MASTER DEGREE IN

ACCOUNTING

MASTER FINAL WORK

THESIS

THE IMPACT OF THE SHIFT TOWARDS BATTERY ELECTRIC VEHICLES ON THE FINANCIAL AND MARKET PERFORMANCE MEASURES IN THE AUTOMOTIVE INDUSTRY.

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MARCH - 2024

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By Marcel Woziwodzki

Abstract

This academic work comprehensively explores the transition of the automotive industry towards battery electric vehicles (BEVs). In particular, it focuses on the implications of this shift from both a financial and market perspective. By studying the 16 currently largest car manufacturing companies between 2009 and 2022, this study evaluates how this transition affects financial performance indicator, namely return on assets (ROA), as well as market performance metric – market-to-book (MTB) ratio. The findings of this paper suggest that while adopting BEVs hurts ROA, which can be linked to the competitive nature of emerging technology and its high costs, it was observed to have a positive effect on long-term market performance. This indicates that car companies involved in engaging and investing in battery electric technology tend to have higher market valuations. Furthermore, the study explores how factors such as company size and research and development (R&D) influence the relationship between embracing green innovation and performance measures. The results highlight firm size as a moderator in the relationship between ROA and green innovation and a moderating role of R&D in the link between green innovation and market performance. The study provides empirical evidence of the interplay between BEV sales figures and the main financial and market performance metrics within the key players in the global automotive industry. The findings fill a gap in the existing literature by offering valuable insight into the automotive sector's adoption of BEVs, presenting a deeper understanding of the phenomenon and suggesting avenues for future research.

Keywords: battery electric vehicles, automotive industry, financial performance, market performance, green innovation

JEL: G32, L10, L25, L62, M41, O30, Q56

Resumo

Este trabalho académico explora de forma abrangente a transição da indústria automóvel para os veículos eléctricos a bateria (BEVs). Em particular, centra-se nas implicações desta mudança, tanto do ponto de vista financeiro como do ponto de vista do mercado. Ao estudar as 16 maiores empresas fabricantes de automóveis da atualidade entre 2009 e 2022, este estudo avalia a forma como esta transição afecta o indicador de desempenho financeiro, nomeadamente a rendibilidade do ativo (ROA), bem como a métrica de desempenho do mercado - o rácio market-to-book (MTB). As conclusões deste estudo sugerem que, embora a adoção de BEVs prejudique o ROA, o que pode estar relacionado com a natureza competitiva da tecnologia emergente e os seus custos elevados, observou-se que tem um efeito positivo no desempenho do mercado a longo prazo. Isto indica que as empresas do sector automóvel envolvidas no envolvimento e investimento na tecnologia de baterias eléctricas tendem a ter avaliações de mercado mais elevadas. Além disso, o estudo explora a forma como factores como a dimensão da empresa e a investigação e desenvolvimento (I&D) influenciam a relação entre a adoção da inovação ecológica e as medidas de desempenho. Os resultados destacam a dimensão da empresa como um moderador na relação entre o ROA e a inovação verde e um papel moderador da I&D na ligação entre a inovação verde e o desempenho do mercado. O estudo fornece provas empíricas da interação entre os números de vendas de BEV e as principais métricas de desempenho financeiro e de mercado dos principais intervenientes na indústria automóvel global. Os resultados preenchem uma lacuna na literatura existente, oferecendo uma visão valiosa sobre a adoção de BEVs pelo sector automóvel, proporcionando uma compreensão mais profunda do fenómeno e sugerindo pistas para investigação futura.

Palavras-chave: veículos eléctricos a bateria, indústria automóvel, desempenho financeiro, desempenho do mercado, inovação verde

JEL: G32, L10, L25, L62, M41, O30, Q56

Acknowledgments

During this exhaustive but also rewarding process of writing this master's thesis, I have experienced the intellectual and personal growth that has shaped the person I am today. However, I would not be able to carry it forward and finalize it without the support of many.

First, I would like to thank my supervisor, Cristina Gaio, for her valuable guidance and knowledge which contributed strongly to the focus and content of this research. I am grateful for all the helpful comments and suggestions that have always pushed me to do more.

Furthermore, I would like to extend my heartfelt thanks to all the professors at ISEG – Lisbon School of Economics & Management. Their experience and practical guidance throughout these years have helped me a lot with the completion of the Master Final Work. Encountering and learning from these knowledgeable professionals has been a crucial experience for me in my academic journey.

On a personal note, I must acknowledge my lovely girlfriend, Ania, for her unlimited love and personal support. She has been my greatest motivator and source of comfort. I will always be grateful for all advice, hugs, and snacks delivered to my workstation.

Above all, to my family and friends, I will always be thankful for their continuous trust in me. I cannot express my gratitude for their love and support that have helped me stay strong even during the most difficult times. Since this work represents the biggest achievement so far in my personal academic experience, I would like to express my heartfelt appreciation to everyone who has been part of this journey.

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List of Abbreviations

ACEA The European Automobile Manufacturers' Association

BEV battery electric vehicle

EC European Commission

EP European Parliament

FCA Fiat Chrysler Automobiles

GDP gross domestic product

GIS green innovation strategy

HEV hybrid electric vehicle

IEA International Energy Agency

ICEV internal combustion engine vehicle

M&A mergers and acquisitions

MTB market-to-book

PHEV plug-in electric vehicle

R&D research and development

ROA return on assets

WHO World Health Organization

1 Introduction

The automotive sector is, at present, in a fundamental innovation shift, channeling substantial investments into green technologies and innovation strategies. While multiple zero-emission technologies such as hydrogen fuel cells and synthetic fuel are being developed, electric technology has become the point of the spear of green innovation in the auto industry (International Energy Agency [IEA], 2023). Specifically, battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs) seem to be becoming increasingly popular among auto manufacturers as well as potential customers. This study, however, is focusing exclusively on BEVs, the alternative mobility technology, that does not have the gasoline engine but relies only on a rechargeable battery, as opposed to PHEVs that combine an electric motor and a gasoline engine.

The surge in popularity of BEVs can be attributed to various factors, with their promising positive environmental performance taking center stage. The European Commission (EC) conducted a survey in 2019 titled "Attitudes of Europeans towards the Environment" about people's approach to environmental protection. The results revealed that 94% of the surveyed Europeans believe that the protection of the environment is very important for them and consider it a priority (EC, 2020). Furthermore, the recently announced call from the EU Parliament (EP) about banning internal combustion engine vehicles (ICEVs) by 2035 also can be classified as an influential factor in making customers more inclined to buy battery electric alternatives (EP, 2023). What is more, government bodies worldwide are enticing buyers with benefits especially in the form of extra tax exemptions for electric mobility, hence contributing to the faster growth of the number of electric vehicles on the roads (The European Automobile Manufacturers' Association [ACEA], 2023). The latest example is the "social leasing" project implemented in France that allows low-income households to rent BEVs for as little as €54 per month without a down payment (Pappas, 2023). With an increasing environmental consciousness among customers, they start to move towards electric substitutes and recognize more potential associated with BEVs than petrol and diesel cars.

However, the transition to BEVs does not come without challenges, particularly those related to costs. BEVs are notably more expensive than ICEVs, a technology that has been well-known for many decades. Stringent CO_2 emission regulations, escalating each year, force car manufacturers to invest in new eco-friendly technologies, necessitating expensive and time-consuming research and development (R&D). This overall consequences in the final product's high market price. For instance, the entry-level fully electric BMW iX1 in Portugal in 2023 was priced at €61,000, significantly surpassing the cost of the BMW X1 with a standard internal combustion engine, with a price of €42,800 (Bayerische Motoren Werke AG, 2023). Additionally, customer skepticism persists due to high concerns about the technology's maturity, limited range, and the underdeveloped infrastructure of electric vehicle chargers (Krishna, 2021).

This scenario presents a complex dilemma for potential customers: whether to choose a BEV or stick with the traditional ICEV. While individual choices vary, the broader spectrum of this decision and its impact on automotive companies' financial and market performance measures is crucial to investigate. The automotive market may be undergoing a shift enforced by regulatory authorities, leading to financial drawbacks due to the high costs associated with the R&D of battery electric technology. On the other hand, the implementation of electric cars could represent a new and lucrative source of income for the business. To confront this matter and address the research question "How does the shift towards BEVs affect the financial and market performance measures of the companies in the automotive industry?", this study assesses financial performance, measured by return on assets (ROA) as well as market performance, proxied by market-to-book (MTB) ratio, in relation to BEV sales. The study includes panel data from 16 of the world's largest automotive companies from 8 different countries over 14 years from 2009 to 2022, utilizing a fixed effects regression model.

Recognizing the backward-looking nature of financial measures and the forward-looking perspective of market-based measures (Demsetz & Villalonga, 2001), the study integrates both types of performance metrics to thoroughly evaluate the whole outlook of the impact of green innovation implementation on the automotive industry. The theoretical framework underpinning this research claims that green vehicle innovation positively influences an automaker's market value, but negatively ROA. What is more, this thesis attempts to investigate the moderating role of firm size in green innovation and financial performance link, and R&D intensity in the relationship between green innovation and market performance. As suggested by the literature, the link between green innovation and ROA appears to be negatively influenced by company size (Lin et al., 2019), while R&D is proven to have a strong moderating effect on the green innovation and brand value relation (Lin et al., 2021).

The goal of this research is to address a significant gap in the literature concerning the impact of electrification in the automotive industry on financial and market performance measures of car manufacturing companies. Acknowledging the ongoing debate on the pros and cons of electric car implementation, this study is motivated by the aim to fill this gap and provide valuable insights, conclusions, and recommendations for future research. Distinguishing itself from existing narrow-focused studies, this empirical work aims to explore the issue from a broader perspective, considering the impact on both past performance (ROA) and future performance (MTB ratio).

The findings presented by this academic work contribute to the empirical evidence highlighting the relationship between the shift towards BEVs and financial as well as market performance metrics of global automotive industry leaders. The implications of the study are especially addressed to directors of automotive companies that are currently sustaining the switch to the BEVs as well as investors and shareholders that may be uncertain about the future of this new technology.

The research study is structured as follows: Section 2 reviews relevant academic literature, Section 3 presents the details about the data and methodology, Section 4 contains the findings as well as the discussion, and Section 5 concludes the study, illuminating limitations and recommendations for future research. This comprehensive approach seeks to offer a reliable understanding of the intricate dynamics shaping the future of the automotive industry that is currently experiencing the green revolution.

2 Literature review

2.1 Overview of the car industry globally

This section presents an overview of the automotive industry and explains why certain specific companies were chosen for this research sample. The automotive sector is known for many mergers and acquisitions (M&A), the process where two companies combine forces to form a bigger entity (Aktas et al., 2003; Warter & Warter, 2017). These M&As are common in the automobile industry because they provide opportunities to create better-equipped vehicles at lower costs thanks to economies of scale and synergistic effects while also complying with various regulations (Aktas et al., 2003). Consequently, it has become rare nowadays for car manufacturers to operate independently due to the rising costs associated with vehicle manufacturing, which has led companies to merge into larger corporations (Wojciechowicz, 2023). Many known car brands on the roads today belong to expansive automotive conglomerates.

Among these car conglomerates, Stellantis N.V. stands out as a global entity with an impressive portfolio of 14 passenger car brands. Similarly, Volkswagen AG is key a player in the industry with 8 brands. Both corporations are included in this study’s sample, making an essential contribution to the research. Toyota Motor Corporation, despite having a portfolio consisting of only 2 car brands, is also a part of an analysis as it holds the position of the world’s second-largest automobile manufacturer (Statista, 2024). Volkswagen AG and Toyota Motor Corporation have been competing for the title of the global leading car company for many years. In 2022, Volkswagen AG secured the first place with Toyota Motor Corporation behind, and Stellantis N.V. claiming the third spot. These 3 corporations altogether accounted for nearly 35% of global car sales in 2022 (Statista, 2024). The study, besides these 3 automotive giants, includes the other of the 13 largest car manufacturers in terms of 2022 revenue, as reported by the Orbis database. The entire sample of car companies used in this academic work was responsible for 86,3% of global car sales in 2022, highlighting the study’s extensive view of the global automobile industry (Statista, 2024).

The wide selection of companies is reflected in the varying approaches they take when it comes to green innovation, which offers sample differentiation and greatly contributes to the research findings. For instance, Tesla, Inc. exclusively offers BEVs. It has been leading global sales charts in that category since 2015 (Irle, 2023). Another prominent player is BYD Company Limited, a Chinese automotive company that reported selling nearly 1 million BEVs in 2022, establishing itself as a major competitor in terms of developing battery electric technology. This is further emphasized by the company’s sales figures with approximately half of their sales being attributed to BEVs in recent years (Kane, 2023). Toyota Motor Corporation has been an industry pioneer in hybrid technology since 2000 with the introduction of the globally successful Toyota Prius (Farr, 2013). Although the company has sold over 1.3 million hybrid electric vehicles (HEVs) by 2016 – accounting for 70% of the global HEV market (EV-volumes, 2017) – their focus on fully electric models is relatively limited. Currently, they offer 4 fully electric models for sale in Europe and place more emphasis on hydrogen fuel cell technology (Greimel, 2023). In contrast to Toyota’s approach, Volkswagen AG stands out with a line-up of 12 electric models available for sale across Europe, as of January 2024

(Volkswagen Group, 2024). Meanwhile, the averse-to-electric technology approach is presented by Honda Motor Company Ltd. which currently offers only 1 BEV (Honda Motor Co., Ltd., 2024). On the other hand, Stellantis N.V. is leading the market with a selection of 25 different electric models available for purchase in Europe as of January 2024 (Stellantis N.V., 2024). Hyundai Motor Company, Mercedes Benz Group AG, and Bayerische Motoren Werke AG are other major competitors in the battery electric car market offering 4, 6, and 10 fully electric models respectively in Europe as of January 2024 (Hyundai Motor Group, 2024; Mercedes Benz Group AG, 2024; Bayerische Motoren Werke AG, 2024).

The changing strategies and positions of these companies in the electric vehicle landscape highlight the complexity and competitiveness of the car industry. These diverse approaches taken by the aforementioned companies raise crucial questions about their potential impact on the companies' financial and market performance measures. Hence, testing a major part of the automotive sector constitutes a differentiated sample and assures an in-depth examination of the impact of electrification on past and future performance metrics.

2.2 Shifts in the history of the automotive industry

The automotive sector is currently experiencing an electric vehicle revolution as the industry transitions from internal combustion engine to zero-emission vehicles. This change is driven by a growing need to decrease the global carbon footprint with a focus on the environmental impact of transportation (Fisher et al., 2023). As this research study is to explore the implications of this transformation, it is worth investigating the impact of other crucial changes in the history of the automotive industry.

The most renowned historical shift in the automotive sector reaches the 1920s when Henry Ford introduced the moving assembly line that revolutionized automobile manufacturing. The moving assembly line accomplished a huge success and started a new chapter in automobile manufacturing called mass production. At the very beginning, though, the development and technology needed to establish it required high expertise and investment. Moreover, the innovation was faced with resistance among many workers who were not satisfied with the change. They found doing only one or two tasks instead of building the whole vehicle from scratch boring and less engaging. In the long-term, however, this innovative way of manufacturing process is now referred to as a game changer, since the invention of the moving assembly line was followed by a drastic fall in manufacturing time and cost, enabling the company to produce more vehicles at a lower price. Despite the early challenges, the assembly line boosted efficiency and allowed for cheaper production. In consequence, mass production allowed the company to offer more affordable vehicles that encouraged customers to purchase new cars, overall having a positive impact on the company's performance (Ford Motor Company, 2020).

The case of Henry Ford and the implementation of the moving assembly line enhances the understandability of value creation and value appropriation in the automotive industry. Mizik & Jacobson (2003) by assessing the financial effect generated by shifts between value creation and value appropriation evaluated that the automotive industry (part of the stable-technology group as of Chan et al., 1990; Chandler, 1994) puts considerable emphasis on value appropriation and consequently struggles to extract surplus. Therefore, to enhance overall performance, Mizik & Jacobson (2003) suggest that automotive firms should shift their focus towards creating value. In other words, investing in innovation, production, and delivery efficiency would bring long-term benefits. In essence, the main takeaway of the historical shifts in the automotive sector, as illustrated by Henry Ford's example, is that strategic investment in creating value can lead to success and boost competitiveness in the market.

In light of the ongoing development and implementation of BEVs in the automotive industry, it is expected that it might face initial challenges with a switch from conventional vehicles to electric ones. However, this transition is anticipated to have long-term positive effects on the industry's performance. The commitment to green practices and innovative technologies not only helps to achieve environmental goals but also drives future economic growth and market competitiveness. As the industry enters a new green innovation transformation, it is important to draw lessons from the past, such as the transformative impact of the moving assembly line, that guides companies through the complexities of an industry transformation and helps to understand its long-term implications. All things considered, the development and implementation of electric vehicles in the automotive industry are expected to hurt companies' past performance but improve future performance.

2.3 Evidence from other industries

Following the review of the impact of incremental shift observed in the history of the automotive industry, it is time to explore the evidence from different sectors. Technological shifts driven by sustainable regulations have a significant impact on the performance of companies in various sectors. Alshehhi et al. (2018) reviewed 132 top-tier academic journals to understand how sustainability impacts performance across different business industries. The scholars found that 78% of publications report a positive relationship between corporate sustainability and financial performance. This supports the idea that sustainable practices are not only aligned with ethical values but also bring financial benefits. In contrast, research by Balatbat et al. (2012), that examined 208 Australian companies across 11 different sectors, failed to identify a strong positive association between a firm's performance and their ESG scores, suggesting a neutral relationship between sustainable change forced by regulatory authorities and company performance. It sheds light on how sustainable practices can differently affect financial success in the context of various sectors.

An example showcasing the connection between regulations focusing on reducing greenhouse gas emissions and performance is evident in the energy sector. Those regulations are shaping the industry's business landscape. The companies involved in fossil fuel extraction may face increased compliance costs, emission-related taxes, and stricter reporting requirements. On the other hand, renewable energy companies may benefit from incentives, grants, and subsidies, positively impacting their performance (Qadir et al., 2021). However, the study of Paun (2017) into the energy sector in Romania presents the complexities within this industry. It reveals that companies producing renewable energy initially encountered financial difficulties, which led to a halt in investments and the questioning of the new technology entering the market. The author also exhibited better performance of the companies that are producing energy from fossil fuels. This highlights the crucial role of government involvement in the success of green energy and the complex nature of regulatory and sustainable shifts that may not immediately result in positive outcomes.

A similar scenario can be observed in the manufacturing industry where new laws targeting emissions, waste reduction, and energy efficiency compelled manufacturing companies to adopt greener innovations and practices. This transition typically demands investments in new technologies, process enhancements, and optimization of supply chains. While there may be initial costs associated with these changes, companies are expected to improve their long-term performance by reducing energy consumption, lowering waste disposal expenses, and enhancing brand reputation. Xie et al. (2019) conducted a study on high-polluting manufacturing industries in China and found a positive relationship between green process innovation and firms' corporate financial performance. Nevertheless, it is worth noting that

Aguilera-Caracuel & Ortiz-de-Mandojana (2013) emphasize that this beneficial impact on manufacturing companies' performance is not immediate and takes time to materialize.

In the agriculture field, the favorable results of economic shifts driven by regulations were ascertained by Crowder & Reganold (2015) regarding organic agriculture as opposed to conventional agriculture. The outcome of the scholars' study further illustrates how embracing environmentally friendly practices can positively impact performance measures.

The varying outcomes observed across different industries underscore the complexity of the relationship between green innovation and companies' corporate performance. The diverse findings may imply the potential effects of BEVs' implementation on past and future performance measures within car manufacturing companies. Development and adoption of BEVs initially require big changes and investment, yet it may bring improvements in the automotive sector's long-term performance.

2.4 Factors for and against the smooth transition to BEVs

The automotive industry is widely recognized as one of the most contaminating sectors with the biggest impact on the environment in the current business landscape. It contributes greatly to pollution and CO_2 emissions (World Health Organization [WHO], 2023). The need to reduce carbon emissions becomes more urgent every day driven by the growth of human development and increasing environmental concerns. The first environmental policy linked to the automotive sector and air pollution can be traced back to the 1960s when the US state of California pioneered implementing emission standards for new vehicles (Watson et al., 1988). Currently, numerous strict regulations require car manufacturers to meet standards aimed at reducing greenhouse gas emissions. To comply with these regulations, automakers must invest and adopt eco-friendly innovations and technologies in their products.

The severe environmental impact caused by ICEVs compelled the EP to make a ground-breaking announcement in March 2023. They approved a ban on fossil fuel cars starting from 2035 (Caroll, 2023). This decision means that all passenger vehicles sold within the EU after 2035 must be completely neutral in terms of carbon emissions. As a result, automakers are obligated by these regulations to develop and incorporate electric vehicle technology which is still not established enough and requires long-term investments.

Consequently, the market cost of BEV is usually much higher than ICEV, making it difficult to purchase for individuals. Governments all over the world are aware of the challenge posed by the prices of BEVs. To address this problem, the authorities started to offer a variety of incentives and tax benefits. For instance, the French government has recently introduced a social leasing program for BEVs specifically designed for low-income households. This program not only offers monthly fees starting at €54 but also eliminates the need for a down payment that is subsidized by the government. However, to be eligible for this program, the individuals must be residents of France, have an income of up to €15,400, travel more than 8,000 km per year, and live at least 15 km away from their workplace (Pappas, 2023).

Several studies highlight the essential role played by government financial incentives and subsidies in boosting electric car sales and promoting their widespread adoption (Sierzchula et al., 2014; Yong & Park, 2017; Münzel et al., 2019; Mpoi et al., 2023). Pavlínek (2023) also emphasizes that there are differences in the transition to electric vehicles between Eastern Europe and Western Europe due to less pronounced levels of government incentives in Eastern countries. Government funding plays a crucial role in encouraging customers to switch from traditional gasoline-powered cars to BEVs, thereby not only considerably boosting sales but also significantly enhancing the financial and market performance indicators of automotive companies.

Despite the need and the global approach to reduce greenhouse gas emissions alongside the availability of incentives for electric cars, many customers still hesitate to embrace this new technology. The main reasons for their reluctance include the upfront cost of electric vehicles which is attributed to the extensive and expensive R&D preceding the manufacturing process (Krishna, 2021). According to Milev et al. (2021), the initial price of a BEV is 75.7% more expensive than that of a conventional car, even after taking into account the government's subsidies. Therefore, car manufacturers must focus on reducing the prices of BEVs as they significantly and negatively influence consumer purchase decisions (Abas et al., 2019).

Concerns expressed by Giansoldati et al. (2020) through a survey about the challenges to wider BEV expansion in Italy highlight an insufficient number of charging stations, potential problems with long-distance trips, and the high purchase price. The lack of widely available charging infrastructure emerges as a critical factor influencing electric vehicle adoption (Sierzchula et al., 2014). Furthermore, Krishna (2021) identifies a 'lack of trust' as a significant barrier to electric vehicle adoption, even among younger generations who are typically more receptive to innovations. Surprisingly, scholars like Brear et al. (2013) and Abas et al. (2019) argue that BEVs may not necessarily perform better environmentally than combustion alternatives, raising questions about the entire rationale behind the electrification of the car industry. Such unexpected study results may heighten consumer uncertainty toward adopting battery electric cars and potentially negatively impact the financial and market performance measures of automotive companies heavily investing in electric technology.

2.5 Theoretical framework and green innovation strategy

As Hardman et al. (2013) discussed, BEV falls under the category of disruptive innovation, hence the need to present the theory behind it. Disruptive Innovation (Bower & Christensen, 1995) theory explains how new technologies start by serving a niche market that existing players may consider unprofitable or too small. Over time, as the technology matures and its advantages become more apparent, it begins to appeal to a broader market. Initially, companies investing in disruptive technologies like BEVs may see a decline in financial performance due to the high costs of R&D, retooling for production, and establishing new supply chains. However, as the market for BEVs expands due to increased consumer demand driven by environmental concerns, technological advancements, and emission regulations, these initial investments are likely to pay off. Companies leading in BEV technology could gain a significant competitive advantage, capturing a larger market share and achieving better long-term performance.

Technology Adoption Lifecycle (Rogers, 1962) also plays a crucial role in the context of BEV adoption and its impact on the automotive industry. It segments consumers into categories based on their willingness to adopt new technologies. In the early stages, BEVs are adopted by innovators and early adopters, which might not be sufficient to recover the initial investment immediately. However, as the technology progresses and moves towards the early and late majority, the market expands and leads to improved performance for those car manufacturers that invested early in battery electric technology.

Each car company's approach toward BEV adoption can be classified as a green innovation strategy (GIS) (Lin et al., 2019; Lin et al., 2021). GIS is a framework that outlines how organizations commit to meeting the expectations of stakeholders and market demands while also minimizing their impact on the environment. The state-of-the-art literature consistently demonstrates that organizations leading in eco-innovation development enjoy advantages such as improved performance, enhanced brand image, and an expanded market presence (Chen et al., 2006; Sarkar, 2012; Lin et al., 2019; Lin et al., 2021). According to Song & Yu (2017), companies must encourage a culture of innovation and explore approaches to drive GIS. Furthermore, the study conducted by Aragón-Correa et al. (2003) establishes a connection between exceeding compliance in green innovation and achieving superior financial and market performance. This highlights the significance of adopting comprehensive green strategies not only for meeting environmental standards but also for enhancing overall organizational performance.

2.6 Adoption of BEVs and financial performance measures

Several scholars and academics argue that eco-innovation within the manufacturing sector not only enhances opportunities for sustainable performance (Provasnek et al., 2017; Peralta et al., 2019) but also significantly improves companies' financial performance (Carrillo-Hermosilla et al., 2009; Roscoe et al., 2019). At present, manufacturing firms are embracing tailored green approaches that align with their business strategies. As these strategies consider all stakeholders, they result in better financial outcomes (Owen et al., 2018). For instance, in a study of 460 companies within the Mexican car industry, Rodríguez-González et al. (2021) revealed a direct positive effect of green strategies and eco-innovation on financial performance metrics. They highlighted that increased financial performance encourages Mexican automotive businesses to integrate initiatives aimed at minimizing their environmental footprint.

Similarly, in a study by Lin et al. (2019) on the international car market from 2011 to 2017, the authors indicated that adopting green strategies is positively associated with corporate financial performance. Likewise, Alt (2018) examined the European automotive industry and found a positive and significant impact of implementing green innovation, measured by R&D intensity and green patents, on automakers' ROA. Another noteworthy finding comes from McPeak & Guo (2014) research which also consolidated this argument. The scholars compared the profitability ratios of Tesla, Inc. with five American consumer goods companies from the S&P 500 and reported notably better results for Tesla, Inc.

However, on the other hand, Alsharari (2022), conducting a real-life case study on Tesla, Inc. and performing a financial analysis, concluded that the company continuously suffers from losses. This is caused by the company's emphasis on adding value to the customers and improving its products. The automobile industry is highly competitive, and electric-based vehicles need significant time to gain the attention of different stakeholders in the market. Accordingly, the research demonstrated that Tesla, Inc. experienced a decline in profit margins over time as it dropped from 21.6%, in 2015 to 4.7% in 2018. The decrease is due to the high costs of R&D together with extremely high maintenance and administrative expenses. Baik et al. (2019) support this view by arguing that automotive companies do not make a profit from selling BEVs, while emission regulations compel them to adapt and invest heavily in new eco-technology. What is more, many studies express skepticism regarding the positive correlation between protecting the environment and manufacturing companies' financial performance, as highlighted by Eiadat et al. (2008), Leonidou et al. (2015), and Yu et al. (2017). These contrasting viewpoints call for further research, especially in the context of the companies from the automotive sector and their adoption of environmental innovations.

Nonetheless, it is anticipated that fully electric vehicle adoption will harm the ROA of automotive companies. As presented by Alsharari (2022), the switch from traditional combustion to electric vehicles is bound to experience initial losses due to high costs and still existing resistance among consumers. While BEV adoption can be profitable in the future, for the time being, this technology is not mature enough to be profitable for car manufacturers.

The research hypothesis is formulated as follows:

Hypothesis 1: BEV sales have a negative effect on return on assets.

2.7 Adoption of BEVs and market performance measures

The influence of incorporating green innovation on market performance has been a topic of discussion and diverse research findings. Some scholars argue that businesses that prioritize environmental initiatives may risk diverting their attention from core business operations, potentially undermining their competitive advantage, profitability, and ultimately market performance (Gardiner & Portney, 1994; Walley & Whitehead, 1994). Conversely, an opposing viewpoint suggests that neglecting market pressures and stakeholder expectations can harm a company's reputation and subsequently impact its market performance. Thus, proponents of eco-innovation assert that enhancing green practices can result in increased efficiency, the emergence of new market opportunities, improved product quality, and as a result, elevated market value (Porter & Linde, 1995; Tseng et al., 2020). A study conducted by Rizki & Hartanti (2021) supports this standpoint by revealing that companies actively involved in environmental responsibility practices and green innovations experience enhanced efficiency and improved market valuation.

Within the automotive industry context, there is an increasing emphasis on adopting environmentally friendly manufacturing processes as a critical necessity (Porter & Kramer, 2006). This shift not only aligns with customer demands and showcases corporate commitment to the environment, but also exerts significant influence on market performance (Lin et al., 2021). Research has shown that implementing environmentally responsible initiatives has several benefits including an improved quality of life, reduced risks, increased profits, and greater efficiency (Lin et al., 2019). Additionally, there is a growing demand among environmentally conscious consumers for brands that prioritize green innovation and offer eco-friendly products (Alfred & Adam, 2009). Companies that focus on sustainability often outperform their competitors, leveraging their market performance by offering value propositions that set them apart from the competitors on the market (Porter & Reinhardt, 2007). What is more, it is anticipated that business operating margins in the BEV sector will surpass those of combustion cars within 3-5 years, as observed by Kaynar & Rijk (2022). Their study also highlights higher equity value for shareholders and improved access to capital in the case of a swift transition to BEVs compared to a slower shift. A study conducted by Lin et al. (2021), analyzing the global industry from 2011 to 2018, confirms the positive impact of green innovation on brand value, characterized in their study by goodwill and intangible assets. Finally, Ba et al. (2013) examined the stock market reaction to announcements of global green vehicle innovation over a 14-year time span using the event study methodology and found that the adoption of green vehicles positively impacts the investors' perception of automakers. The authors' findings suggest that automotive companies can strategically implement sustainable initiatives to enhance their brand value.

In contrast, a counter perspective was presented by Ngwakwe & Musandiwa (2022). Their research focused on the link between BEV products and stock market performance. They reported a significant negative relationship, which adds complexity to the overall understanding of market dynamics in the context of green innovation within the automotive sector. Nevertheless, their study was based on stock market prices and was limited to only 40 observations in four world economies – USA, China, Japan, and Germany, hence not providing enough empirical evidence.

Overall, the implementation of BEVs in the automotive industry is expected to affect favorably the carmaker's future performance. It creates new market opportunities and offers unique value propositions that are aligned with customer demands. Implementing green strategies, as argued by various scholars, can enhance brand reputation, and positively impact how investors perceive and value car companies. Despite green car technology being deemed as costly and still under continuous development, it is already projected to outperform the conventional combustion car industry. All in all, it highlights the good prospects for the future automotive sector's performance (Kaynar & Rijk, 2022).

Therefore, the research hypothesis is formulated as follows:

Hypothesis 2: BEV sales have a positive effect on the market-to-book ratio.

2.8 Moderating roles of firm size and R&D intensity

The literature suggests firm size as a factor that strongly influences the relationship between financial performance and green innovation. The firm-level characteristics have a substantial impact on involvement in green innovation, with the size of the company as a critical factor that has not been thoroughly explored yet (Madden et al., 2006; Hörisch et al., 2015). Even though this academic study focuses on the largest car corporations by revenue in 2022, it covers the significant majority of the whole automobile industry worldwide as the companies from the sample altogether accounted for 86,3% of global car sales in 2022 (Statista, 2024). Moreover, not only large companies are observed throughout the whole observation period, for example, Tesla, Inc. or BYD Company Limited were not always at the forefront and their dominance has only started recently mostly due to BEV introduction. Consequently, it is justified to examine the moderating effect of company size to provide valuable implications regarding BEV adoption in the automotive industry.

Larger companies, due to their simultaneously bigger scale of operations tend to have a greater social impact and take more responsibility for environmental matters by engaging in green innovation activities (Cowen et al., 1987). However, it needs to be noted that smaller companies also participate in eco-innovation often making financial sacrifices (Madden et al., 2006), which raises questions about their motivations and the economic rationale behind such endeavors. Moreover, financial limitations strongly affect companies' engagement in green innovation; resource-rich companies are far better equipped to respond to stakeholder pressure for actions like environmental innovation (McGuire et al., 1988) while companies with tighter budgets may face challenges to do so (Brammer & Millington, 2006). A mature organizational structure and established processes facilitate the implementation of innovation initiatives since companies with clear structures and capabilities are better positioned to manage external pressures without incurring excessive costs (Miles, 1987; Hess et al., 2002). Lastly, the effectiveness of embracing environmental practices is greater for larger companies, indicating that they have a better ability to drive significant environmental changes (Brammer & Millington, 2006).

On the other hand, Lin et al. (2019) discovered a contrasting dynamic in the automotive industry, where the relationship between green innovation and ROA appeared to be negatively influenced by company size. Their analysis uncovered that smaller firms achieve higher returns on their investments in green innovation than larger companies, simultaneously demonstrating a stronger inclination towards innovation and visibility. This tendency allows smaller companies to access superior resources and further enables them to extract improved profit margins due to increased stakeholder scrutiny.

Thus, since Lin et al. (2019) obtained such results by focusing their study on the car industry, the research hypothesis to test the moderating role of firm size is formulated as follows:

Hypothesis 3: Firm size negates the relationship between green innovation and return on assets.

Regarding the moderating role in the context of green innovation and market performance, previous academic studies point to R&D. Studies show that investing in R&D is crucial for a company's growth, competitiveness (Conner, 1991; Tidd et al., 2001), and overall performance (Padgett & Galan, 2010; Weerawardena & Mavondo, 2011). It has been proved that greater R&D intensity favorably impacts a firm's productivity and long-term success (Hitt et al., 1997). R&D intensity, recognized as a dynamic capability (Sharma et al., 2016), encourages product innovation (Gupta et al., 1986). For instance, innovations in the automotive industry drive the adoption of new production methods and technologies, such as the transition from traditional to hybrid or electric vehicles, and help to adapt products to meet regulatory standards. The introduction of electric vehicles has propelled changes in product development and marketing strategies, including consumer segmentation and branding. McWilliams & Siegel (2000) noted that R&D investment enables product differentiation, enhancing social and environmental features of the product, which does not go unnoticed by consumers. Based on the research performed by Lin et al. (2021) that was focused solely on the automotive industry, R&D intensity has a strong moderating effect on the link between green innovation and brand value. According to the scholars' arguments, car companies that invest in R&D are expected to experience a better connection between sales of BEVs and their overall market performance.

Hence, the research hypothesis to test the moderating role of R&D is formulated as follows:

Hypothesis 4: R&D moderates the relationship between green innovation and the market-to-book ratio.

3 Methodology

3.1 Data sample

In order to test the hypotheses outlined in the literature review, this academic work focuses solely on the companies from the automotive industry. In detail, the sample of this study consists of the 16 car manufacturing firms with the largest revenue in 2022, as reported by the Orbis database. However, since this study's approach focuses on the major companies of that particular year, it must be noted that this research may overlook data from firms that used to be leaders in the industry in the previous years, but then did not appear in the top 16 ranking of 2022. This research, thus, addresses this limitation arguing that the automotive industry is commonly known for a stable and relatively unchanging landscape. Rizwana (2019) supports this, discussing that the automotive industry can be characterized by a low chance of new competitors entering the market. Therefore, the likelihood of a significant look-ahead bias is reduced. To provide an example, while comparing the car manufacturers by revenue in 2015 and 2022, one can note only two changes - Mazda Motor Corporation and Suzuki Motor Corporation were replaced by Tesla, Inc. and BYD Company Limited, as set side by side. It is also worth noting that all 16 companies from this study's sample combined accounted for 86.3% of total global car sales in 2022 (Statista, 2024). For that reason, it can be concluded that this study reflects the outlook of the vast majority of the automotive industry.

Table 1 presents all car companies used as a sample in this study. Furthermore, it displays the countries of origin of the respective car companies to account for country-level control characteristics. The usage of country-level control characteristics is essential in this study and will be further elaborated upon in the next section. One noteworthy example is Stellantis N.V., a multinational automotive manufacturing corporation that was formed from the merger of Italian-American Fiat Chrysler Automobiles (FCA) and the French PSA Group. Despite the corporation being born out of a cross-national merger, this research identifies the Netherlands as the company's home country. This is, hence, in line with where it is officially registered and where the headquarters of the company are located (Naughton, 2020). Moreover, since the merger took place in 2021, the scope of the research and its analysis combines the data from FCA and PSA groups for Stellantis N.V. spanning from 2009 to 2020 to precisely depict the company's pre-merger performance.

Insert Table 1 here

As far as the study's observation period is concerned, its range extends over 14 years, namely from 2009 to 2022. The choice behind this timeframe is reasoned by wanting to reflect its key developments concerning electric vehicle technology. Such developments primarily refer to the emergence of BEVs or the worldwide expansion of Tesla, Inc., i.e., the largest manufacturer of BEVs to date (Akbar, 2022). Furthermore, it must also be noted that these years saw most of the car manufacturers pushing their first electric models into the market. This was predominantly caused by the increasing number of vehicle emissions regulations implemented by legal entities worldwide during this period. Even though the observation period covers two crises - subprime and COVID-19, this research does not consider these circumstances since the existing literature studying BEV adoption in the automotive industry did not find the 2007-2008 financial crisis to have a significant impact on companies' performance metrics (Ba et al., 2013). By using this observational period with a broad scope, this research study can precisely examine how the electric vehicle revolution impacts both financial and market performance measures in the context of the automotive sector.

3.2 Variables and data extraction

This study is among the first to try to understand how adopting BEVs affects both the past and future performance metrics of car companies worldwide. As illustrated in the literature review, in which hypotheses were formulated, the perspectives of the market and financial standpoint in the context of BEV adoption in the automobile sector differ. The combination of theories declares that adding BEVs to a car company’s lineup could help the company in terms of its market performance, as shown by studies from Ba et al. (2012), Lin et al. (2021), and Kaynar & Rijk (2022). However, there is also a chance that such implementation could hurt the company’s financial health, according to research by Baik et al. (2019) and Alsharari (2022). Moreover, the models testing ROA and MTB ratio require different control variables. Hence, this study builds its analysis on a mix of previous studies, putting together various insights to form two different models to test financial and market measures separately.

Model (1) assesses performance using ROA as the primary metric. The model measures the performance of companies in the automotive industry, drawing upon the framework established by Yuniningsih et al. (2018). This research methodology builds upon the authors' model, adding variables responsible for measuring the extent of adoption of BEVs, in line with the study’s focus on the impact of that factor on performance. What is more, the model incorporates both company and country-level characteristics to accurately assess the interaction results of the link between BEV adoption and ROA.

The selection of ROA as the dependent variable to assess a company’s profitability aligns with findings from Subramanian & Nilakanta (1996), Sher & Yang (2005), Artz et al., (2010), Ken & Tsai (2010), and Alt (2018). Aliabadi et al. (2013) further emphasize the significance of ROA, describing it as a pivotal financial performance metric. Following the methodology of Ngwakwe & Musandiwa (2022), this research looks at the percentage of BEV sales compared to the total sales units to represent BEV adoption. It is also crucial to account for additional variables that could interact with ROA. One of the influencing factors is research & development (RD) intensity, as suggested by Lin et al. (2019). R&D in the automotive industry is usually a part of intangible assets, hence it must be acknowledged that in this case only the R&D expenditures are considered. Additionally, other firm-level control variables, namely company size (S), leverage (LEV), current ratio (CR), and sales growth (SG) are included to assess their impact on profitability, in line with the research conducted by Demiraj et al. (2022).

Moreover, the study also highlights the moderating role of size (S) in the relationship between BEV and ROA and introduces it as a moderating variable (Lin et al., 2019). Country-level variables such as gross domestic product (GDP) and inflation rate (I) are also considered, aligning with the approach of Chew (2019). These variables were chosen to include the broader economic environment in which the different automotive companies from this study's sample operate. All the variables used in Model (1) are specified in Table 2, together with the information about measurement and the sources where the data was collected from.

Insert Table 2 here

Both financial and market performance metrics have their pros and cons. According to Demsetz & Villalonga (2001), financial measures reflect past performance, while market measures are forward-looking and consider future expectations. This research recognizes the relationship between these two aspects, noting that stronger economic performance often precedes improved market performance.

Therefore, Model (2) is set with MTB ratio as a key metric for a future performance check, in line with the approach adopted by Kramaric et al. (2021). Pontiff & Schall (1998) find that the MTB ratio provides some predictive ability, which stems from the relation between book value and future earnings. The MTB ratio compares market value (reflecting investor expectations) with book value (representing historical cost) and offers insights into growth prospects, particularly in the realm of new green technology adoption. The significance of the MTB ratio in this context is confirmed by studies such as Ionescu et al. (2019), Reschiwati et al. (2021), and Sulitiyani & Noor (2022). The Model's (2) independent variable is the percentage of BEV sales, which acts as a proxy of electric vehicle adoption (Ngwakwe & Musandiwa, 2022). Next, the control variable RD is utilized as a measure of a company's focus on R&D activities (only R&D expenditures are considered). The importance of R&D in influencing the connection between green innovation and market performance has been emphasized by Lin et al. (2022). Hence, this research aims to investigate this correlation by introducing RD as a moderating variable to precisely examine how it affects the link between market performance and BEV adoption. Furthermore, the model includes multiple firm-level control factors like company size (S), profitability (ROA), leverage (LEV), and current ratio (CR). These factors have been recognized in existing literature for their impact on market performance as discussed by Ionescu et al. (2019), Lin et al. (2021), Reschiwati et al. (2021), Rizki & Hartanti (2021), and Sulitiyani & Noor (2022).

Additionally, considering the scale of this research which involves 16 car manufacturers from 8 different countries, it is essential to account for country-level characteristics that could influence the MTB ratio. Insights from Doidge et al. (2004) and Aggarwal et al. (2009) are drawn upon for this purpose, thus this research considers the chosen companies' country of origin's economic development level (GDP) as well as the market capitalization (MAC). Moreover, inflation (I) is examined, drawing from Agrawal et al. (1996) findings that established a significant influence between the inflation rate and the MTB ratio. Table 3 thoroughly details these variables, outlining how they are measured and the sources where the data was obtained.

Insert Table 3 here

The financial data of the analyzed companies was meticulously extracted from the Orbis database, which is well known for its detailed and reliable financial insights on worldwide companies. Market information, such as market capitalization and book values, was sourced from Bloomberg, a globally trusted provider of financial data and analytics. The reliability and depth of information provided by these sources guided the selection of databases to use in this study. Country-specific data was obtained from The World Bank, offering a context for understanding the overall economic landscape in which tested companies operate. A significant aspect of this research focuses on the adoption of BEVs measured by calculating the ratio of a company's BEV sales to its total sales volume. The data on BEV sales was sourced from the EV-volumes database, while carmakers' total sales figures were extracted from their financial annual reports. It is worth noting, however, that in this case there are some limitations and challenges associated with BEV data. In detail, the EV-volumes database offers information on BEVs sales only starting from 2013. As a result, this study assumes that there were no BEV sales from 2009 to 2012 for all the companies included in the sample, except for Tesla, Inc., which, as established before, is known for producing and selling only fully electric vehicles. Another limitation can be associated with the BEV sales figures data availability for 2013 and

2014. That data was gathered from the lists of the 20 best-selling BEVs in the years 2013 and 2014. This methodology might overlook BEV sales for some manufacturers. Nevertheless, this potential gap is reduced by the fact that only a small portion of BEV sales (14.3% or 18,064 units in 2013 and 8.1% or 16,258 units in 2014) was not accounted for in these lists, based on the information from the EV-volumes database. The years from 2015 to 2022 were a vital period for this research characterized by an incremental rise in BEV sales. In these years, a comprehensive report on fully electric car sales figures was provided by the EV-volumes database for all companies included in this academic work's sample. This extensive data extraction and dataset establishment is crucial for research purposes as it forms a solid basis for assessing the impact of BEVs' adoption within the sector.

3.3 Research model

This study applies panel data regression, a technique most appropriate for handling complex datasets. Panel data, which involves multidimensional data with multiple measurements over a particular interval, carries many benefits that are suitable for addressing the matter considered in this study. Firstly, it provides a dataset with more information and variability compared to the cross-sectional data. It is vital for the authenticity of the simulated behavior of the firms in the automotive sector. What is more, one of the greatest benefits of panel data is that it can effectively deal with problems of multicollinearity, which may create confusion and result in misunderstanding regression outcomes. According to Hsiao (2014), by incorporating cross-sectional and time series variations, panel data are better equipped to isolate the influence of independent variables on the dependent variable. Also, panel data is one of the most economically comprehensive methods and leads to solid and accurate statistical outcomes. This efficiency is particularly valuable in econometric analyses, where data limitations often pose challenges. Another pivotal benefit of choosing panel data is that it allows the researcher to capture the special features and behaviors of individual constructs within the group (Hsiao, 2014). Applying it to the case of the automobile industry firms, this feature becomes even more relevant. Car manufacturing firms are heterogeneous entities, each displaying specific characteristics that affect the market and financial performance metrics differently. Hence, this form of data enables this exploration to consider discrepancies through controlled heterogeneity, which eventually results in the prevention of group aggregation bias. This characteristic of the panel dataset is essential, as it enables the sharpening of a clear and detailed picture of the performance of firms within the sector.

The importance of controlling for individual heterogeneity in firm-level studies is underscored by Krasova (2018). The scholar highlighted the diverse nature of firms and the need for analytical approaches that reflect this diversity. Panel data's versatility and effectiveness are well-documented in the literature. Numerous studies employed this method to examine various market and financial performance measures in the automotive sector. For instance, Reschiwati et al. (2021) and Sultiyani & Noor (2022) have used panel data to explore market performance, while Demiraj et al. (2022) and Sultiyani & Noor (2022) have applied it to assess financial performance within this industry. These studies demonstrate the widespread application and relevance of panel data in research, underscoring its suitability for the current study's objectives.

The research has started with the data collection. The study encompasses 16 automotive companies observed over 14 years, cumulating in a maximum of 224 observations. The sample is characterized as unbalanced since not all companies in the sample were consistently listed throughout the entire observed period. In addition to that, some outliers were removed.

Then, the stationarity in the panel dataset was examined. The presence of the unit root test was tested in all variables using a Fisher-type unit-root test based on the Phillips-Perron test. The results showed that variables BEV, RD, GDP, MAC, and I were not stationary. After finding the first difference for non-stationary variables, the same unit-root test was conducted again. The result showed that the first differences of the variables mentioned above were then stationary. After conducting testing for stationarity, different variables (D_BEV, D_RD, D_GDP, D_MAC, and D_I) were used in the research. Table 4 presents the results of the conducted Fisher-type unit-root test based on the Phillips-Perron test.

Insert Table 4 here

Before conducting panel data regression, the dataset had to be tested to determine the correct approach for panel data regression analysis. There are three models used in the panel data regression analysis - common effects, fixed effects, and random effects. The tests carried out to get the best approach are the F Restricted test (Chow test) which determines whether the fixed effects or common effects model should be used in estimating panel data. If the result indicates a fixed effects model, then the analysis needs to be continued with the Hausman test to decide whether to employ fixed effects or random effects regressions. If the result specifies random effect, then the last statistical test is necessary, the Lagrange Multiplier (LM) used to determine whether the random effects or common effects model is more appropriate (Reschiwati et al., 2021; Sultiyani & Noor, 2022). In this case, as the Chow test indicated using a fixed effects approach for both Model (1) and Model (2), the Hausman test was conducted to decide whether to employ fixed effects or random effects. Since the Hausman test suggested fixed effects, the Lagrange Multiplier test was no longer needed. Based on the statistical test values, the fixed effects model was used for both Model (1) with ROA as the dependent variable as well as Model (2) with MTB ratio as the dependent variable.

Last but not least, the Breusch-Pagan test was used to test for heteroscedasticity in each model and results showed that the problem of heteroscedasticity was observed in both models. The first, and most common, strategy for dealing with the possibility of heteroscedasticity is to use robust errors, which was done in research.

To test the research hypotheses, the following models were adopted. The models aim to reveal the specific effects of the selected variables across the firms over time.

Model (1)

Financial performance (past performance) = f (BEV, Control Variables)

FINANCIAL PERFORMANCE = $\propto_{it}$ + β_1BEV + β_2FIRM-LEVEL CONTROL VARIABLES + β_3COUNTRY-LEVEL CONTROL VARIABLES + FixedEffects + ε_{it}

where:

- FINANCIAL PERFORMANCE refers to the ROA of firm i in year t;
- BEV refers to BEV sales of firm i in year t;
- Firm-level control variables refer to research & development (RD) expenses, size (S), leverage (LEV), current ratio (CR), and sales growth (SG) of firm i in year t;
- Country-level control variables refer to the GDP, and inflation rate (I) of the firm i's country of origin in year t;
- Year-fixed effects are included in the model;
- ε_{it} denotes the error term.

Model (2)

Market performance (future performance) = f (BEV, Control Variables)

MARKET PERFORMANCE = $\propto_{it}$ + β_1BEV + β_2FIRM-LEVEL CONTROL VARIABLES + β_3COUNTRY-LEVEL CONTROL VARIABLES + FixedEffects + ε_{it}

where:

- MARKET PERFORMANCE refers to the MTB ratio of firm i in year t;
- BEV refers to BEV sales of firm i in year t;
- Firm-level control variables refer to research & development (RD) expenses, size (S), profitability (ROA), leverage (LEV), and current ratio (CR) of firm i in year t;
- Country-level control variables refer to GDP, market capitalization (MAC), and inflation rate (I) of the firm i's country of origin in year t;
- Year-fixed effects are included in the model;
- ε_{it} denotes the error term.

To obtain the results, the following simple regression equations were used:

(1.1) $ROA_{it} = \beta_0 + \beta_1 D\_BEV_{it} + \beta_2 S_{it} + \beta_3 D\_RD_{it} + \beta_4 LEV_{it} + \beta_5 CR_{it} + \beta_6 SG_{it} + \beta_7 D\_GDP_{it} + \beta_8 D\_I_{it} + \varepsilon_{it}$

(1.2) $ROA_{it} = \beta_0 + \beta_1 D\_BEV_{it} + \beta_2 S_{it} + \beta_3 D\_BEV{*}S_{it} + \beta_4 D\_RD_{it} + \beta_5 LEV_{it} + \beta_6 CR_{it} + \beta_7 SG_{it} + \beta_8 D\_GDP_{it} + \beta_9 D\_I_{it} + \varepsilon_{it}$

(2.1) $MTB_{it} = \beta_0 + \beta_1 D\_BEV_{it} + \beta_2 D\_RD_{it} + \beta_3 S_{it} + \beta_4 ROA_{it} + \beta_5 LEV_{it} + \beta_6 CR_{it} + \beta_7 D\_GDP_{it} + \beta_8 D\_MAC_{it} + \beta_9 D\_I_{it} + \varepsilon_{it}$

(2.2) $MTB_{it} = \beta_0 + \beta_1 D\_BEV_{it} + \beta_2 D\_RD_{it} + \beta_3 D\_BEV{*}D\_RD_{it} + \beta_4 S_{it} + \beta_5 ROA_{it} + \beta_6 LEV_{it} + \beta_7 CR_{it} + \beta_8 D\_GDP_{it} + \beta_9 D\_MAC_{it} + \beta_{10} D\_I_{it} + \varepsilon_{it}$

The data was processed using the STATA 17.0 SE-Standard Edition software package.

4 Results and discussion

4.1 Descriptive statistics and variable correlation

Descriptive statistics for all variables employed in this research are provided in Table 5. As presented, automotive companies sell on average 8% of battery electric cars. This number is depleted as most of the companies implemented BEVs just recently. On the other hand, however, Tesla, Inc. is significantly contributing to this figure by selling 100% of BEVs throughout the whole sample period. Additionally, a closer look at the means of BEV market share demonstrates a stable increase from 6.25% in 2009 to 13.83% in 2022. Furthermore, the high standard deviation of the MTB ratio at 5.270 is due to the high variability between the minimum and maximum values of 35.848. Regarding the company size (S), the mean of 25.391 is close to the maximum value of 27.137, indicating that the sample with similar characteristics and sizes is being compared. Moreover, all independent variables display symmetric distributions without any noticeable outliers based on Skewness and Kurtosis values.

Insert Table 5 here

The next step in the research was to carry out the correlation analysis to determine the degree of correlation among the variables, if any. The pairwise variable correlation matrix is presented in Table 6. The correlation coefficient of BEV and ROA (-0.45) is significant, negative, and shows moderate correlation. On the other hand, BEV is strongly correlated to MTB (0.85), showing a significant and positive correlation. This means that BEV is inversely related to ROA, but positively to MTB. Other strong connections are demonstrated by the RD variable. RD is negatively correlated with ROA (-0.57) and positively correlated with MTB (0.47). These correlations are explained by high expenditures related to R&D and its advantageous potential for long-term performance. The high costs of implementing BEVs are supported by a strong and significant link between BEV and RD (0.54). Interestingly, the correlation coefficient of MTB and size (S) (-0.55) is negative and shows a strong correlation. Conversely, size (S) is positively related to ROA (0.42), exposing a significant and moderate link.

Insert Table 6 here

4.2 Regression results

The panel regression analysis was used in this part to examine the influence of each of the independent variables on the dependent variables, namely ROA and MTB ratio. To ensure accuracy and specificity, separate models were built for each dependent variable, based on the unique sets of explanatory variables needed for Model (1) and Model (2). Additionally, two regressions were conducted for each model, the first one testing the relationships between BEV and dependent variables and the second one exploring the moderating effect of firm size and R&D on the link between BEV adoption and ROA and MTB in Model (1) and Model (2) respectively. Then, the time-fixed effects necessity was checked to determine whether a Year dummy is needed to include in each regression analysis. Furthermore, the decision between using a common, fixed, or random effects model was guided by various tests, as already explained in section 3 of this work. What is more, the VIF values were displayed in two individual model outputs to confirm the absence of multicollinearity in the data (Hair et al., 1998). Lastly, the Breusch-Pagan test was used to test for heteroscedasticity in the models, which added support to the trustworthiness and credibility of the results obtained from the panel regression analysis. The regression outcomes together with all the statistical tests' results referenced earlier can be found in Table 7 and Table 8.

In Table 7, the results of Model (1) with fixed effects are shown, which have achieved the objectives of this study concerning the impact of D_BEV sales on the automotive firms' financial performance, proxied by ROA. Both regressions in the model include a Year dummy as indicated by the interaction term test. Based on the Hausman test statistic [p = 0.0448 for (1.1) and p=0.0488 for (1.2)], only the fixed-effects results were analyzed. According to the VIF values, the mean of 2.1238 suggests that there are no multicollinearity problems in the model. Furthermore, Breusch-Pagan test results showed that the problem of heteroscedasticity is present, thus the use of robust standard errors in the regression was necessary. The model is established based on 220 observations.

The results of regression (1.1) revealed a negative and statistically significant ($p < 0.05$) coefficient of D_BEV concerning ROA. Therefore, BEV sales have a negative effect on ROA, which supports *Hypothesis 1*. Firm size is positively associated with ROA, however the result obtained is not significant ($p > 0.05$). Research & development (D_RD) has a negative and statistically significant ($p < 0.05$) relationship with ROA. Regarding other firm-level control variables, LEV, CR, and SG have all negative coefficients, indicating an adverse effect on ROA. However, only LEV is statistically significant with $p < 0.05$.

The second regression (1.2) was set to test the contingency effect of firm size (S) on the D_BEV-ROA link. The new variable D_BEV*S, which describes the interaction between D_BEV and firm size (S), was introduced. The results obtained are not statistically significant but present size as a moderator in the link between D_BEV and ROA ($\beta = 0.0042$, $p > 0.05$), meaning that this link is stronger with increasing firm size (S). Hence, the results endorse the view that larger companies implement BEVs more easily. This outcome and the fact that the result is not statistically significant means that the *Hypothesis 3* cannot be supported.

Insert Table 7 here

In Table 8, the results of Model (2) with fixed effects are shown, which have achieved the objectives of this study concerning the impact of D_BEV sales on the automotive firms' market performance, proxied by the MTB ratio. Both regressions in the model include a Year dummy as indicated by the interaction term test. Based on the Hausman test statistic [$p = 0.0004$ for (2.1) and (2.2)], only the fixed-effects results were analyzed. According to the VIF values, the mean of 2.7522 suggests that there are no multicollinearity problems in the model. Furthermore, Breusch-Pagan test results showed that the problem of heteroscedasticity is present, thus the use of robust standard errors in the regression was necessary. The model is established based on 214 observations.

The results of regression (2.1) revealed a positive and statistically significant ($p < 0.05$) coefficient of D_BEV with respect to MTB. Thus, BEV sales have a positive effect on market performance, which supports *Hypothesis 2*. Research & development (D_RD) has a negative and statistically significant ($p < 0.05$) relationship with MTB. Firm size is negatively linked to

MTB and presents statistical significance ($p > 0.05$). The coefficient of ROA is positive, specifying a positive association with MTB. As for the other firm-level control variables, LEV and CR have negative coefficients, indicating a negative effect on MTB. However, the p-values of ROA, LEV, and CR are less than 0.05, meaning that they are not statistically significant.

The second regression (2.2) was set to test the contingency effect of research & development (D_RD) on the D_BEV-MTB link. The new variable D_BEV*D_RD, which describes the interaction between D_BEV and D_RD, was introduced. The results obtained are not statistically significant but present R&D as a moderator in the link between D_BEV and MTB ($\beta = 9.0350$, $p > 0.05$), meaning that this link is stronger with increasing R&D intensity. Thus, a high level of R&D enhances the market performance under BEV implementation. This outcome corresponds with the assumptions of *Hypothesis 4*; however, it is not supported as the result is not statistically significant.

Insert Table 8 here

4.3 Additional analysis

Most corporations tested in this study are well-established producers of ICEVs that started to recently implement BEVs. Now these companies offer a mix of different vehicle technologies, with growing battery electric technology set to take charge of the whole market in the future. However, the currently leading manufacturer in the electric cars market – Tesla, Inc. – stands out from the sample by selling exclusively BEVs since the establishment of the company. The company was founded in 2003 and presented its first mass-produced electric model in 2009. Tesla, Inc. has massively grown from a small firm only experimenting with battery electric technology to the presently largest provider of BEV and one of the major car corporations in the world. Precisely, the company's operating revenue has increased from $112 million in 2009 to $81 billion in 2022, as reported by the Orbis database. As opposed to other companies from the sample, Tesla, Inc. became so successful by offering solely BEVs. Being this exception and operating in the market for such a short time, the company might have influenced the results of a regression analysis. Therefore, to ensure robustness, all the regressions were performed one more time without the data from Tesla, Inc. The outcome suggested that the main conclusions of the analysis persist, indicating that Tesla, Inc. has not had a significant effect on the results of the regression, and the models tested in the previous section were robust.

4.4 Discussion

The regression analysis supported *Hypothesis 1*, i.e. “BEV sales have a negative effect on return on assets”. The results from section 4.2 revealed a negative impact of the adoption of BEVs on ROA within companies from the automotive sector. This is in line with the Disruptive Innovation theory by Bower & Christensen (1995) as well as the Technology Adoption Lifecycle by Rogers (1962) due to immature innovation that is not yet sufficient to recover the initial investment. Furthermore, the finding corresponds with numerous studies, i.e. Alsharari (2022) who conducted a detailed analysis of Tesla, Inc. According to the scholar, car manufacturers that implement battery electric technology in their products consistently experience losses. This observation can be attributed to the extremely competitive market and customers who are still not entirely convinced regarding the emerging technology. As indicated by a large body of academic work, the adoption of battery electric technology still encounters several barriers and downsides that hinder the smooth switch and cause multiple losses to the car industry (Sierzchula et al., 2014; Giansoldati et al., 2020; Krishna, 2021). Another reason pointed out by Alsharari (2022) for such an outcome is primarily the high cost of electric vehicle development mainly attributed to elevated maintenance costs, R&D expenses, selling costs, and administrative fees. The view that automotive companies do not profit from selling BEVs, while emission regulations compel them to produce and invest in new eco-friendly technology is also supported by Baik et al. (2019). Moreover, the skepticism surrounding the positive correlation between corporate environmental responsibility and manufacturing companies' performance, that is supporting this study’s findings, has also been underscored by Eiadat et al. (2008), Leonidou et al. (2015), and Yu et al. (2017). On the other hand, however, this study’s findings do not agree with previous research performed by McPeak & Guo (2014), Alt (2018), Lin et al. (2019), and Rodríguez-González et al. (2021) that recorded a positive association between green innovation practices and financial performance of carmakers.

Likewise, the results of the regression analysis supported *Hypothesis 2*, stating that “BEV sales have a positive effect on the market-to-book ratio”. This is in line with the Disruptive Innovation theory by Bower & Christensen (1995) as well as the Technology Adoption Lifecycle by Rogers (1962) thanks to increased competitive advantage and market expansion.

Moreover, this observation is in harmony with the analysis by Kaynar & Rijk (2022), who predict that the BEV market will surpass the traditional combustion engine vehicle sector, offering optimistic prospects for the automotive industry. This positive perspective is further reinforced by Lin et al. (2021) who affirmed the positive influence of green innovation on market performance, by analyzing the global automotive industry from 2011 to 2018. Finally, the findings of this thesis are backed by Ba et al. (2013). The authors examined the stock market reaction to announcements of global green vehicle innovation over a 14-year period and found that the adoption of green vehicles positively impacts how investors perceive and value automakers. Complementing these findings by Mizik & Jacobson (2003), firms in the automotive sector should prioritize investment in innovation, production, and efficient market delivery as such investments will yield long-term benefits. Rizki & Hartanti (2021) support this perspective, revealing that companies actively involved in environmental responsibility practices and green innovation experience improved efficiency and market valuation. Conversely, contradictory findings were presented by Ngwakwe & Musandiwa (2022) who explored the relationship between BEV products and stock market performance and reported a significant negative relationship.

When it comes to testing *Hypothesis 3*, declaring that "firm size negates the relationship between green innovation and return on assets", it could not be supported as the outcome of an analytical test was not statistically significant. What is more, the results were contrary to the literature review's findings. As Lin et al. (2019) identified firm size as a moderating factor between ROA and BEVs' adoption, this thesis followed that line of argumentation. The scholars, by analyzing the automotive industry, revealed that smaller firms achieve a higher return on their green innovation investments compared to their larger counterparts. Nevertheless, the results of this study, despite being not statistically significant, present a contradictory view and offer an alternative perspective. According to the regression outcome, the moderating impact of BEV on ROA strengthens with firm size, meaning that larger companies are more adept at implementing BEVs. This conclusion is supported by Cowen et al. (1987) who claim that larger firms, due to their scale of operations, tend to engage more in green innovation activities. Moreover, well-established companies are usually more stable financially and have the resources to easily respond to stakeholder pressures for discretionary activities such as green innovation (McGuire et al. (1988). A corresponding view is presented by Brammer & Millington (2006) who claimed that scale economies magnify the effectiveness of green innovation activities and suggested that larger firms are more adept at initiating significant environmental transformations, such as the switch from traditional combustion to BEVs' production and implementation. The strategic advantage held by the larger firms helps explain the results of this study.

The findings highlighted also the moderating role of R&D in the relationship between green innovation and market performance. However, as this result was not statistically relevant, *Hypothesis 4*, assuming that "R&D moderates the relationship between green innovation and the market-to-book ratio", could not be supported. Nonetheless, the moderating role of R&D was likewise reported by Lin et al. (2021) who confirmed that R&D intensity affects positively the link between green innovation and brand value. According to the scholars, car manufacturers that engage in R&D are anticipated to encounter a stronger relationship between BEV sales and market performance. This view is furtherly recognized by Hitt et al. (1997) asserting that R&D investment positively impacts a firm's productivity and long-term performance. R&D intensity fosters product innovation (Gupta et al. (1986) that drives the adoption of new production methods and technologies, such as the transition from traditional to electric vehicles and adapting products to meet regulatory standards. Other research studies that confirm this paper's findings are Conner (1991) and Tidd et al. (2001) claiming that investing in R&D is crucial for a company's growth, competitiveness as well as Padgett & Galan (2010) and Weerawardena & Mavondo (2011) who reported increased performance because of higher R&D intensity.

5 Conclusion

5.1 Summary

As the automotive industry currently experiences a significant shift from old-fashioned combustion cars to modern zero-emission vehicles and the topic of electric technology is in widespread discussion, this analysis aims to explore this transition from a detailed perspective. This empirical work discusses the impact of the shift towards BEVs on the financial and market performance measures of companies from the automotive sector. The sample used in this study is a panel of 16 currently largest, in terms of revenue in 2022, car manufacturing companies globally. Furthermore, the sample is observed over 14 years, namely from 2009 to 2022, covering the most significant global events in the development and adoption of electric vehicle technology.

Recognizing the backward-looking nature of financial performance measures and the forward-looking perspective of market-based measures (Demsetz & Villalonga, 2001), the study combines both types of performance metrics to thoroughly evaluate the impact of BEV implementation in the automotive industry. The mix of theoretical frameworks underpinning this study claims that green vehicle innovation positively influences an automaker’s market value, but negatively financial performance. As for the financial performance that focuses on measuring the impact on past performance, this empirical work uses ROA. The findings report a negative effect of the shift towards BEVs on ROA. This can be mostly attributed to the competitive market together with high costs and still underdeveloped battery electric technology (Baik et al., 2019; Alsharari, 2022). As far as market performance is concerned, understood as estimating the impact on future performance, this study measures it through the MTB ratio. In contrast to the measure of financial performance, market performance is found to be positively influenced by increasing the sales of BEVs. The results indicate higher market performance of car manufacturing companies that engage more in developing and implementing zero-emission technology in their products.

At present, the automotive sector is undeniably under high market pressures and regulations that comply with car companies to establish electric cars, not to mention the already announced ban on selling new combustion engine cars by 2035 (EP, 2023). As a result, stakeholders value the automakers that are already focusing on developing environmentally friendly technologies on a belief that in the future this very technology will be extremely crucial in order to operate successfully on the market. On the other hand, however, it is found that the establishment and adoption of BEVs affect the financial performance of car firms negatively due to high cost and complexity. Overall, while BEV adoption presents positive prospects for future performance, it is not profitable for car manufacturers for the time being.

Additionally, this research attempts to evaluate the significance of company size in the relationship between green innovation and corporate financial performance (Lin et al., 2019). The outcome, even though not statistically significant, suggests a moderating effect of firm size in the link between performance and electric car adoption, meaning that the influence of BEVs on ROA is amplified with increasing firm size. In other words, larger companies are better positioned to integrate BEV technology successfully. Finally, the academic study investigates also R&D as a moderator between green innovation and market performance, as suggested previously by Lin et al. (2021). The findings, despite being not statistically significant, reveal that high R&D intensity has a positive effect on the link between market performance and electric car adoption, meaning that the influence of BEVs on market performance is amplified with increasing R&D intensity. Hence, automobile manufacturers with a strong commitment to R&D are likely to experience a more robust linkage between implementing BEVs and overall market performance.

This research addresses a significant gap in the literature on the impact of electrification in the automotive industry on financial and market performance measures of car manufacturing companies. Acknowledging the ongoing debate on the advantages and disadvantages of electric car popularisation, this research is set to fill this gap and successfully provide valuable insights on that matter. It outlines the implications of this new technology and delivers valuable information for car manufacturers and their directors to facilitate related impediments and changes. To illustrate, a substantial effect of vehicle electrification on car manufacturers' financial and market performance measures may indicate the potential for upcoming changes in financial structures as well as new global strategies (e.g., components sharing). Distinguishing itself from existing narrow-focused studies, this empirical work explores the issue from a broader perspective, considering the impact on both past performance and future performance. Therefore, another valuable practical contribution of this study is addressed to investors and shareholders, who by looking at the results of this analysis may recognize the future potential of a new technology and commit to the automotive corporations. The findings presented by this thesis contribute to the empirical evidence illuminating the relationship between the shift towards BEVs and financial and market performance metrics of global automotive industry leaders.

5.2 Limitations

This study encounters some limitations that need to be recognized. One significant limitation is the exclusion of China's major automakers. The Orbis database lacks data from key Chinese car manufacturing companies such as China FAW Group, Guangzhou Automobile Industry Group, Dongfeng Motor Corporation, Beijing Automotive Group, and Zhejiang Geely Holding Group. All these companies put a strong emphasis on BEVs and are part of the 20 biggest car manufacturers in the world by 2023 revenue (Ahmed, 2023). The lack of availability of that information restricts the analysis's scope by not including data from a market as pivotal as

China's. Therefore, it presents a significant limitation to the global context of the analysis and potentially might distort the overall findings on BEV adoption worldwide.

Moreover, the study primarily examines the period when BEV sales were not that prominent (2009-2017). As pointed out by Marshall (2022), a real surge in BEV adoption has only started and will accelerate in the upcoming years. In light of this observation, this research captures and examines only the negligible part of that transition. Consequently, this discrepancy in data availability may influence the comparison to a certain extent. It might hinder an understanding of how BEV technology development and market acceptance influence the automotive sector's performance metrics.

What is more, the study focuses only on the most successful companies, i.e., the biggest 16 automotive firms globally by turnover in 2022. Such focus introduces a looking-ahead bias that may overlook the challenges and failures of companies that are not tested in this paper but would otherwise be crucial for an extensive view of the industry's transition to BEVs.

Another limitation is related to the R&D measure used in this study. While analyzing the impact of R&D intensity and its moderating role on performance metrics, this research considers only R&D expenditures. R&D in the automotive industry usually falls into the category of intangible assets, which in this case has not been accounted.

Finally, the dataset's limitations need to be acknowledged. The results of this research are based on 220 observations for testing ROA and 214 for MTB ratio. The small sample size might cause some omissions and neglect of substantial to this analysis data. Furthermore, the limited availability of information regarding BEV sales due to the absence of years 2009-2012 and sparse data in the following two years may hinder the thoroughness and scope of the study. The lack of such data across the entire period undoubtedly limits the reliability and applicability of the results.

5.3 Future research

Considering the limitations of the research method pointed out earlier, an overall suggestion for studies delving deeper into the green revolution's impact on the automotive industry in the future is to focus on addressing these gaps. This approach would help enhance the understanding of the transition highlighted throughout the study. Future research endeavors should aim to expand the dataset by incorporating companies from China and other emerging markets. Having a broader dataset would offer a more global perspective thus enabling further exploration through a detailed analysis of regional differences.

Future research could also benefit from extending the analysis period to include a longer period of BEV development and adoption. This academic paper examines only a small part of the transition as it has just recently embarked. This extension would provide future researchers with an understanding of the evolving dynamics within the industry.

Additionally, another recommendation for future research would be to consider a more diverse range of companies. Including those who have faced challenges transitioning to BEVs could shed light on industry issues and obstacles. Looking at the whole industry landscape rather than just focusing on the biggest companies by revenue in 2022 could offer valuable insights for future research.

As indicated by the study, car companies nowadays are considering other zero-emission technologies such as hydrogen fuel cells and synthetic fuel that might overcome battery electric technology in the future. Hence, this work recommends that future publications delve into the impact of other emerging technologies that may shape the industry moving toward emissions-free vehicles.

Lastly, a deeper examination of the moderating effects of company size, R&D investments, and other strategic factors on the relationship between green innovation adoption and performance metrics would offer valuable insights into how businesses can navigate this transformation successfully.

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7 Appendices

Table 1. Research sample.

Automobile manufacturer	Country of origin
Volkswagen AG	Germany
Toyota Motor Corporation	Japan
Stellantis N.V.	Netherlands
Mercedes-Benz Group AG	Germany
Ford Motor Company	United States of America
General Motors Company	United States of America
Bayerische Motoren Werke AG	Germany
Honda Motor Co., Ltd.	Japan
Hyundai Motor Company	South Korea
SAIC Motor Corporation Limited	China
Tesla, Inc.	United States of America
Nissan Motor Co., Ltd.	Japan
Kia Corporation	South Korea
BYD Company	China
Renault Group	France
Tata Motors Limited	India

Source: Author's work

Table 2. Model (1) testing financial performance metric ROA.

Categories	Variables	Measurements	Sources
Dependent variable	Return on assets (ROA)	Profit (loss) before tax (PBT) / Total assets	Orbis
Independent variable	Battery electric vehicles (BEV) sales	BEV sales / Total sales volume	EV volumes; companies' reports
Firm-level control variables	Size (S)	Natural logarithm of Total assets	Orbis
	Research & development (RD)	R&D expenses / Operating revenue (Turnover)	Orbis
	Leverage (LEV)	Total debt (Long-term debt + Loans & short-term debt) / Total assets	Orbis
	Current ratio (CR)	Current assets / Current liabilities	Orbis
	Sales growth (SG)	$(Sales_t – Sales_{t-1}) / Sales_{t-1}$	Orbis
Country-level control variables	Gross domestic product (GDP)	GDP / Total population	The World Bank
	Inflation rate (I)	Inflation rate	The World Bank

Source: Author's work

Table 3. Model (2) testing market performance metric MTB ratio.

Categories	Variables	Measurements	Sources
Dependent variable	Market-to-book (MTB) ratio	Market capitalization / Book value	Bloomberg
Independent variables	Battery electric vehicles (BEV) sales	BEV sales / Total sales volume	EV volumes; companies' reports
Firm-level control variables	Research & development (RD)	R&D expenses / Operating revenue (Turnover)	Orbis
	Size (S)	Natural logarithm of Total assets	Orbis
	Return on assets (ROA)	Profit (loss) before tax (PBT) / Total assets	Orbis
	Leverage (LEV)	Total debt (Long-term debt + Loans & short-term debt) / Total assets	Orbis
	Current ratio (CR)	Current assets / Current liabilities	Orbis
Country-level control variables	Gross domestic product (GDP)	GDP / Total population	The World Bank
	Market capitalization (MAC)	Market capitalization / GDP	The World Bank
	Inflation rate (I)	Inflation rate	The World Bank

Source: Author's work

Table 4. Fisher-type unit-root test for panel data.

Variables	Inverse chi-squared (p-value)	Inverse normal (p-value)	Inverse logit (p-value)	Modified inverse chi-squared (p-value)
MTB	0.0000	0.0033	0.0000	0.0000
BEV	1.0000	1.0000	1.0000	0.9998
RD	0.2246	0.1143	0.1376	0.2380
S	0.0227	0.1605	0.0973	0.0125
ROA	0.0000	0.0000	0.0000	0.0000
LEV	0.0044	0.1142	0.0266	0.0010
CR	0.0062	0.0107	0.0060	0.0017
SG	0.0000	0.0000	0.0000	0.0000
GDP	0.3281	0.9232	0.9674	0.3545
MAC	0.1879	0.1225	0.1550	0.1953
I	0.1724	0.5569	0.4436	0.1772

Source: Author's work

Table 5. Descriptive statistics.

Variables	N	Mean	Std. Dev.	Min	Max	Pr (Skewness)	Pr (Kurtosis)
MTB	215	2.459	5.270	0.313	36.161	0.000	0.000
BEV	224	0.080	0.245	0.000	1.000	0.000	0.000
RD	222	0.042	0.070	0.000	0.797	0.000	0.000
S	224	25.391	1.237	18.686	27.137	0.000	0.000
ROA	224	0.036	0.085	-0.427	0.752	0.016	0.000
LEV	224	0.335	0.130	0.022	0.602	0.000	0.463
CR	224	1.180	0.278	0.627	2.757	0.000	0.000
SG	222	0.095	0.256	-0.526	1.894	0.000	0.000
GDP	224	37663.000	18143.220	1096.636	76398.590	0.001	0.261
MAC	224	91.317	37.234	31.592	193.346	0.003	0.018
I	224	1.991	2.208	-1.353	11.989	0.000	0.000

Source: Author's work

Table 6. Correlation matrix.

Variables	MTB	BEV	RD	S	ROA	LEV	CR	SG	GDP	MAC	I
MTB	1.00										
BEV	0.85*	1.00									
RD	0.47*	0.54*	1.00								
S	-0.55*	-0.58*	-0.44*	1.00							
ROA	-0.39*	-0.45*	-0.57*	0.42*	1.00						
LEV	-0.11	-0.15*	0.01	0.36*	-0.19*	1.00					
CR	0.15*	0.23*	0.30*	-0.07*	-0.22*	0.04	1.00				
SG	0.44*	0.45*	0.16*	-0.36*	-0.11	-0.23*	-0.10	1.00			
GDP	0.17*	0.26*	0.23*	0.37*	-0.13*	0.34*	0.29*	-0.04	1.00		
MAC	0.30*	0.34*	0.17*	-0.05	-0.12	0.07	0.22*	0.12	0.41*	1.00	
I	0.06	0.05	-0.09	-0.18*	0.10	-0.09	-0.21*	0.20*	-0.25*	0.07	1.00

*Statistically significant at 5 percent level

Source: Author's work

Table 7. Regression results of Model (1) with fixed effects.

Variables	**ROA (1.1)**	**ROA (1.2)**	**VIF for (1.1)**	**1/VIF for (1.1)**
D_BEV	-0.0718** (0.0328)	-0.1711 (0.5010)	2.78	0.3597
S	0.0242 (0.0220)	0.0226 (0.0265)	3.69	0.2707
D_BEV*S		0.0042 (0.0219)		
D_RD	-0.4590** (0.1631)	-0.4430** (0.1558)	2.01	0.4977
LEV	-0.3014*** (0.0429)	-0.2997*** (0.0472)	1.31	0.7608
CR	-0.0139 (0.0306)	-0.0136 (0.0311)	1.29	0.7757
SG	-0.0075 (0.0269)	-0.0074 (0.0271)	1.57	0.6353
D_GDP	-1.63e-06** (7.38e-07)	-1.64e-06** (7.60e-07)	2.57	0.3897
D_I	0.0079*** (0.0020)	0.0078*** (0.0021)	1.77	0.5638
_cons	-0.3429 (0.4720)	-0.3049 (0.5839)		
Year dummy	Yes	Yes		
Observations	220	220		
Prob > F	0.0000	0.0000		
R-squared overall	0.3476	0.3456		
Hausman test	0.0448**	0.0488**		
Breusch-Pagan test	0.0001***	0.0001***		
Mean VIF			2.1238	

Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$.

Source: Author's work

Table 8. Regression results of Model (2) with fixed effects.

Variables	**MTB (2.1)**	**MTB (2.2)**	**VIF for (2.1)**	**1/VIF for (2.1)**
D_BEV	12.0981*** (2.1609)	11.8109*** (2.1334)	2.63	0.3805
D_RD	-10.7986*** (3.3545)	-19.7921 (31.9654)	3.78	0.2646
D_BEV*D_RD		9.0350 (30.3319)		
S	-3.1193** (1.0817)	-3.1285** (1.1178)	4.45	0.2246
ROA	8.5973 (5.1035)	8.5577 (5.0408)	3.32	0.3008
LEV	-1.6505 (1.9723)	-1.6467 (1.9755)	1.54	0.6492
CR	-0.8916 (0.8179)	-0.9068 (0.8513)	1.35	0.7394
D_GDP	-2.86e-05 (3.39e-05)	-2.73e-05 (3.22e-05)	3.65	0.2741
D_MAC	-0.0113 (0.0187)	-0.0121 (0.0206)	2.12	0.4720
D_I	-0.1433* (0.0786)	-0.1474* (0.0833)	1.93	0.5186
_cons	84.0095** (30.1669)	84.5414** (31.7127)		
Year dummy	Yes	Yes		
Observations	214	214		
Prob > F	0.0194	0.0273		
R-squared overall	0.5012	0.4937		
Hausman test	0.0004***	0.0004***		
Breusch-Pagan test	0.0000***	0.0000***		
Mean VIF			2.7522	

Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Author’s work