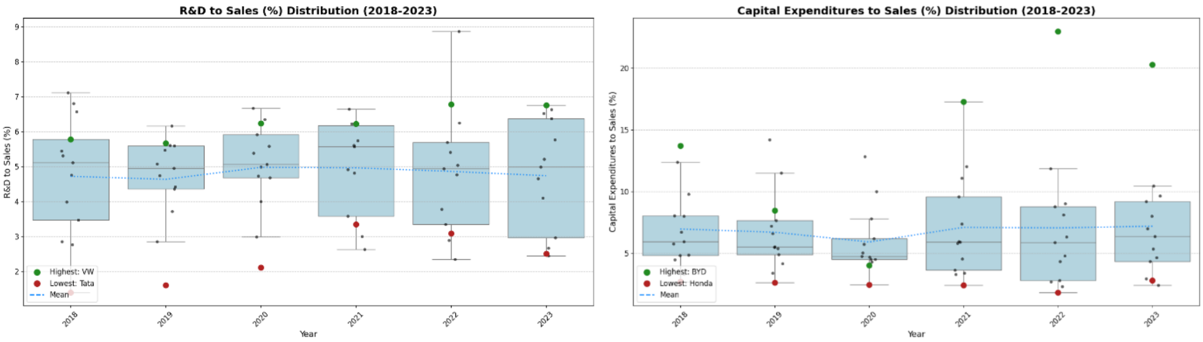

Figure 17 – R&D-to-sales Capex-to-sales Development

Among high performers, VW's substantial R&D-to-sales ratio illustrates its enforced drive toward technological leadership, while BYD's elevated capex aligns with an aggressive strategy to rapidly scale EV production and capture market share. Such firms are well positioned to lead in nascent EV and autonomous segments, reinforcing brand equity and enhancing their competitive stance. In contrast, more conservative investors, like Honda, or firms struggling to maintain positive FCFF, such as Toyota, face inherent trade-offs. Toyota's negative FCFF, for instance, may signal a conscious decision to invest heavily now, expecting longer-term payoffs even at the expense of near-term cash flow stability. Looking ahead, the synchronization of R&D intensity, capex allocation, and cash flow discipline will likely define the industry's trajectory (Harvard Business Review, 2021). As automakers navigate regulatory demands, consumer shifts, and intensifying competition, those adept at aligning ambitious innovation agendas with sound financial stewardship are poised to drive sustainable growth and cement their technological leadership in the evolving mobility landscape (Moody's, 2022).

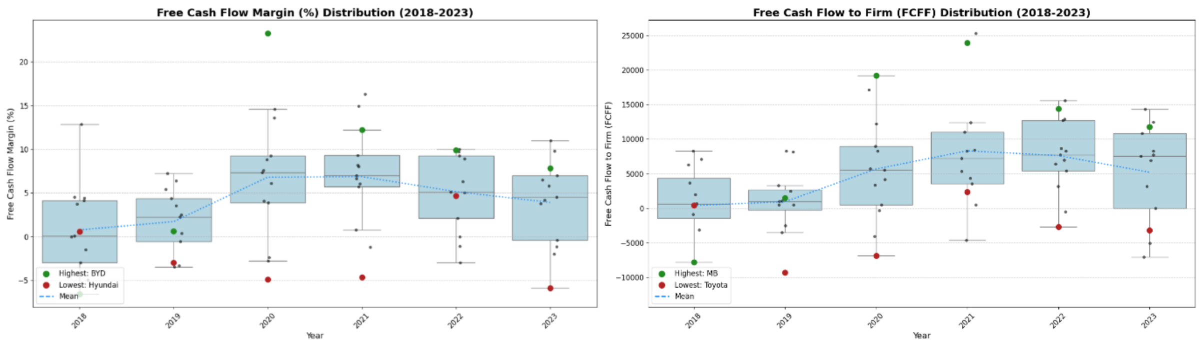

Figure 18 – Free Cash Flow Margin and FCFF Development

3.4 ESG and Sustainability

The automotive sector's ESG performance signals a shift toward more robust sustainability practices, enhanced corporate governance, and improved stakeholder relations. Across the industry, both ESG disclosure and overall ESG scores (Figure 19) have risen, suggesting that firms increasingly recognize the strategic importance of comprehensive reporting, environmental stewardship, social responsibility, and sound governance frameworks. These indicators evaluate companies based on publicly available information such as sustainability reports, corporate policies, emissions targets, supply chain audits, board diversity, and community engagement initiatives (Giese & Lee, 2019; Eccles & Michael P., 2010).

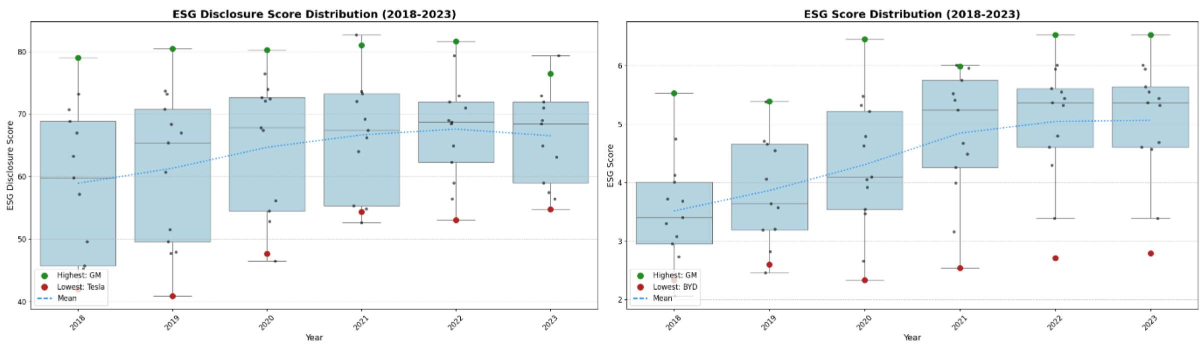

Figure 19 – Development of Sectors' Bloomberg ESG and ESG Disclosure Score

Despite the conventional expectation that younger, EV-focused companies would outpace LAMs on ESG metrics, a notable paradox emerges. GM, a long-established LAM, consistently surpasses its industry peers on both ESG disclosure and overall ESG scores. This achievement underscores GM's proactive engagement with formalized reporting standards and strategic ESG integration, from reducing emissions and improving labor conditions to enhancing corporate governance structures. By contrast, Tesla, widely regarded as a trailblazer in the EV space, continues to record lower ESG disclosure scores, reflecting gaps in transparency and standardized reporting frameworks that rating agencies and stakeholders increasingly demand.

The persistently high ESG performance of GM, along with the low scores recorded by BYD and the relatively weak ESG disclosure profile of Tesla, signals that best practices in sustainability and governance do not hinge solely on product type or technological leadership. Instead, effective ESG performance appears to stem from a company's willingness to embrace comprehensive reporting, set quantifiable targets, and engage actively with stakeholder concerns. As the automotive sector advances, fulfilling regulatory mandates, meeting investor expectations, and securing consumer trust will require greater alignment of corporate strategies with ESG criteria. Firms that excel in transparent, data-driven sustainability efforts are poised to strengthen their competitive advantage, enhance long-term value creation, and influence the sector's progression toward more responsible and inclusive mobility solutions (Clark, Feiner, & Viehs, 2015; McKinsey & Company, 2022).

3.5 Growth and Profitability

The growth and profitability metrics of the peer group depict a broad realignment of strategies, capital structures, and operational frameworks in response to shifting market demands and technological imperatives in the Automotive sector.

Revenue growth (Figure 20) patterns diverged considerably after 2020, reflecting the uneven pace of recovery and adaptation across the industry. BYD and Tesla stand out for their aggressive top-line expansions, driven by their substantial investments in electrification and brand equity.

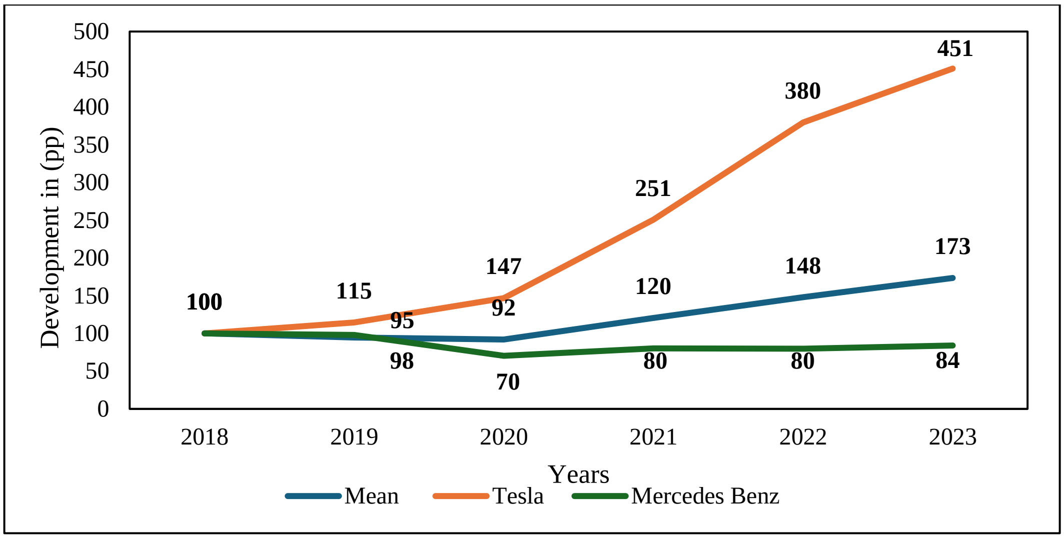

Figure 20 – Indexed Revenue Development of mean, highest and lowest performing company

Tata's and Mercedes's stagnation underscores difficulties in scaling operations and capitalizing on emerging consumer trends or a switch in strategic segment focus. In parallel, rising EPS across the sector, displayed in Figure 21, signals that many automakers successfully translated revenue gains into improved shareholder returns, VW's notably high EPS exemplifies operational efficiency, supply chain resiliency, and robust market positioning can reinforce profitability.

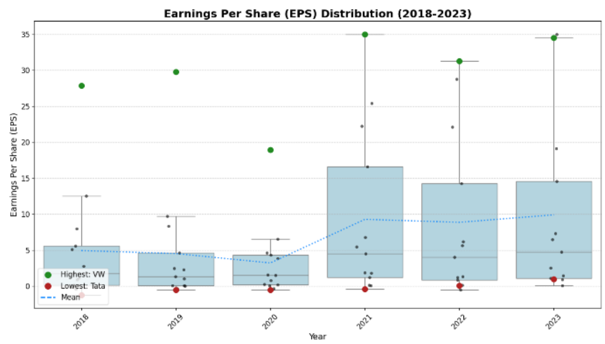

Figure 21 – Development of Sectors' EPS

This enhanced profitability emerges not in isolation, but as the culmination of strategic shifts observed across previously analyzed KPI domains. Improved capital structures, evident in lower leverage and heightened liquidity, offered a more stable financial foundation, reducing vulnerability to economic shocks and freeing resources for innovation. Stronger working capital management and efficiency metrics, including leaner supply chains and enhanced asset utilization, laid the groundwork for profitable growth. Meanwhile, disciplined cost control and a measured approach to capital expenditure enabled firms to reinvest savings into R&D, scale EV production, and refine product portfolios to meet evolving regulatory standards and consumer preferences (Moody’s, 2022). This comprehensive reorientation was further buttressed by better ESG scores and disclosures, particularly for legacy players like GM. Although ESG leadership did not correlate with top-line dominance, it contributed to stronger stakeholder trust, brand value, and long-term strategic positioning, factors that, in turn, can support resilient growth and stable margins (Eccles & Michael P., 2010)

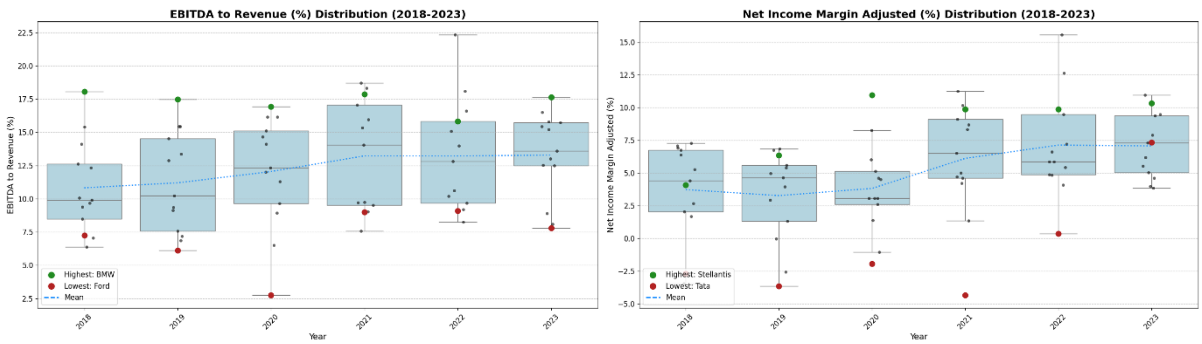

Figure 22 – EBITDA Margin and Net Income Margin Development

As profitability improved, key return metrics paint a nuanced picture of value creation. Net income margins and EBITDA margins trended upward, as outlined in Figure 22, illustrating the sector’s success in extracting greater profit from each unit of revenue. Similarly, positive trajectories in ROE and operating ROIC (Figure 23) reflect management teams’ enhanced ability to deploy capital effectively, translating innovative investments into tangible returns. Stellantis exemplifies this trend, leveraging merger synergies and efficient resource allocation to achieve superior ROE, operating ROIC, and EBITDA margins. Conversely, persistent underperformance by certain firms, such as Tata and Ford, highlights the challenges of structural inefficiencies, delayed strategic pivots, or underinvestment in emerging technologies.

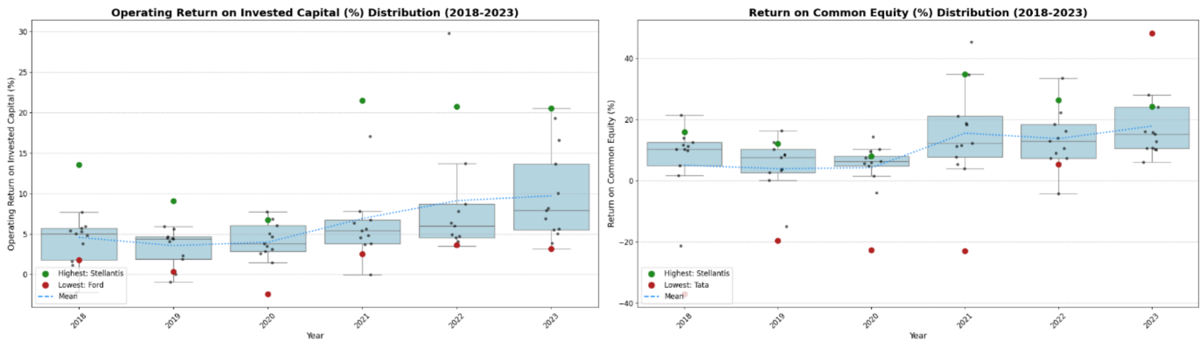

Figure 23 – ROIC and ROE Development

Among the profitability indicators, the ROIC/WACC ratio stands as a critical benchmark for assessing the sector's capacity to create true economic value. The observed upward trend pictured in Figure 24 in mean and median ROIC/WACC ratios suggests that, over time, more firms have begun generating returns that surpass their cost of capital. This shift reflects the interplay of improved balance sheets, operational discipline, strategic product focus, and market realignment. However, only a few companies constantly surpass unity. Stellantis, with its consistently high ROIC/WACC ratio, exemplifies a firm that has managed to unify these elements into a cohesive, value-generating strategy. In contrast, persistent underperformance by certain laggards indicates (e.g Ford and Tata) that not all companies have fully adapted their business models, leaving room for further consolidation, innovation, or strategic reorientation.

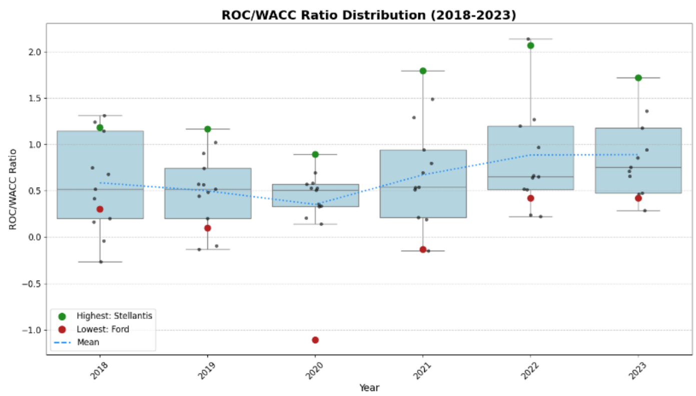

Figure 24 – ROIC/WACC Ratio Development

In sum, the progression of growth and profitability metrics in the automotive sector underscores an industry transitioning toward sustainable value creation. Enhanced cost structures, forward-looking investments in EV technologies, stronger ESG frameworks, and more nimble operations have collectively enabled companies to capture market opportunities and refine their strategic focus. Although performance differentials remain, the general upward momentum in ROIC/WACC ratios signals a strengthening foundation for long-term economic value generation, setting the stage for the sector's future competitiveness and resilience.

3.6 Market-Based Valuation

Market-based valuations in the automotive sector have evolved through phases of initial optimism, subsequent normalization, and increasing differentiation. To better capture general sector trends, valuation multiples were winsorized at the upper 15% (Dixon, 1960) to mitigate the distortion caused by extreme values mostly attributable to Tesla. In the early post-2020 period, multiples such as P/E, EV/EBITDA, P/B, and P/S were elevated due to strong investor expectations for rapid innovation, particularly among PP EV manufacturers, and anticipated recoveries following pandemic-related disruptions (Bloomberg, 2023)

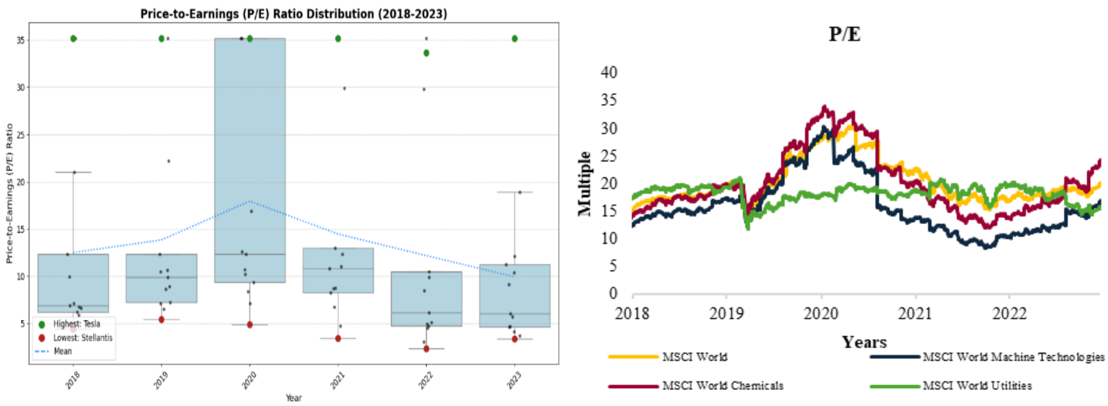

Figure 25 – P/E development in the Automotive sector versus other industries

(Figure 25 and Figure 26). Over time, as macroeconomic conditions stabilized, supply chain constraints persisted, inflationary pressures emerged, and consumer preferences evolved, market sentiment shifted toward a more selective and nuanced view of the sector.

Throughout this period, Tesla consistently commanded premium multiples across key metrics such as P/E, EV/EBITDA, P/B, and P/S ratios. This valuation premium mirrors market conviction in Tesla's disruptive business model, proprietary technology, and future growth potential in EV penetration and autonomous driving capabilities (IEA, Global EV Outlook, 2021). In contrast, more traditional automakers, such as Hyundai and Stellantis, recorded substantially lower multiples, reflecting investor skepticism about their ability to adapt rapidly to an evolving market. Although fundamental improvements in capital structure, efficiency, and profitability were evident across many of these LAMs, the market discounted these gains relative to the more ambitious growth narratives favored by investors. The divergence between high-growth innovators and established incumbents highlights how intangible factors like brand perception, technological capability, and strategic alignment with sustainability goals can weigh heavily on market valuations, even when fundamental financial indicators point toward ongoing operational improvements. Macroeconomic events and sector-specific challenges further shaped investor perceptions (Moody's, 2022). Semiconductor shortages, commodity price volatility, and evolving trade policies exposed vulnerabilities in certain automotive business models, leading investors to reward companies demonstrating supply chain resilience and diversified revenue streams such as Tesla with vertical integration more favorable multiples. As the market's initial euphoria moderated, valuations increasingly reflected measured assessments of execution risk and sustainable profitability rather than mere technological promises.

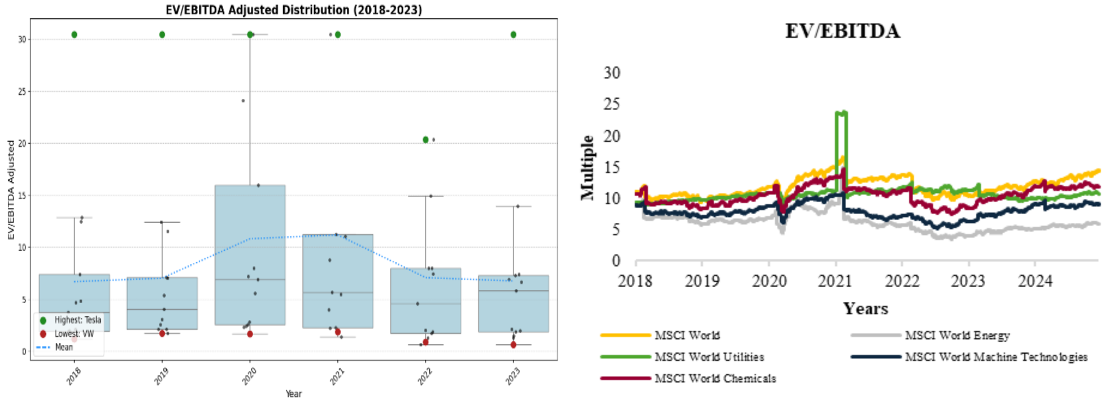

Figure 26 – EV/EBITDA development in the Automotive sector versus other industries

Dividend yields, displayed in Figure 27, added another dimension to these developments. While growth-oriented innovators such as Tesla abstain from dividends, income-focused investors found value in companies like Mercedes-Benz, which offered regular payouts. This bifurcation underscores the diversity of investor preferences: some prioritize long-term growth, while others seek stable, near-term returns.

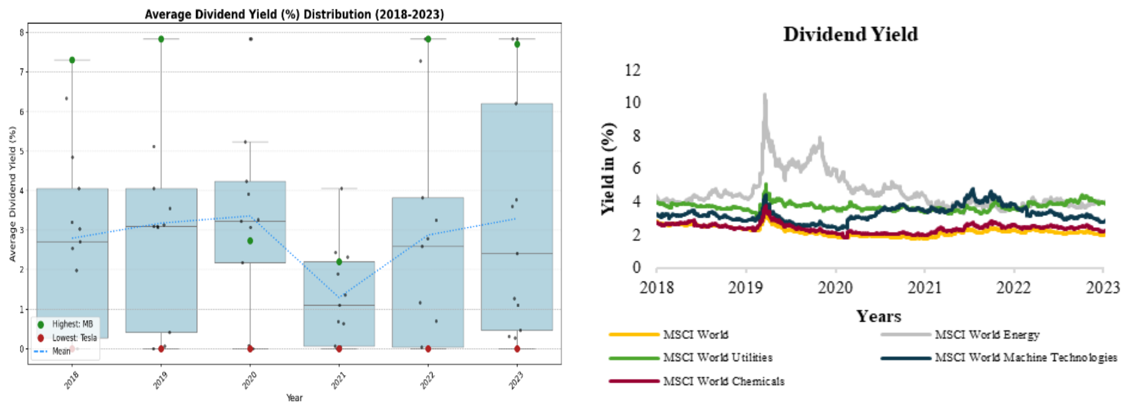

Figure 27 – Dividend yield development in the Automotive sector versus other industries

Compared to the broader MSCI World index, as well as other sectors such as chemicals, utilities, and energy, the automotive sector's valuation multiples generally remained at a discount. Although the global index's composition, dominated by technology firms with high growth expectations, partly explains this disparity, the automotive sector's structural challenges, including capital intensity and slower adoption of new technologies among some incumbents, also contributed to the lower valuations. In contrast, dividend yields in the automotive sector have remained competitive, reflecting both discounted share prices and generally higher payout ratios, positioning these firms in a middle range of around 3% mean and 2.5 % median dividend yield in 2023 relative to other industries.

Bringing all these observations together, the contrast between market-based valuations and the previously analyzed fundamentals, improvements in leverage, liquidity, and profitability, underscores the multifaceted nature of investor decision-making. While robust operational and financial metrics lay the groundwork for sustained competitiveness, market sentiment ultimately hinges on a firm's perceived future trajectory. In a landscape characterized by regulatory transformation, technological disruption, and changing consumer tastes, companies that can convincingly articulate and execute on a growth narrative aligned with macro trends and sustainability goals are more likely to maintain elevated valuations. In turn, as fundamentals continue to improve across the sector, e.g., stronger balance sheets, efficient working capital management, and stable returns on capital, firms have a tangible opportunity to translate these gains into a more compelling value proposition for investors, potentially narrowing the valuation gap between market darlings and more traditional incumbents.

3.7 Regression

To statistically evaluate how the market values the company traits assessed in the benchmark analysis, a multivariate panel regression was employed. Drawing on a balanced panel of the selected peer group over a decade, this approach captures both the temporal dynamics and the firm-level heterogeneity within the sector. The dependent variable defined as a total return index, encompassing both price appreciation and dividends, thereby providing a comprehensive measure of investor sentiment toward these firms.

On the explanatory side, total assets were included to represent operational scale and complexity, total debt-to-equity was introduced to reflect the influence of leverage on performance, and R&D expenditures served as a proxy for innovative capacity and long-term strategic orientation. Additionally, a dummy variable was incorporated to distinguish pure-play PP EV manufacturers (Tesla, BYD, Nio) from LAMs, and another dummy variable captured the structural changes triggered by the COVID-19 pandemic. An interaction term (EV:Covid_19) was then introduced to assess whether pandemic conditions differentially influenced PP EVs relative to LAMs.

Following diagnostic tests, a random effects panel model was chosen for the estimation. This specification allows for the inclusion of time-invariant firm characteristics, enabling a nuanced understanding of how intrinsic company traits interact with evolving market conditions (Baltagi, 2005; Wooldridge, 2010). By leveraging random effects, the model provides a balanced treatment of cross-sectional and temporal variation, ensuring that persistent firm-level attributes and strategic orientations are appropriately captured over the study period. A detailed model description and diagnostic can be found in Appendix 4.

The regression results are displayed in Table 4. Model diagnostics indicate a strong explanatory power. The model accounts for 70% of the variation in TSR, underscoring that the chosen factors are materially relevant. Chi-Square tests confirm the joint significance of explanatory variables. Firm-level fixed traits dominate residual variability, suggesting that intrinsic corporate characteristics, such as brand strength, geographic diversification, and managerial quality, play a substantial role in shaping TSR.

Table 4 – Regression Results of the RE Panel Model

Coefficients:	Estimate	Std. Error	z-value	Pr(>|z|)	
(Intercept)	-0.857	0.721	-1.189	0.234	
LOG_SIZE	0.261	0.061	4.304	0.000	***
CS	-0.001	0.000	-4.570	0.000	***
ROIC	0.027	0.003	9.016	0.000	***
LOG_RnD	0.129	0.041	3.184	0.001	**
EV	0.206	0.904	0.228	0.820	
COVID_19	0.261	0.031	8.517	0.000	***
EV:COVID_19	0.618	0.095	6.529	0.000	***
Total Sum of Squares:	157.420		adj. R^2	0.69943	
Residual Sum of Squares:	46.722		Chisq:	1305.49 on 7 DF	
R^2	0.7032		p-value:	< 2.22e-16	

Note: .*, ** and *** denote that the null can be rejected at the 1%, 0.1% and 0% levels of significance, respectivel

The regression results highlight several key drivers of total shareholder return (TSR) in the automotive sector, confirming and extending insights from the earlier financial analysis. Larger firms (LOG_SIZE: $\beta=0.2608$, $p<0.001$) appear to enjoy a clear advantage, due to more entrenched market positions, global reach, and resource endowments that help buffer against market shocks and support continuous innovation (Barney 1991; Penrose 1959). In contrast, high leverage (debt-to-equity: $\beta=-0.0013$, $p<0.001$) is penalized, underscoring the sector's sensitivity to cyclical demand and high fixed costs. Firms such as Stellantis and Mercedes-Benz, which maintained more prudent leverage profiles, seem better positioned to sustain favorable TSR, while Ford and Hyundai, with relatively higher leverage, may face investor skepticism. This finding aligns with capital structure theory suggesting that excessive reliance on debt can exacerbate risk perceptions (Titman & Wessels, 1988; Myers, 1984).

Superior operational performance and effective capital allocation further enhance TSR. The positive and highly significant coefficient for ROIC ($\beta=0.0267$, $p<0.001$) validates that firms excelling in operational efficiency and project selection, like Stellantis, earn stronger investor confidence. Additionally, innovation capacity proves instrumental: higher R&D intensity ($\beta=0.1295$, $p=0.001$) emerges as a strategic differentiator in an era of electrification and autonomous technologies, with VW standing out as a leader in research-driven initiatives. These results confirm that forward-looking investments and technologically advanced offerings underpin long-term competitiveness.

While simply being classified as a PP EV firm does not guarantee superior TSR (EV dummy not significant), the positive and significant interaction term EV × COVID_19 ($\beta=0.6175$, $p<0.001$) indicates that pandemic-era conditions shifted market perceptions, disproportionately benefiting EV-focused firms. Pandemic-related policy incentives, heightened environmental awareness, and consumer receptivity to cleaner transport modes coalesced to favor PP EVs. Correspondingly, the COVID_19 dummy ($\beta=0.2610$, $p<0.001$) confirms that the sector's adaptability and structural flexibility allowed it to recover and even capitalize on emergent opportunities. This interplay, where COVID-19 acted as a catalyst, reinforces the notion that macroeconomic shocks can accelerate structural change, rewarding firms aligned with evolving consumer preferences and regulatory directives.

These findings resonate with the broader patterns identified earlier. Improving capital structures, prudent debt management, robust liquidity, and operational efficiency established a baseline for sustainable future TSR growth in the sector (Eccles & Michael P., 2010). Complementing these fundamentals with strategic innovation efforts, evidenced by R&D spending, positions firms to excel in a market progressively converging toward EVs and sustainability goals (Giese & Lee, 2019).

A paradox emerges, however, as companies like VW and Stellantis, whose solid fundamentals align with the model's prescriptions, continue to trade at discounted valuation multiples such as P/E (Stellantis) and EV/EBITDA (VW). This discrepancy may reflect investors' disproportionate emphasis on EV narratives and rapid growth promises, suggesting potential undervaluation of well-managed LAMs. Alternatively, it may indicate that conventional metrics have yet to capture the full extent of the structural challenges LAMs face in transforming their business models.

From a strategic perspective, this analysis underscores that stable TSR depends on balanced financial policies, careful capital deployment, and commitment to long-term innovation. Excessive leverage is viewed unfavorably, whereas strong operational performance and robust R&D pipelines are rewarded, particularly when external shocks accelerate sectoral transitions. For investors, the results reinforce the importance of evaluating firms' capital efficiency, strategic adaptability, and innovation capacity rather than relying solely on market share or legacy brand strength. For policymakers and industry stakeholders, the positive response to innovation spending and EV readiness validates the effectiveness of supportive policies and incentives aimed at driving energy transitions in transportation.

4 Conclusion: Quo Vadis Automotive Sector?

This thesis has examined the financial and operational trajectories LAMs and PP EV manufacturers in a rapidly evolving automotive sector. LAMs continue to yield EBITDA margins exceeding 15% and strong cash flows from ICE-based portfolios and diversified markets, yet their growth is constrained by mature segments. Pure-play EV manufacturers record annual revenue increases above 50% due to technological leadership and regulatory incentives, but face heightened volatility, narrower margins, and raw material dependencies.

As the industry shifts upstream toward critical battery materials, China's dominance prompts localization efforts in the EU and US. Emerging technologies like solid-state batteries, AI, and digital sales models (e.g., Tesla's direct-to-consumer approach) redefine competitive strategies. Chinese firms are poised to dominate their domestic market, European automakers confront fragmented demand, and emerging economies offer growth beyond saturated regions.

Building on these insights, three future scenarios emerge: accelerated electrification (EV penetration above 60%), a hybrid evolution (40–50%), or a fragmented transition (around 25–30%). Each requires tailored responses. Policymakers must secure infrastructure and material flows. Industry actors must balance ICE stability with EV and hybrid investments, while investors should diversify to capture upside from disruptors and upstream resource providers without forsaking the resilience of established incumbents.

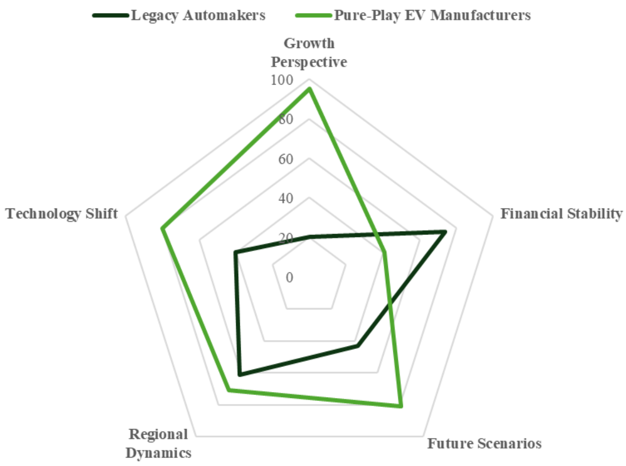

Figure 28 – Overview of Findings

Synthesizing Three Possible Scenarios

Based on the thesis findings, displayed in Figure 28, we have synthesized three plausible trajectories that outline how the automotive sector may evolve, reflecting varying degrees of technological progress, policy ambition, and resource availability.

Scenario 1: Accelerated Electrification - In this trajectory, global EV penetration surpasses 60% by 2035, supported by significant advances in battery efficiency, falling production costs, and strict environmental regulations. LAMs are compelled to allocate unprecedented capital to research, development, and upstream integration to remain competitive. While some effectively transition and capture substantial market share, others, unable to adapt quickly, risk obsolescence as established EV pioneers consolidate their leadership.

Scenario 2: Hybrid Evolution - A more balanced outcome envisions global EV adoption stabilizing at around 40–50%. Under these conditions, persistent infrastructure gaps and uneven policy support render hybrid solutions a practical interim technology. LAMs that pursue a deliberately balanced approach, refining ICE models, scaling hybrids, and gradually expanding EV offerings, benefit from flexible production platforms and strategic portfolio diversification. These firms secure competitive advantages and maintain stable profitability throughout the transition.

Scenario 3: Fragmented Transition - In the most pessimistic scenario, global EV penetration stagnates at approximately 25–30%, constrained by supply chain disruptions, resource scarcity, geopolitical strains, and macroeconomic volatility. Here, LAMs retaining robust ICE capabilities and diversified markets outperform, given the enduring appeal of cost-effective conventional vehicles. In contrast, firms that overinvested in EV platforms and failed to achieve cost parity or technological differentiation face profitability pressures and diminished prospects for long-term viability.

Action Recommendations

In view of this study's findings and the three outlined scenarios, ranging from accelerated electrification to a more moderate hybrid landscape, and finally to a stagnated, low-EV future, key stakeholders must align their strategies with the shifting contours of the industry.

Policymakers: Advancing robust charging infrastructure, ensuring stable and ethically sourced raw materials, and enhancing regulatory coherence across regions become urgent priorities. In a high-EV scenario, their focus must be on expediting technological adoption and resource diversification. In the hybrid evolution scenario, policymakers should foster incremental transitions, supporting hybrid technologies where infrastructure challenges persist. Under conditions of low EV penetration, efforts may need to turn toward reinforcing resilient ICE fleets and mitigating workforce disruptions through large-scale reskilling programs, while maintaining long-term incentives for more sustainable technologies.

Industry participants: Will need to hedge their bets according to market signals and policy frameworks. In a high-EV future, securing vertical integration in battery supply chains and accelerating advanced R&D investments will be critical. EV specialists must aim for breakthroughs in cost reduction and energy density, while LAMs consider taking on higher risk through substantial EV investments to avoid long-term obsolescence. Should the market evolve around hybrids, balancing ICE profitability with incremental electrification offers a secure foothold. In a low-EV scenario, maintaining a competitive ICE portfolio, emphasizing cost control, and cautiously allocating capital toward EV programs safeguard against supply chain volatility and uncertain returns.

Investors: For investors, prudent diversification is paramount. Under conditions of rapid electrification, EV pioneers and upstream resource players stand to generate substantial growth, albeit with higher volatility. In a hybrid scenario, well-managed LAMs with balanced portfolios become attractive targets, offering stability alongside moderate upside potential. In a slower EV transition, undervalued incumbents with robust ICE operations provide defensive qualities. Across all scenarios, positioning portfolios to capture both technological innovation and established fundamentals, through allocations to EV disruptors, resource providers, and resilient LAMs, will protect against downside risks and capitalize on long-term opportunities.

In essence, the future of the automotive sector will be shaped by the interplay of technological innovation, resource constraints, and policy interventions, compelling policymakers, industry actors, and investors alike to adopt flexible, forward-looking strategies that anticipate and adapt to a range of possible evolutionary paths.

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Appendix

A1 – Factsheet: Auto Index

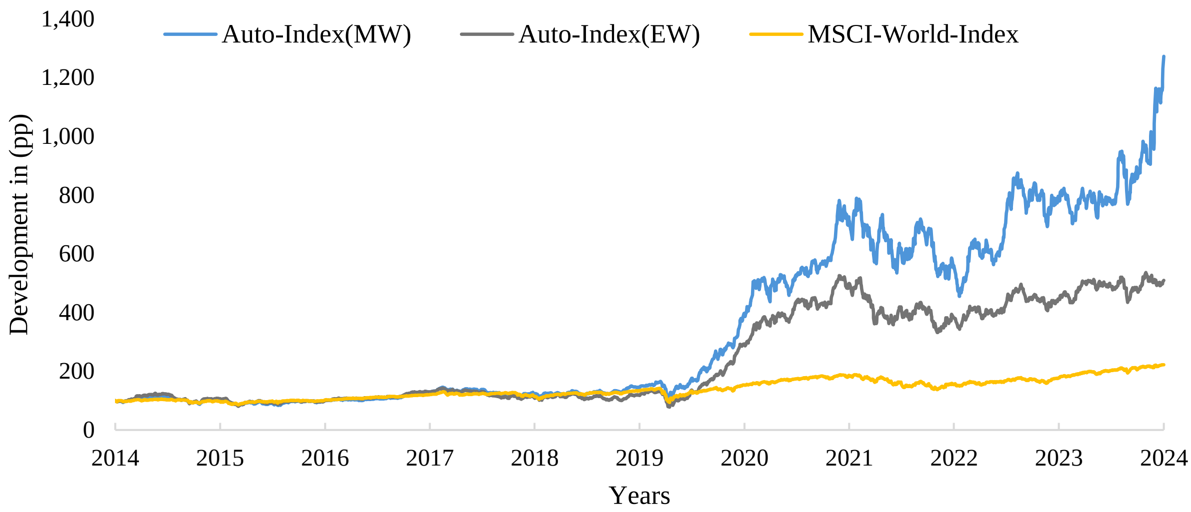


Figure 29 – Index Development Comparison

Index Methodology

Equal-Weighted Index (EW)

In the Equal-Weighted Index, all 14 companies are assigned the same weight. This means that each company contributes equally to the overall index performance, regardless of its market size or value.

To calculate the index, each company starts with the same weight (approximately 7.14% for 14 companies). The performance of the index is based on the simple average of all individual company returns over a specific period. This approach ensures that smaller companies, such as NIO or Great Wall Motors, have the same influence as larger companies like Toyota or Tesla.

Market-Capitalization Weighted Index (MW)

In the Market-Capitalization Weighted Index, the weight of each company is determined by its market capitalization (total market value of the company's shares). Companies with a higher market capitalization, like Toyota or Tesla, have a larger impact on the index compared to smaller companies.

To calculate the index, the market value of each company is measured, and the weight is proportional to its size relative to the total market value of all 14 companies. The overall index performance reflects a weighted average, where larger companies influence the index more than smaller companies. This method better represents the real economic impact of each company on the automotive market.

Performance Figures:

Table 5 – Performance figure comparison

Index	Year	Ann. Return	Cum. Return	Ann. Volatility	Sharpe Ratio	Max. Drawdown	1-Month VaR at 95% C.	CVaR	Beta
Auto-Index(MW)	3Y	22.0%		33.0%	0.58	-42.3%	-2.4%	-3.6%	
	5Y	54.3%	777%	33.0%	1.22				1.21
	10Y	29.0%	1172%	25.8%	0.84				1.14
Auto-Index(EW)	3Y	1.3%		22.4%	-0.04	-45.4%	-1.9%	-2.9%	
	5Y	34.0%	333%	25.3%	0.91				1.05
	10Y	17.7%	410%	21.3%	0.53				1.04
MSCI-WORLD-INDEX	3Y	6.4%		15.0%	0.17	-34.2%	-1.4%	-2.3%	
	5Y	10.7%	0%	17.9%	0.43				
	10Y	8.3%	122%	15.0%	0.34				

Table 6 – Market Capitalization vs 5y Sharpe Ratio

Company	Market Capitalization	5Y Sharpe Ratio
Toyota	277,774.66	0.36
Volkswagen	45,504.81	-0.09
Stellantis	41,266.25	0.26
GM	58,729.41	0.37
Honda	45,629.20	0.17
Hyundai	29,386.10	0.42
Ford	41,769.77	0.31
BYD	108,574.98	1.01
MB	61,854.95	0.44
BMW	52,591.31	0.25
Tesla	1,249,419.42	1.16
Great Wall Motor	27,181.63	0.85
Tata	39,513.83	0.79
NIO	9,621.20	0.47

Table 7 – 5y beta for our AutoRep Basket

TICKER	5Y Beta at 95% C.
Toyota	0.4
Volkswagen	1.4
Stellantis	1.5
GM	1.5
Honda	0.4
Hyundai	0.6
Ford	1.5
BYD	0.3
MB	1.4
BMW	1.2
Tesla	1.9
Great Wall Motor	0.4
Tata	0.6
NIO	1.7

A2 – VAR (2) Model Explanation

Model Specification

A Vector Autoregressive (VAR) model of order two, VAR(2), is estimated to analyze the dynamic interdependencies among the selected endogenous variables (Lütkepohl, 2005). Let $y_t = (y_{1t}, \dots, y_{Kt})$ be a K-dimensional vector of endogenous variables. The VAR model is given by:

$$y_t = v + A_1 y_{(t-1)} + \cdots + A_p y_{t-p} + u_t \quad (1)$$

where $v = (v_1, \dots, v_K)'$ is a fixed $(Kx1)$ vector of intercepts, A_i are (KxK) matrices of regression coefficients, and $u_t = (u_{1t}, \dots, u_{Kt})$ is the *K*-dimensional vector of error terms, assumed to be $u_t \sim i.i.d.N(0, \Omega)$. Coefficients are estimated equation-by-equation via ordinary least squares. A detailed description of the model variables is displayed in Table 8.

Table 8 – Overview over the selected model variables

Variable	Data	Description	Source	Unit of measure	Frequency
Index	Own Market-Weighted Index	Market-cap-weighted index derived from 14 global automotive companies.	Bloomberg, own calculations	Index	Daily
Commodities	S&P Global Metals Index - SPGSIN Index	Benchmark reflecting investment performance of industrial metals, including aluminum, copper, and zinc.	Bloomberg	USD	Daily
Oil	Bloomberg Crude Oil Historical Prices	Historical price series for WTI crude oil, representing global energy cost trends.	Bloomberg	USD	Daily
Currency	Global Trade-Weighted Dollar Index DTWEXBGS	Index measuring the U.S. dollar's value against a basket of major trading partners' currencies, weighted by trade volumes.	Fred St. Louis	Index	Daily
Interest	LGTRTRUU Index - Bloomberg Global Treasuries	Weighted index tracking global government bond yields, emphasizing liquidity and maturity across sovereign treasuries from developed markets.	Bloomberg	Percentage	Daily
Volatility	Bloomberg VIX Index	Financial benchmark measuring expected S&P 500 volatility based on options pricing, providing insights into market uncertainty.	Bloomberg	Index	

Data and Preprocessing

The dataset consists of daily observations from December 9, 2014, to December 8, 2024, yielding 2,606 observations. Variables include an automotive sector index and several macroeconomic factors. Stationarity was assessed via Augmented Dickey-Fuller (ADF) tests (Dickey & Fuller, 1979). Non-stationary series were differenced to achieve stationarity. All data were sourced from Bloomberg.

Lag Selection and Estimation

The Akaike Information Criterion (AIC) was used to determine the appropriate lag length. A VAR(2) specification was selected, balancing model complexity and fit. Estimation was performed using the stable, differenced series to ensure valid inference (Lütkepohl, 2005).

Impulse Response Functions

Impulse response functions were computed to examine the dynamic effects of one-standard-deviation shocks to each endogenous variable on the Index. Bootstrapped 95% confidence intervals were employed for statistical inference (Kilian & Lütkepohl, 2017). The IRFs trace the effect of shocks over an 8-day horizon.

Granger Causality Tests

Granger causality tests were conducted to assess predictive relationships among variables, determining whether past values of one variable enhance the forecasting ability of another. Test results are provided in Table 9.

Table 9 – Overview model results for Granger Causality

Variable	F-Test Value	p-Value	Result
Commodities	3.7901	0.00004	Significant Granger causality on the index
Oil	2.3604	0.00876	Significant Granger causality on the index
Currency	1.6159	0.09529	No significant causality
Interest	4.5287	0.00000	Significant Granger causality on the index
Volatility	3.337	0.00024	Significant Granger causality on the index

Model Stability and Serial Correlation

Model stability was evaluated using CUSUM tests on the recursive residuals. The CUSUM plots remained within critical bounds for most equations, indicating no structural breaks. Minor deviations in certain equations were observed but did not persistently exceed critical thresholds, confirming overall model stability (see Figure 30). To account for serial correlation the Portmanteau Test was employed. This result suggests no presence of significant serial correlation in the residuals of the VAR(2) model.

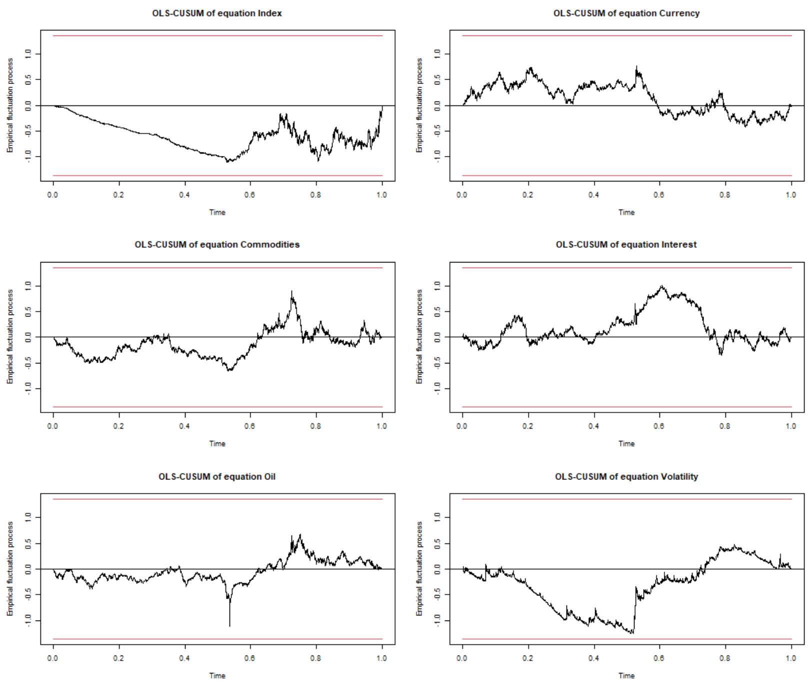
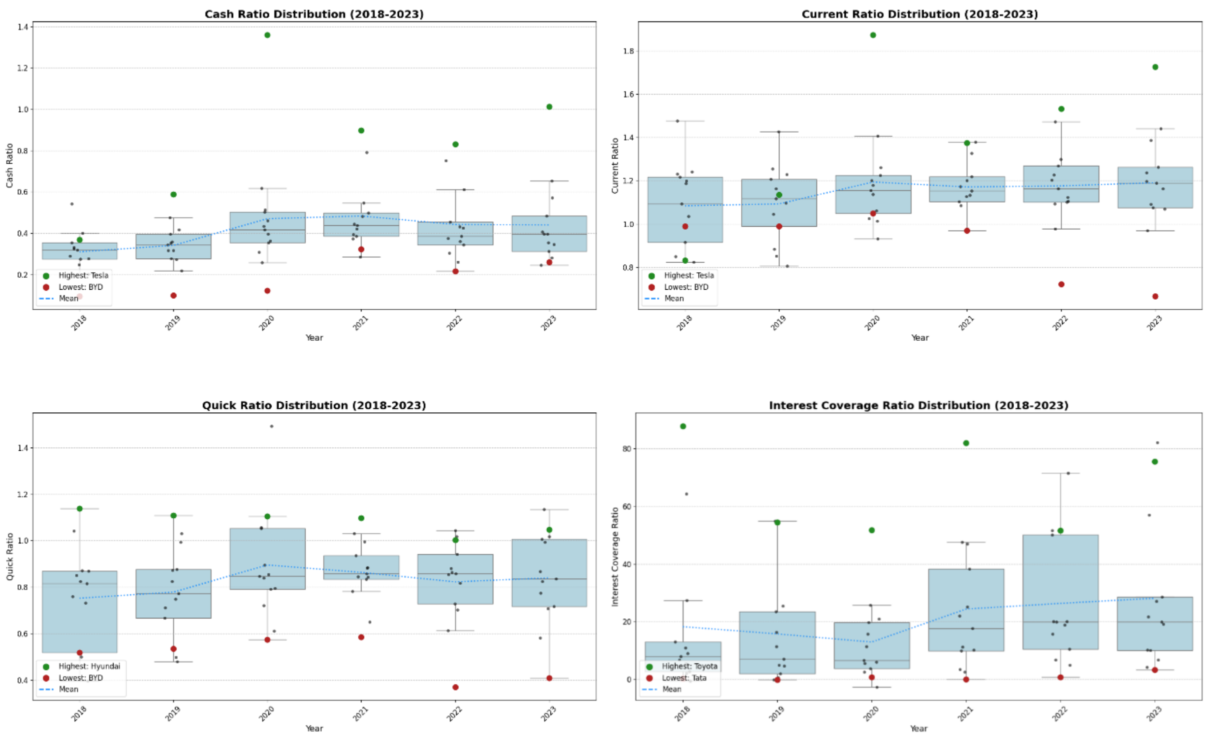
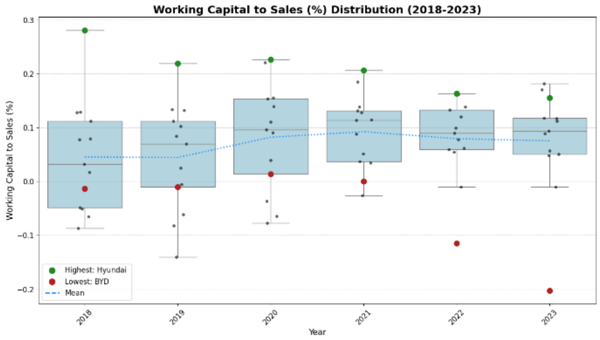
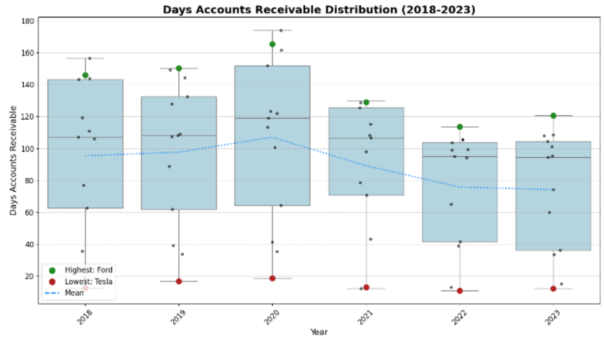


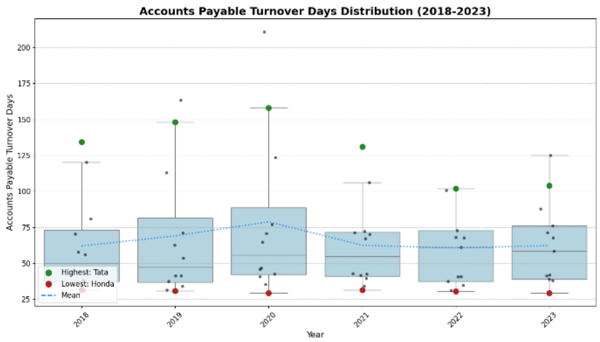
Figure 30 – Stability test results of the VAR(2) model

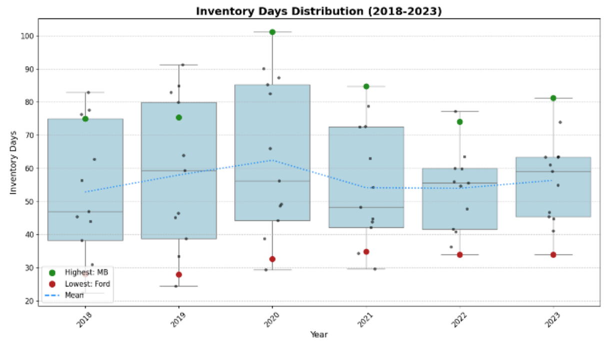
A3 – Additional Benchmark Results

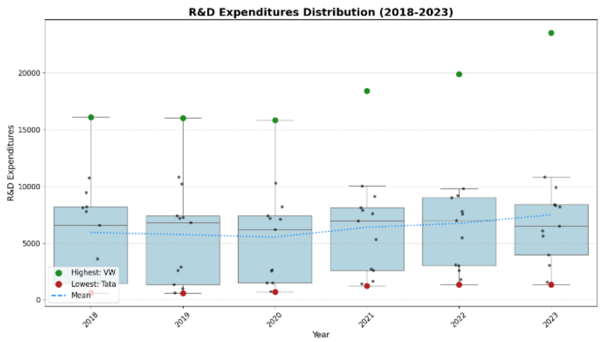


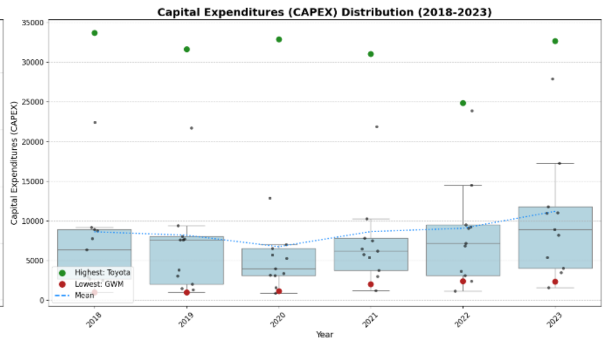

Working Capital to Sales (%) Distribution (2018-2023)
Working Capital to Sales (%)
Year
Highest: Hyundai
Lowest: BYD
Mean

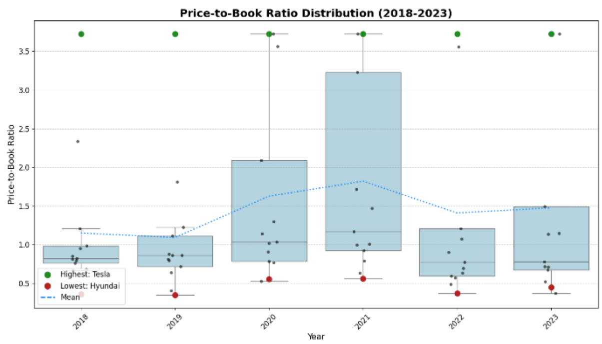

Days Accounts Receivable Distribution (2018-2023)
Days Accounts Receivable
Year
Highest: Ford
Lowest: Tesla
Mean

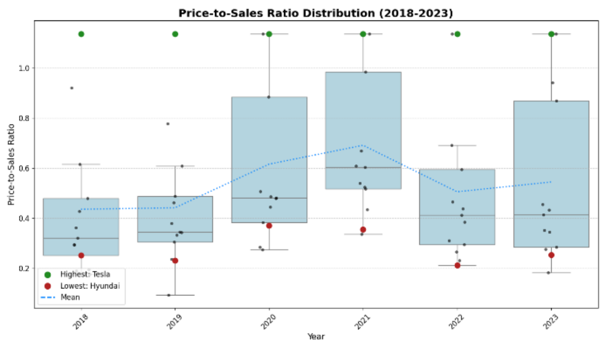

Accounts Payable Turnover Days Distribution (2018-2023)
Accounts Payable Turnover Days
Year
Highest: Tata
Lowest: Honda
Mean


Inventory Days Distribution (2018-2023)
Inventory Days
Year
Highest: MB
Lowest: Ford
Mean


R&D Expenditures Distribution (2018-2023)
R&D Expenditures
Year
Highest: VW
Lowest: Tata
Mean


Capital Expenditures (CAPEX) Distribution (2018-2023)
Capital Expenditures (CAPEX)
Year
Highest: Toyota
Lowest: GWM
Mean


Price-to-Book Ratio Distribution (2018-2023)
Price-to-Book Ratio
Year
Highest: Tesla
Lowest: Hyundai
Mean


Price-to-Sales Ratio Distribution (2018-2023)
Price-to-Sales Ratio
Year
Highest: Tesla
Lowest: Hyundai
Mean

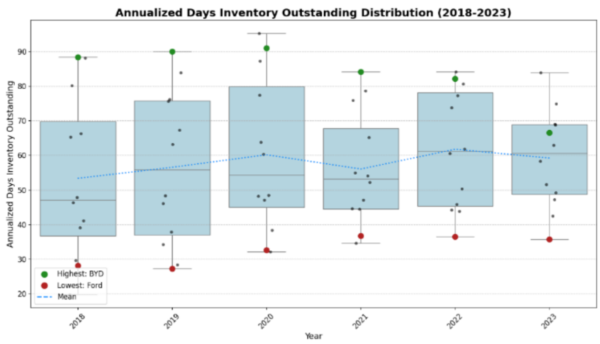


Figure 31 - Additional benchmarked KPIs

A4 – Panel Regression Model Explanation

Model Specification

A random effects (RE) panel model is employed to exploit both cross-sectional and temporal variation while allowing for time-invariant firm-level characteristics (Hsiao, 2003).

Let Y_{it} represent the Total Shareholder Return (TSR) for firm i at time t. The RE model is specified as:

$$(1)\ \mathrm{Y}_{it} = \beta_0 + \beta_1 \,\mathrm{LOG\_SIZE}_{it} + \beta_2 \, CS_{it} + \beta_3 \,\mathrm{ROIC}_{it} + \beta_4 \,\mathrm{LOG\_R\&D}_{it} + \beta_5 \,\mathrm{EV}_i + \beta_6 \, COVID_t + \beta_7 \,(\mathrm{EV}_i \times COVID_t) + \mu_i + \varepsilon_t \quad (2)$$

Where Y_{it} = Total Shareholder Return for firm i at time t, β_0 = Intercept, $\beta_1 - \beta_7$ = Coefficients of the explanatory variables, μ_i = Firm-specific random effects (unobserved heterogeneity), ε_t = Idiosyncratic error term, $\mathrm{LOG\_SIZE}_{it}$ = Logarithm of total assets, CS_{it} = Total debt-to-equity ratio (capital structure), ROIC_{it} = Operating Return on Invested Capital, $\mathrm{LOG\_R\&D}_{it}$ = Logarithm of Research & Development expenditures, EV_i = Dummy variable for pure-play EV producers (1 if firm i is EV-focused, 0 otherwise), $COVID_t$ = Dummy variable for quarters after December 31, 2019 (1 if t is affected by COVID-19, 0 otherwise), ($\mathrm{EV}_i \times COVID_t$) = Interaction term to assess combined effects of EV focus and the pandemic.

Data and Sample

The panel dataset comprises thirteen automotive firms (both LAMs and PP EV) over the period from March 31, 2014, to September 30, 2024, with quarterly observations. Excluding Nio Inc. due to insufficient pre-IPO data yields a balanced sample of 559 firm-quarter observations (43 quarters per firm). All data were sourced from Bloomberg for consistency and comparability. Variables were selected on theoretical and empirical grounds, covering firm size, capital structure, operational efficiency, R&D investment, and strategic orientation (EV focus). The dependent variable is Total Shareholder Return (TSR), incorporating capital gains and dividends.

Estimation and Model Choice

A Hausman test (Hausman, 1978) comparing fixed effects (FE) and RE specifications indicated no significant difference (χ^2=7.058, p=0.3155). Given that time-invariant regressors (e.g., EV dummy) are of interest, and no strong correlation with the error term was detected, the RE model was chosen as the most consistent and efficient estimator (Baltagi, 2005; Wooldridge, 2010).