A Work Project, presented as part of the requirements for the Award of a Master's degree in Management, from the Nova School of Business and Economics.

"Does Corporate Governance as an essential element of ESG impact the stock performance of the German DAX40 members"

an empirical study on sustainable investing

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Abstract

This research paper investigates the effects of Corporate Governance on shareholder returns in Germany. The research enhances the current literature landscape on the German investment market by examining unique contextual factors influencing the relationship between Corporate Governance ratings and shareholder performance. The study applied a Random Effects Model to a sample of DAX40 companies between 2014 and 2022. The results suggest a modest impact of governance ratings on shareholder returns in Germany. The research, aligned with present literature, implies that German companies remain under stakeholder control and focus their governance activities on stakeholder rather than shareholder value maximization.

Keywords: Shareholder Performance, ESG, Governance, Ethics, R, Python, DAX40, Stock Market, Board of Directors

Table of Contents

List of Abbreviations

AG ..... Aktiengesellschaft

AUM..... Assets under management

CEO..... Chief Executive Officer

DAX ..... Deutscher Aktien Index

ESG ..... Environmental, Social, Governance

ETF..... Exchange Traded Funds

FEM..... Fixed Effects Model

MDAX..... Mid-Cap Deutscher Aktien Index

MSCI ..... Morgan Stanley Capital International

NASDAQ……..National Association of Securities Dealers Automated Quotations

PLC..... Public Limited Company

RQ ..... Research Questions

REM ..... Random Effects Model

ROE..... Return on Equity

SDG..... Sustainable Development Goals

SE ..... Societas Europaea

S&P 500 ..... Standard & Poor's 500

T ..... Trillion

UN ..... United Nations

USD..... United States Dollars

USA..... United States of America

VIF ..... Variance Inflation Factor

% ..... Percent

List of Figures

1 Introduction

In breaking news, the world watched as the German tech powerhouse, Wirecard AG, turned into the country's economic scandal of the century. The beacon of hope in the German FinTech sector embezzled millions of euros, possible through its disastrous Corporate Governance standards (Fockenbrock and Kewes 2020). This scandal revealed significant deficiencies in the overall German governance landscape, reiterating the importance of Corporate Governance for stake- and shareholders.

Corporate Governance assumes a critical and influential role in shaping the long-term success of companies. Within the overarching Environmental, Social, and Governance (ESG) framework, governance is central, attracting substantial interest from private and institutional investors. Germany, historically known for its strong governance mechanisms, backed by its stakeholder value maximization focus, its unique shareholder landscape and state-of-the-art control mechanisms, such as the two-tier board system, now faces scrutiny due to recent events. This salience of the subject matter has served as the impetus for the current academic inquiry, driven by its topical significance for companies and investors, its contentious nature, and the imperative for meticulous examination.

The applied research aims to understand whether Corporate Governance significantly impacts a company's stock performance in Germany. It evaluates whether investors are particularly willing to pay a premium for companies that focus on specific Corporate Governance criteria related to the themes of management boards, compensation, shareholder rights, and internal auditing. This should create momentum and open up an alternative way of investing for individuals and institutions as well as enable companies to identify specific governance attributes relevant or irrelevant to their respective stock performance.

Hence, the article's research question reads: "Does Corporate Governance as an essential element of ESG impact the stock performance of the German DAX40 members?"

H_0: Corporate Governance does not impact stock performance.

H_1: Corporate Governance impacts stock performance.

In order to test the H_0 hypothesis, hence, to analyze the correlation between governance and stock price movements of the DAX40 members between 2014 and 2022, it has been decided to apply a Random Effects Model (REM) built in R (Appendix A).

The paper follows a well-structured scope. Chapter 2 provides a solid foundation through a detailed literature review, while Chapter 3 centers around dataset generation, highlighting the critical variables that feed into the econometric specification as well as delineates the implied methodology. Chapter 4 presents the research findings, Chapter 5 critically discusses the limitations, and Chapter 6 encapsulates the primary results and discusses on tangible ramifications for share- and stakeholders.

2 Literature Review

2.1 Growing Investor Demand for ESG-compliant Investments Reshapes Portfolio Strategies

ESG investing, commonly called sustainable investing, can be comprehensively characterized as integrating a company's Ecological, Social, and Governance aspects into the investment portfolio selection (Daugaard 2019). While some investors may be attracted due to social responsibility aspects, others view incorporating ESG criteria into their investment decisions as reducing portfolio risk and focusing on companies with best-in-class ethical behavior (Oliveira, et al. 2017).

The acronym ESG has garnered significant attention since its inception in 2005. According to McKinsey (2022), there has been a five-fold increase in Google searches related to ESG from 2019 to 2022, indicating a surge in interest in this investment approach. Simultaneously companies have adapted to this trend. Over 90 percent (%) of companies listed in the Standard & Poor's 500 (S&P500) Index have released corporate ESG reports in 2022, underscoring the widespread adoption of this investment philosophy.

Not only are investors raising the pressure on corporations, but also policymakers are increasingly advocating for proper ethical conduct of companies (Hite and Seitz 2021). Investigations by the Global Sustainable Investment Alliance from 2018 have disclosed that private- and institutional investors have equally developed a greater sensitivity to ESG-conform investing worldwide (Bianchi and Drew 2012). Bloomberg Professional Services (2021) projects that global AUM prioritizing ESG conducts will reach $53 trillion (T) by 2025. (Bloomberg Professional Services 2021)

United Nations (UN) decided on a 15-year agenda of 17 Sustainable Development Goals (SDG), such as *Gender Equality*, *Decent Work & Economics* and *Peace, Justice, and Strong Institutions* to provide a roadmap for a sustainable way of ethical, social, and economic

coexistence between all countries and corporations (United Nations 2022). Exchange-traded funds (ETFs) focusing on ESG factors are designed to reflect these 17 principles. The number of ESG ETFs has increased significantly since 2005, with 456 funds in 2021 (Kishan 2022), whereas 10% specifically focus on governance related SDGs (diversity, strong institutions, transparent communication) (Statista 2022).

Literature indicates that ESG not only has gained importance for companies, governments, and investors from an ethical perspective, but indicates that sustainability recognition may impact stock performance (Bianchi and Drew 2012). Further, it advocates that companies that are part of a sustainability index generate higher returns. Companies of the Dow Jones Sustainability Index North America have shown abnormal returns of 3.64% to 4.85% after their index inclusion. In addition, there was also evidence of increased institutional ownership after joining the index (Moonsoo, et al. 2021, 120-132). Comparing 2019 to 2022, the S&P500 ESG outperformed the S&P500 by four percentage points (Statista 2022).

Forecasts anticipate that the momentum surrounding ESG is poised to persist (Statista 2022). More and more investors are pushing into ESG asset classes, especially investors from Europe and USA operate at the forefront of ESG trading. As of 2022, over half of the total volume of the global ESG index is traded in Europe (Statista 2022), while the USA is experiencing the most substantial growth in financial products in this field (Bloomberg 2021). This expansion is expected to accelerate as ESG investment becomes more diversified across various asset classes and themes. Equity products allow for diversification across different themes (energy type, industry type, innovation type), with climate change currently being the most significant theme, comprising approximately 50% of all ESG traded funds in 2021 (Statista 2022). While considering the other building blocks of ESG, is Corporate Governance relevant enough to warrant its prominence as a significant theme for equity products in the future, and thereby justifying the pursuit of this research?

2.2 The Importance of Corporate Governance

The relationship between Corporate Governance and stock performance is a frequently discussed topic in corporate Finance, driven by prominent scandals such as the Enron Fraud, the WorldCom accounting scandal and the Wirecard swindle, leaving investors with millions in losses while underlying the importance of Corporate Governance again and again. Jensen and Meckling's seminal work from 1976 first underscored the high relevance of suitable Corporate Governance for a company, delineating it as the fundamental tool for alleviating the principle-agent problem between managed and shareholders (Jensen and Meckling 1976, 305-360). The principal-agent problem arises from asymmetric information and heterogenic interests between principle and agent (Jensen 2001, 11-27). Corporate Governance aligns interests between management and shareholder and fosters a reliable and transparent exchange of information between the two, making it a vital tool for the long-term term success of a company (Kaskarelis 2010). Most existing literature suggests that companies with well-established Corporate Governance structures perform better than companies with weaker ones (Grewal, Lilien and Mallapragada 2018).

The classification of Corporate Governance often involves four primary categories: board composition, executive compensation, shareholder rights, and auditing (Becht, Bolton and Röell 2005). These categories are then based on sub-categorical governance markers such as age diversity or voting rights. The relative importance of each of these criteria varies, with the list comprising twelve subtitles and 30 independent variables (Bloomberg 2023).

I. **Board Composition**			
Director Roles	***Diversity***	***Independence***	***Refreshment***
CEO Roles	Age Diversity	Board Leadership Independence	Board Refreshment
Chair Roles	Gender Diversity	Board Independence	Chair Refreshment
Board Roles			

II. Executive compensation		
Incentive Structure	***Pay Governance***	***Pay for Performance***
CEO Incentive Plan Design	Compensation Board Oversight	Fixed Pay Alignment
Executive Incentive Plan Design	Say on Pay	Variable Pay Performance
Executive Pay Equity	Pay Policies	
Executive Pay Linkages		
III. Shareholder Rights		
Shareholder Policies	***Director Voting***	
Takeover Defense	Director Terms	
Voting Rights	Director Support	
Director Election Policies		
IV. Audit		
Audit Committee	***External Auditor***	***Audit Outcome***
Audit Committee Meetings	Auditor Approval	Accounting Restatements
Audit Committee Structure	Auditor Fees	Auditor Opinion
	Auditor Tenure	

Figure 1: Score Framework and Structure, Bloomberg (2023)

The board of directors plays a pivot role in Corporate Governance. Its main task is to serve as a control and monitoring mechanism while supporting the overall strategic course of a company (Adams and Ferreira 2007, 217–250). The literature claims that diverse and independent boards are more effective in monitoring and controlling a company due to their heterogenous perspectives and enhanced decision-making capabilities. Diversity criteria encompass industry backgrounds, age, culture, geography, and gender (Pechersky 2016). An independent board benefits a company's comprehensive monitoring, controlling, and strategic decision-making capabilities, which are at the core of the Corporate Governance field of responsibility.

As early as 1985, the literature agreed that the best way to align shareholders' and management's interests is through the compensation structure (Brindisi 1985, 14-17). Robust Corporate Governance allows companies to link compensation to meaningful long-term performance indicators maximizing the alignment of interest between agent and principle,

reducing the principle-agent dilemma while operating at the forefront of long-term economic and ethical standards (Jensen 2001, 11-27).

Corporate Governance incorporates shareholders' rights as a critical element, which refers to the contractual and legal entitlements shareholders possess regarding the company in which they own shares. These rights typically include the election of directors, significant corporate actions, dividends, and access to company records (Becht, Bolton and Röell 2005). Bloomberg identifies five subcategories that quantify shareholders' rights: *Takeover Defense, Director Terms, Voting Rights, Director Support, and Director Election Policies.* Strengthening these rights can contribute to successful long-term performance and safeguard investors' property (Bloomberg 2023). Implementing robust shareholder rights governance mechanisms amplifies shareholders' ability to shape the strategic trajectory of any company successfully. This underpins the importance of Corporate Governance as it allows for better alignment between corporate goals and investor expectations.

As previously outlined, a critical problem between agent and principal is the disparity in information. In adhering to its objective to implement a solid internal audit system, Corporate Governance facilitates companies to produce transparent, reliable, and high-quality information with the aim of minimizing the disparity in information between management and investor (Banerjee 2022).

2.3 Corporate Governance in Germany: A Stakeholder Driven Approach

The debate about Corporate Governance in Germany started in 1990, driven by the dire economic conditions triggered by the distress in the German iron and steel industry (Du Plessis, et al. 2007). Germany's Corporate Governance landscape is characterized by its two-tier board structure, the strong stakeholder focus, a bank-based funding approach, and an overall concentrated investor base (Jungmann 2007).

The two-tier board system in Germany is the golden standard (Goergen, Manjon and Renneboog 2008). It allows for a rigorous separation between independent directors and managers. According to Jungmann (2007), Germany is considered a paradigm for corporate structures when it comes to the control of company directors being in the hands of a separate supervisory board. A two-tier board structure reduces a company's overall risk. Literature underpins that claim, according to a study from Younas et al. in 2019, evaluating whether risk appetite differs between dual- vs. single-board systems. The paper's meta-analysis featuring 600 companies from Germany and the USA identified significant disparities between risk appetite and board structure. The study showed that an increase in independent board members led to a reduction in risk appetite among companies (Younas, et al. 2019).

According to Goergen, Manjon, and Renneboog (2008), German corporations overall focus on maximizing stakeholder value rather than shareholder value (Goergen, Manjon and Renneboog 2008). Germany fosters a high degree of employee participation at the management level. The country follows the "co-determination" principle, linking labor and corporate law, granting employees the right to participate in a company's decision-making process (Du Plessis, et al. 2007). Companies with two thousand employees or more must make up half of the supervisory board with employee representatives. This results in long-term equality of power between share- and stakeholders (Schröter 2008). An aspect that may pertain to the attenuation of the investor's responsibility to observe the company's Corporate Governance.

In Germany, banks play a unique position in companies' internal affairs. This has been driven historically by two reasons: 1. Banks are the primary source of funding in Germany 2. They historically exercised the depository voting rights of the shares of their customers. Since the 20th century, it has been common for investors to deposit their shares with banks for security and tax reasons. These banks offered their customers the service of voting on their behalf at the annual shareholder meeting. This led historically to particularly disinterested shareholders and

high voting powers for banks at annual shareholder meetings. Controlling majority shareholder rights at various companies enabled banks to often appoint a majority of the shareholder representatives, which represented the bank's interest (Du Plessis, et al. 2007). In the 1990s, banks controlled more than 50% of the voting rights at 31 of the 32 biggest German companies and appointed 6% of the overall supervisory board positions employed (Baum 1992, 503-526). A high number when considering that most supervisory board seats were reserved for employee representatives under the "co-determination" law (Du Plessis, et al. 2007). Despite a recognizable decrease in bank control in Germany over the past two decades, the phenomenon that investors transfer their duty to actively govern a company's Corporate Governance to a bank or similar institution still materializes in some instances.

The ownership structure of German companies is typically more concentrated than in other places, like the USA or UK (Schröter 2008). In 1990, over 80% of the listed companies featured at least one shareholder owning more than 25%. These major shareholders are often founding families, banks, or corporations. They are also called "blockholders". In Germany, major strategic decisions of a company often constitute the change of the company's bylaws, which requires the consent of more than 75% in a general vote, allowing “blockholders” to veto such a vote (Schmidt 2003). Germany typically does not exhibit many institutional investors (Höpner and Krempel 2011, 271-299).

Considering that the company's stakeholders dominate the shareholder landscape in Germany, it can be assumed that the Corporate Governance mechanisms focus their strategic decision-making on stakeholder protection, i.e., sustainable growth, rather than on shareholder value maximization. Banks aim to secure their loans, employee representatives focus on staff protection, and founding families want to preserve their name and heritage. Literature suggest nevertheless, that these structures have been slowly crumbling in the recent decade, the amount of minority investors in Germany is increasing (Deutsche Aktieninstitute 2020), globalization

is bringing big institutional investors to the German equity markets (Du Plessis, et al. 2007), and scandals such as the Wirecard fraud keep the importance of governance for shareholders vivid and omnipresent (Fockenbrock and Kewes 2020).

2.4 Governance Risk Rating Landscape: How can Governance be Quantified?

To enhance the understandability and comparability of a company's Corporate Governance performance, rating such as Bloomberg, S&P, Moody's, and Morningstar have implemented various Corporate Governance ratings (Bloomberg 2023), (Moody's 2023), (Morningstar 2023) & (Standart & Poor's 2023). These ratings serve as a valuable tool for share- and stakeholders assess the quality of a company’s governance.

Even though Corporate Governance ratings ensure comparability on a within-raking basis, they often lag in providing comparability capabilities across ratings, a frequently cited criticism (McKinsey 2022). The most notable disparities arise from less tangible indicators such as the level of information disclosure or overall company complexity (Gyönyörová, Stachoň and Stašek 2021). 2019 more than 125 rating agencies evaluated ESG criteria, all using different formulas and recipes (Kesterton 2019), making it highly opaque for share- and stakeholders to identify which recipe i.e., rating to trust (Bloomberg 2023), (Morningstar 2023), (MSCI 2023), (Moody's 2023) (Standart & Poor's 2023).

Considering that, may it be justifiable to utilize a governance risk rating as an adequate tool to assess the impact of the governance performance of a company on its respective stock market performance?

2.5 Are Governance Risk Ratings a Suitable Tool for Assessing Stock Performance?

Historically, the fair value of publicly traded stocks was based on the anticipated future worth of the company’s assets (Hague 2002). However, it is widely recognized today that

evaluating the fair value of a share encompasses much more than merely assessing the company’s assets. A more accurate depiction of a company's potential for success entails a comprehensive evaluation of its Balance Sheet and all other potentially value-adding capabilities like brand recognition, social capabilities, or Corporate Governance performance. However, the primary challenge with such assets lies in their fair determination of their value, given that they are not numerically quantifiable and are contingent on subjective perceptions varying across individuals. Consequently, the willingness to pay for these intangible assets can vary considerably (Ajour El Zein, Consolacion-Segura and Huertas-Garcia 2019).

The Global Sustainable Investment Alliance (2018) notes an increasing interest among investors in assessing the impact of companies' sustainable, social, and governance capabilities on their fair value. As a result, such valuation capabilities are continuously refined and enhanced (Alliance Global Sustainable Investment 2018). A particular one is the governance risk rating, a key building block of the ESG risk rating, created to quantify the impact of ethical behavior on the fair value of a firm. The most recognized independent ratings are those provided by MSCI, Morningstar, S&P and Bloomberg Global (MSCI 2023), (Standart & Poor's 2023), (Morningstar 2023) & (Bloomberg 2023).

According to the available literature, approximately 83% of senior executives expect ecological, social and governance factors to have a more significant impact on shareholder value in the next five years compared to today. Furthermore, surveys suggest that a favorable ESG risk rating can result in a 10% increase in price premiums, as noted in the McKinsey 2020 report (McKinsey 2020).

In the following literature section will review research that examines the correlation between positive governance ratings and the performance of firms. The results vary, particularly across regions, company size, and market criteria.

The academic paper of Grewal, Lilien and Mallapraganda (2018), using a sample of 1,734 firms from the MSCI ESG Database, revealed a positive relationship between higher Ecological, Social and Governance ratings and a company's market capitalization. On average, their findings suggest that an increase of one point within the ESG score results in a 0.62% increase in firm value (Grewal, Lilien and Mallapragada 2018, 397-416).

The contribution of Core, Holthausen and Larcker (1999), focusing merely on governance, confirmed the findings from Grewal, Lilien and Mallapraganda already two decades earlier. Their meta-analysis proves that companies with overall weaker governance structures face more severe agency problems and therewith perform worse. Additionally, the study reveals a negative correlation between governance and executive compensation, implying that companies with weaker governance pay higher salaries (Core, Holthausen and F. Larcker 1999, 371-406).

Gompers et al. can provide concurring evidence by analyzing over 1,500 companies to prove a correlation between governance scores and firm value, indicating that weak shareholder rights are directly associated with lower profits, higher capital expenditures and higher threat of corporate acquisitions. However, according to his results, the degree of impact varies enormously between companies (Gompers, Ishii and Metrick 2003, 107-155).

The meta-analysis of 2,000 companies by Friede, Busch and Bassen illustrates that the impact of Corporate Governance on stock performance significantly varies between industries. They also point out limitations, such as publication bias, the differences in governance measurements, and the varying data quality (Friede, Busch and Bassen 2015).

Research on ESG ratings on companies listed in Australia suggested that only environment and governance factors present a statistically relevant impact on stock performance. Notably, a more substantial relationship was found between small firms and firms

with low levels of analyst coverage. However, the study also revealed varying success rates across different industries (Rogers and van der Laan Smith 2020, 155-176).

The general sentiment of the analysis indicates some correlation between stock performance and governance risk ratings implying that Corporate Governance risk ratings may present a valuable measure to evaluate the impact of Corporate Governance on stock performance, even though results might differ between company types, legal systems, geographical regions, and industries. It is crucial to note that the reasons for these contradictory results can be multifaceted and may be influenced by the measurements of governance factors, sample selection, and analytical methods employed. Therefore, it important to consider the individual research purpose when choosing the risk rating score to be applied.

2.6 Research Gap

Despite the extensive research exploring the relationship between various ESG components and stock performance, the precedent literature review indicated a gap in comprehensive studies that assess the impact of specific Corporate Governance provisions on the financial performance of publicly traded companies in Germany within the last decade.

The literature review denotes a correlation between governance and stock market performance. It underlines the importance of governance for investors and companies while highlighting the difficulty of correctly evaluating the impact of governance covenants on a company's fair value. This paper aims to fill this gap by enriching the existing research on the impact of Corporate Governance on stock performance in Germany between 2014 and 2022.

3 Methodological Approach

The methodology employed in this article is explanatory, utilizing an inductive approach to examine a novel hypothesis. The investigation will concentrate on relevant Corporate Governance markers of the DAX40 members. The variables included relate to the board composition, executive compensation, shareholder rights, and auditing capabilities of a company. These variables will be juxtaposed with the equity market behavior of the DAX40 index members. The research question posed in the article is as follows:

"Does Corporate Governance as an essential element of ESG impact the stock performance of the German DAX40 members?"

H_0: Corporate Governance does not impact stock performance.

H_1: Corporate Governance impacts stock performance.

3.1 Data and Variable Description

According to the literature, the stock market performance was identified as the dependent variable in this study (Ajour El Zein, Consolacion-Segura and Huertas-Garcia 2019). The DAX40 index was selected as it covers approximately 80% of the market capitalization of publicly listed companies in Germany (Deutsche Börse AG 2021). Considering the disparities between stake- and shareholder value maximization approaches across countries, along with the literature suggesting that results vary by company size, industry and geographics, it is reasonable to expect diverse results in other indexes, such as the S&P500 or subcategories like the NASDAQ and MDAX. When analyzing the impact of governance on stock market performance, it is paramount to consider the market dynamics, legal system, and share- and stakeholder landscapes of the analyzed market or region.

It was decided to consider annualized market capitalization data as the literature suggested strong seasonality in stock market returns throughout the year, driven by disproportional returns in January (Gultekin and Gultekin 1983, 469-481). To study the behavior of the DAX40 members, the yearly adjusted market capitalization between 2014 and 2022 was extracted and observed from Bloomberg. To comprehensively address the theme of Corporate Governance, the literature suggests selecting independent variables from four subcategories:

1. Board of Directors: Literature suggests that a board of directors should be diverse, competent, and independent (Stefanescu 2013, 127-146) (Erhardt, Werbel and Shrader 2003, 102-111). Therefore, it has been decided to consider the *Percentage of Independent Directors*, *Chairperson Tenure*, and *CEO on the Board* (Baltagi 2008) as a variable to analyze the board's independence. The degree of independent directors ranged between 20% to 100%. Only Airbus SE and Linde PLC included their CEO on the board throughout the valuation timeline. The chairperson's tenure ranged between 0.08 years to 20 years, with a mean of 5.6 years. The competence of the board was factored in by including the *Board Age Range*; boards with a greater age range feature higher problem-solving capabilities as younger board members contribute new skills and perspectives (PWC 2019). The maximum age range was observed at the board of Volkswagen in 2022 with 44 years, and the minimum at the board of Covestro with 14 years. To include diversity of the board in the evaluation, it has been decided to consider whether the *Chairperson or Equivalent is a Woman* and *The Percentage of Board Members that are Women*. Henkel, Zalando, Deutsche Wohnen, and Puma employed a female as their chairperson in the valuation duration. Zalando stood out as the only company in the data set to have a board composed of more women than men, with 56% from 2020 to 2022.

2. Executive Compensation: As pointed out by the literature review in Chapter 2.4, executive compensation is an intrinsic element of governance and directly affects the behavior of a company's top executive (Bebehuk and Fried 2003, 71-92). To consider pay and pay for performance, it was determined to incorporate *Total Salaries Paid to the CEO* and *Total Bonuses Paid to Executives* as independent variables. Deutsche Bank paid the highest salary among all observations in 2014, with €10.4 million. In the same year, BMW paid €35.9 million in bonus payments, the highest bonus across the observation's duration. According to Bloomberg Intelligence research, linking executive compensation to ESG performance is an effective means of promoting accountability and driving improvements in significant ESG related challenges; therefore, it was decided to consider *Executive Compensation Linked to ESG* as an independent variable (Flammer 2015) (Bloomberg Intelligence 2020). Twenty-six companies in the data set linked their compensation to ESG criteria throughout the observation period. Linking ESG criteria to compensation has more than doubled among the DAX40 members within the observation duration, from less than 23% in 2014 to more than 50% in 2022, emphasizing once more the growing importance of ESG for German companies throughout the past decade. To ensure that management incentives are aligned with the long-term interests of shareholders, a company must establish appropriate governance policies and compensation practices. This includes establishing effective oversight mechanisms at the board level, promoting shareholder engagement, and establishing policies to ensure the integrity of long-term equity-based awards. Having independent directors is crucial for ensuring adequate oversight and representing minority shareholders, particularly those who serve on the compensation/remuneration committee; the variable *Percentage of Independent Executives on the Compensation Committee* was considered to model that effect (Mizruchi 2003). The degree of

independent executive on the compensation committee ranged between 100% and 0%, averaging 66.71%.

3. Shareholder Rights: The literature argues that the primary responsibility of Corporate Governance is to ensure that companies consider the interests of all stakeholders, including shareholders, in their decision-making process (Freemann 2015, 276). Therefore, it was decided to consider the *Board Duration*, as multi-year director terms indicate low voting intervals. Refraining from subjecting directors to annual elections decreases accountability. Thus, frequent elections motivate board members to prioritize shareholder interests. The board duration ranged from six years at SAP to one year at companies such as Hello Fresh and Zalando. It was decided to consider *Dual Class Unequal Voting Rights* to model the effect of voting rights. State-of-the-art Corporate Governance endorses a "one-share-one-vote" system. The presence of multiple share classes with unequal voting rights can create a heightened risk of poor accountability for entrenched managers. In such cases, companies that grant low voting power to outside shareholders offer limited avenues for recourse in the event of poor strategic decisions, leaving minority shareholders with little influence over the company's direction (Bloomberg 2021). Nineteen companies within the observation duration employed a dual-class unequal voting rights system.
4. Audit and Risk Management: Effective Corporate Governance ensures that companies produce reliable, comparable, and accessible information. This is merely provided through the process of auditing. One objective approach to assessing the effectiveness of the audit committee's oversight is to analyze the frequency of *Audit Committee Meetings* and the *Audit Committee Independence*. Research suggests a direct correlation between meeting frequency and the quality of financial reporting (Qamhan, et al. 2018). Audit committee meetings ranged between 17 at Deutsche Bank in 2015 and 1 at Linde

PLC in 2018. The independence of the audit committee ranged between 100% and 20%, with a mean of 71.35%.

Name	Variable Type	Number of Observations	Average
Audit Committee Independence	Number	327	3.54
Audit Committee Meetings	Number	323	5.63
Board Age Range	Number	284	27.78
Board Duration	Years	287	4.01
CEO on the Board	Boolean	339	0.04
Chairperson Tenure	Years	343	5.65
Chairperson or Equivalent a Woman	Boolean	343	0.05
Dual Class Unequal Voting Rights	Boolean	325	0.36
Executive Compensation Linked to ESG	Boolean	336	0.32
Percentage of Board Members that are Women	%	343	30.59
Percentage of Independent Directors	%	244	71.35
Percentage of Independent Directors on Compensation Committee	%	186	66.71
Total Salaries Paid to CEO and Equivalent	USD	324	1,681,110.34
Total Bonuses Paid to Executives	USD	334	5,776,829.62

Figure 2: Independent Variables

3.2 Data Selection

For this study, the decision was made to utilize the German industry index DAX40 as of December 2022. To establish a reliable regression and portray a meaningful correlation between dependent and independent variables, the dataset has been adjusted for companies listed after the fiscal year of 2017 and companies that did not have any data on governance available. These companies included Siemens Healthineers, Siemens Energy, Delivery Hero and Brenntag. To enhance the meaningfulness of the index, these companies have been exchanged for previous long-term members of the DAX40, namely, Deutsche Lufthansa, Wirecard, Rheinmetall and Commerzbank. The chosen evaluation period ranges from 2014 until 2022. Based on the disparities in listing periods of the companies included, it should be

noted that some companies contributed less than nine years of stock data. Thus, 40 companies were considered throughout the evaluation period accumulating a dataset of 343 observations.

Name	Ticker	Total Years Analyzed	Average Performance
adidas AG	ADS GR	10	12.8%
Airbus SE	AIR FP	10	18.8%
Allianz SE	ALV GR	10	6.2%
BASF SE	BAS GY	10	-2.9%
Bayer AG	BAYN GR	10	0.5%
Bayerische Motoren Werke AG	BMW GY	10	2.1%
Commerzbank AG	CBK GY	10	9.4%
Continental AG	CON GR	10	1.6%
Covestro AG	1COV GR	7	9.8%
Delivery Hero SE	DHER GR	5	30.7%
Deutsche Bank AG	DBK GR	10	1.1%
Deutsche Boerse AG	DB1 GR	10	14.4%
Deutsche Lufthansa AG	LHA GY	10	13.0%
Deutsche Post AG	DPW GR	10	10.7%
Deutsche Telekom AG	DTE GR	10	20.4%
Deutsche Wohnen SE	DWNI GR	10	2.6%
E. ON SE	EOAN GR	10	3.0%
Fresenius Medical Care AG & Co KGaA	FME GR	10	-2.6%
Fresenius SE & Co KGaA	FRE GR	10	3.7%
HeidelbergCement AG	HEI GR	5	70.7%
HelloFresh SE	HFG GR	10	1.5%
Henkel AG & Co KGaA	HEN GY	10	22.8%
Infineon Technologies AG	IFX GR	5	36.7%
Linde PLC	LIN USA	10	14.6%
Merck KGaA	MRK GR	10	15.8%
MTU Aero Engines AG	MTX GR	10	14.2%
Muenchener Rueckversicherungs	MUV2 GR	10	6.4%
Porsche Automobil Holding SE	PAH3 GR	10	14.6%
Puma SE	PUM GR	10	2.1%
QIAGEN NV	QIA GY	10	13.6%
Rheinmetall AG	RHM GY	10	27.6%
RWE AG	RWE GY	10	9.0%
SAP SE	SAP GY	10	6.0%
Sartorius AG	SRT GR	10	48.7%

Siemens AG	SIE GR	10	3.7%
Symrise AG	SY1 GR	10	18.8%
Volkswagen AG	VOW3 GY	10	1.9%
Vonovia SE	VNA GR	8	10.0%
Wirecard AG	WDI GR	9	25.3%
Zalando SE	ZAL GR	8	18.8%
Average		**9.4**	**13.4%**

Figure 3: Description of the Dependent Data Set

3.3 Data Extraction

Due to the sheer number of datasets created daily by a company as well as its privacy regulations, it is only possible to observe factors of governance accurately and efficiently by utilizing secondary research from a rating benchmark. Using benchmark data will help ensure transparency, objectivity, standardization, and comparability between all observations within a dataset (Willmington, et al. 2022)

The data of the Bloomberg Governance Rating is used as the primary benchmark for this research. The decision was based on the rating's vast industry and company coverage, best-in-class methodology, stakeholder feedback, timeliness, duration of historical data, and overall transparency (Bloomberg 2023).

To uphold the precision and dependability of its governance ratings, Bloomberg employs a data collection approach that involves extracting information from publicly accessible corporate reports and publications. This encompasses an array of sources, such as annual reports, proxy statements, Corporate Governance reports, supplemental disclosures, corporate websites, and news providers (Bloomberg 2023).

Bloomberg employs a comprehensive quality control system to ensure the accuracy and consistency of data collected for its governance assessments. This system includes multi-level reviews by analysts who evaluate initial assessments of disclosures and perform secondary validations. In addition, statistical and heuristic analyzes are performed to ensure

that only comparable data is included in the rating. Through a thorough and meticulous data collection approach, Bloomberg ensures its governance assessments' integrity (Bloomberg 2023).

Upon completion of the data extraction, the data set required necessary reorganization and adjustments. The DAX40 constituents' daily stock performance has been adjusted for an annual viewpoint. In light of existing literature as well as considering the characteristics of the stock market, a yearly average view of the values was deemed superior for the statistical analysis (Gultekin and Gultekin 1983, 469-481). Additionally, it has been considered to not adjust the data for outliers and to consider extreme effects of governance on companies, such as the failure of Wirecard due to a lack of auditing (Fockenbrock and Kewes 2020). In the second step, the company's stock performance data was matched with the respective governance performance scores. In the third step, the data needed to be adjusted for R. In this case, all Boolean variables had to be transformed into integer variables, and large numbers were made smaller to reduce the needed calculation capacity of the program. The data cleaning has been done using R.

With the assumption that a year comprises an average of 252 trading days (Mayo 2020), it can be inferred that the study encompasses 2,268 trading days, thus representing a comprehensive nine-year observation period.

3.4 Random Effects Model

Following the data-cleaning process, a statistical model must be applied to ascertain the results' reliability and test the proposed hypothesis. This study applied the Random Effects Regression Model as the preferred statistical technique for analyzing the panel data set. This decision was based on the literature demonstrating the suitability of the REM model to analyze the panel data in question (Wooldridge 2010), (Baltagi 2008), (Allison 2009).

In panel data, the same individuals, i.e., companies, are observed over multiple time periods, focusing on individual-level variation over time. The Random Effects Model accounts for the individual-level variation by a composite error term comprising individual-specific effects and idiosyncratic errors in the regression equation (Allison 2009).

In addition, it presents a superior alternative to the OLS model as it allows for the estimation of time-invariant variables and controls for unobserved heterogeneity at the individual level that potentially biases slope coefficient estimates.

It has been decided to include time dummies in the model to account for time-specific effects such as political changes, natural disasters, or macroeconomic shocks that equally affect all individuals in the panel. This method permits the inclusion of the causal effect of independent variables on the dependent variable by controlling for time-invariant unobserved factors and time-specific effects (Bertrand 2004, 249-275).

The complete REM model was run on R programming language (Appendix A). R has been chosen as it provides researchers with the effective means to estimate random-effects regression models for panel data using its extensive library (Hanck, et al. 2021). R's flexibility and extensibility allow users to customize and extend their analysis to fit their research needs.

The Random Effects Model describes a set of regression equations in which the dependent variable is a function of the independent variable(s) and a composite error term that features individual-specific effects and idiosyncratic errors. The REM assumes that the independent variable(s) are uncorrelated with the individual-specific effects. When the assumptions of uncorrelated individual-specific effects hold true, the model delivers a higher output quality than the Fixed Effects Model while allowing to estimate of time-invariant variables (Wooldridge 2010). Consequently, the equation system of the Random Effects Model for n observations in t periods is as follows:

Random Effects Model Equation:

$$y_{it} = X_{it}\beta + u_i + \varepsilon_i$$

y_{it} = Dependent variable observed at time t and individual i

X_{it} = Time-variant Regressor Vector

β = Vector of Coefficient

u_i= Individual Specific Effect (unobserved heterogeneity)

ε_i = Random Error Term

Assumptions Associated with the use of REM models:

- Normality: The error term follows a normal distribution with a mean of zero [Histogram]
- Exogeneity: The independent variables are not correlated with the error term. There is no feedback between dependent variable and independent variable(s) [Hausmann Test]
- Homoscedasticity: The variance of the error term is constant across the values of the independent variables [Breusch-Pagan Test]
- No autocorrelation: The error term is not correlated with itself over time or across individuals [Durbin-Watson Test]
- No perfect multicollinearity: The independent variables are not perfectly correlated with each other [VIF Test] (Wooldridge 2010)

For the verification of all tests and the output of the REM model, an alpha level of 0.05 has been chosen. Literature indicates that for this specific analysis choosing a p-value significance level of 0.05 reduces the probability of making a Type II Error (failing to reject the H_0) to a minimum. Using a more conservative alpha level to reduce the probability of making a Type I Error (accepting a false H_0 hypothesis) may not be appropriate for the analysis of stock performance. A p-value of 0.01 is usually limited to medical and pharmaceutical research (Ioannidis 2005, 124).

To validate the findings of the REM, the Random Forest Regressor model was selected. The Random Forest Regressor Model is a machine learning framework for solving sophisticated regression and categorization problems utilizing an ensemble learning technique, in which multiple decision trees are combined to enhance predictive performance and reduce over-fitting. The model is non-parametric and presumes an underlying data allocation, which makes it very flexible and adaptive to different regressions (Breimann 2001).

It is used in predictive modeling to predict stock performance based on exogenous variables such as social or governance indicators. In addition, it provides the opportunity to assess the effect of any independent variables on the dependent variable (Liaw 2002). In this academic paper, the Random Forest Regressor was built and run using Phyton (Appendix B).

3.4.1 Normality

To assess whether the data follows a normal like distribution, it has been decided to establish a histogram.

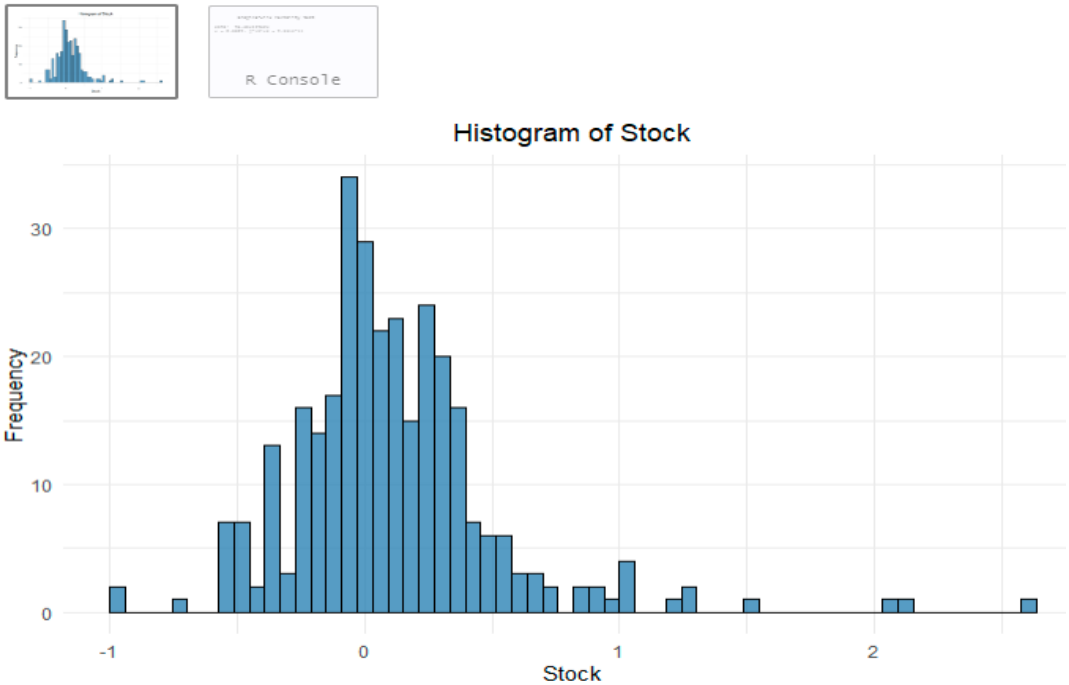

Figure 4: Histogram of the Stock Performance Variable

Even though the literature states that stock prices exhibit non-normal characteristics such as volatility clustering, heavy tails, and skewness (Appendix C) (Harvey 2000, 189-200), (Fama 1965, 34-105), they generally follow a normal-like distribution (see Figure 4.). Performing a normality test such as the Shapiro-Wilk Test or the Kolmogorov-Smirnov Test on stock data may not be particularly informative or meaningful, as the data is unlikely to be entirely normally distributed (Petersen 2019). While the REM model assumes normality of the errors, it can deal with deviations from normality, as the estimates are consistent even under mid-departures from normality (Verbeek 2008).

3.4.2 Hausmann Test

The Hausman Test is a statistical test employed in econometrics to assess whether a Fixed Effects Model or Random Effects Model is more appropriate for a considered panel data set. The test ensures that the modeling approach is appropriate and that the analysis results are reliable and valid (Wooldridge 2010) (Cameron 2010).

The Hausman Test compares the estimated coefficients of fixed and Random Effects Models and computes a test statistic that adheres to a chi-squared distribution. The test is predicated on the principle of consistency, which states that the estimator shown to be efficient and consistent should be employed in the model. The Fixed Effects Estimator is consistent but not efficient, whereas the Random Effects Estimator is efficient but inconsistent (Wooldridge 2010).

The Fixed Effects Estimator is consistent, meaning that the estimator approximates the actual value of the estimated parameter as the sample size expands. However, the Fixed Effects Estimator can be more efficient, meaning it may not provide the most accurate parameter estimation as the Fixed Effects Estimator needs to take advantage of individual variation, reducing efficiency (Cameron 2010).

In contrast, the Random Effects Estimator is efficient, providing the most accurate estimation of the parameter. However, the Random Effects Estimator is sometimes inconsistent. It may not converge to the parameter's actual value if the sample size increases. This results because the Random Effects Estimator exploits between-individual variation by assuming that the individual-specific effects are randomly distributed (Verbeek 2008).

The model's hypothesis predicts the coefficient difference. If the test statistic is more significant than the corresponding quantile of the chi-squared distribution with K degrees of freedom, the null hypothesis that the Random Effects Model is preferable is rejectable in favor of the alternative hypothesis that the Fixed Effects Model is preferable.

Hausmann Test Equation:

$$\alpha = \left(\widehat{\beta_{FE}} - \widehat{\beta_{RE}}\right)' \left(Cov\left(\widehat{\beta_{FE}}\right) - Cov\left(\widehat{\beta_{RE}}\right)\right)^{-1} \left(\widehat{\beta_{FE}} - \widehat{\beta_{RE}}\right) \sim x^2(K)$$

α = Test Statistics

$\widehat{\beta_{RE}}$ = Estimation of Random Effects

$\widehat{\beta_{FE}}$ = Estimation of Fixed Effects

$Cov(x)$ = Covariation Matrix

$x^2(K)$ = Number of regressors in the panel data

The results of the Hausmann Test show a p-value of 0.2722. Therefore, it can be concluded that at a significance level of 0.05 the Random Effects Model is the preferrable tool for the analysis of the data set. Therewith the Random Effects Model will be employed as the main tool for the hypothesis testing of the research question.

3.4.3 Breusch-Pagan Test

The Breusch-Pagan Test is employed in econometrics to determine evidence of heteroskedasticity in a regression model.

It should be noted that heteroscedasticity occurs when the variance of appearing errors in a regression model is not uniform across all independent variable values. If the test indicates that the variance of the errors is not constant, it suggests that heteroscedasticity is present in the model. This may lead to biased and inefficient estimates of the parameters and standard errors. The Breusch-Pagan Test ensures that the regression model assumptions are met and that the analysis results are reliable and valid (Gujarati 2003).

The Breusch-Pagan Test adds a set of squared independent variables to the regression model and re-runs the model. The null hypothesis of the test reads that the variance of the errors is consistent. In contrast, the alternative hypothesis reads that the error variance is inconsistent (Greene 2012). As the auxiliary regression in the test is based on the squared residuals from the original model as the dependent variable, the computation of the test is as follows:

Breusch-Pagan Test Equation:

$$e_i^2 = Z_i \, x \, \alpha + \mu_i$$

e_i^2= Squared residual from the original model

Z_i = Value matrix of the original explanatory values

α = Coefficient Vector

μ_i = Error Term

The test statistic adheres to a chi-square distribution with degrees of freedom corresponding to the number of independent variables. The critical value for the Breusch-Pagan

Test is determined based on the significance level and the number of degrees of freedom. The results of the Breusch-Pagan Test indicate no heteroscedasticity as the p-value is 0.1577, which is above the significance level of 0.05 with 18 degrees of freedom (Greene 2012).

3.4.4 Breusch-Godfrey Test

As previously outlined, one key assumption in random effects analysis is that the residuals are not correlated across observations or over time. Violating this assumption may affect the efficiency and consistency of the Random Effects Estimator, leading to incorrect inferences and biased estimates of the models' parameters (Baltagi 2008).

The Breusch-Godfrey Test is beneficial as it considers higher-order autocorrelation as well as proves to be robust in different structures of autocorrelation within a panel (Baltagi 2008). For this purpose, the squared residuals are regressed on a specific set of explanatory variables from the original regression model, and the lagged values of the residuals (Gujarati 2003).

The hypothesis of the Breusch-Godfrey Test reads as follows:

H_0: There is no autocorrelation in the residuals.

H_1: There is autocorrelation in the residuals.

The H_0 is supposed to be rejected in favor of H_1 in case the p-value of the test falls below 0.05. This implies that the assumption of no autocorrelation is violated, and the model may bias. The computation of the test is as follows:

Breusch-Godfrey Test Equation:

$$e_t = Z_t \, x \, y + v_t$$

e_i^2= Residual from the original model

Z_i = Value matrix of the original explanatory values (X_t) along with the lagged values of the residuals $\left(e_{(t-1)}\right)$

y = Coefficient Vector

v_t = Error Term

The main difference between the Breusch-Godfrey Test and the Breusch-Pagan Test is the auxiliary regression's dependent variable and the lagged residuals' inclusion in the value matrix. The Breusch-Pagan Test employs squared residuals as dependent variables to analyze heteroskedasticity, while the Breusch-Godfrey uses residuals along their lagged values to test for autocorrelation (Breusch and Pagan 1979, 1287-1294).

The results of the Breusch-Godfrey Test for the panel data employed indicated no autocorrelation as the test revealed a p-value of 0.0628 at 1 degree of freedom, which is above the threshold of 0.05. H_0 cannot be rejected in favor of H_1.

3.4.5 VIF-Test

Multicollinearity can become a substantial concern in regression analysis if two or more independent variables are significantly correlated. This can result in imprecise and unreliable estimates of the regression coefficients and standard errors, reducing statistical power. The Variance Inflation Factor (VIF) measures the extent of multicollinearity in a regression model and is commonly used to diagnose the existence of multicollinearity (Hill 2018).

A VIF score of 1 signals no multicollinearity, while values above 1 suggest an increased degree of multicollinearity. A VIF score above 10 indicates high multicollinearity. The VIF is computed as the ratio of the variance of the regression coefficient in a model that contains all independent variables to the variance of the coefficient in a model that contains only the independent variable of interest (Kutner, et al. 2005).

VIF-Test Equation:

$$VIF_i = \frac{1}{1 - R_i^2}$$

R_i^2 = Coefficient of determination of the regression equation

The panel data set does not show the behavior of inflated multicollinearity for the independent variables. The highest VIF score was exhibited by the variable *Year. T*his can be attributed to the fact that *Years* is a factor variable. Factor variables usually portray higher levels of multicollinearity (Kutner, et al. 2005)

Results:

Variable	**Value**
Audit Committee Meetings	1.207959
Board Age Range	1.255791
Board Duration	1.521348
CEO on the Board	1.475876
Dual Class Unequal Voting Rights - Common (Y/N)	1.494061
Executive Compensation Linked to ESG	1.353917
Percentage of Board Members that are Women	1.652673
Percentage of Independent Directors	1.344985
Total Salaries Paid to CEO and Equivalent	1.710221
Total Bonuses Paid to Executives	1.493698
Years	2.095440

Figure 5: VIF-Test Results

The verification of the underlying assumptions of the REM model has been substantiated by applying the appropriate test statistics, indicating that this statistical tool is fit to test the hypothesis of this study. In the subsequent chapter, the outcomes derived from the Random Effects Model are subjected to investigation, analysis, and interpretation.

4 Analysis and Discussion of Results

This scholarly article explores the potential impact of governance practices on the corresponding stock performance of a corporation. As previously outlined, literature generally focuses on the influence of governance ratings and stock performance across markets, geographies, and industries. This research aims to address scarcities in the literature by analyzing the impact of governance practices of the German DAX40 members on their respective performance. The intended result of the research delineated in this paper is to augment prior conducted research, associating governance and stock market performance to furnish auxiliary input for investment strategies for investors and highlight focal areas for corporate entities.

The companies considered in this research paper exhibit a degree of disparity in their focus on governance and publication standards. The average observation (company x in year y) carries 12.38 of the 14.00 variables. Thus, it is evident that specific observations influence the total research outcome more than others.

4.1 Autocorrelation Analysis

Autocorrelation refers to the degree of correlation a variable in a data set exhibits with a lagging version of itself within a given period. Therefore, it is crucial to analyze the autocorrelation of panel data to identify recurring trends over time (Chatfield 2004). Autocorrelation ranges between -1 to 1.

For the consideration of the independent variables in the constraints of the Random Effects Model, it is paramount to consider the following outcomes of the autocorrelation analysis:

1. The analysis should only consider variables that exhibit correlation coefficients on the dependent variable greater than zero. This is paramount for a meaningful evaluation of the dataset, as only variables that exhibit a significant impact on the dependent variable may add valuable results (Dormann 2013, 27-46).
2. Considering variables in the analysis with low or no correlation with the dependent variable may create random noise in the regression, leading to potentially misleading results and false conclusions (Taylor 2019).
3. The analysis should not consider explanatory variables that exhibit traits of linearity, ergo correlation coefficients above 0.7, as such variables fail to provide unique and independent input on the response (O'Brien 2007, 673-690). Multicollinearity has been checked with the VIF-Test (O'Brien 2007, 673-690). No considered variables exhibit the behavior of multicollinearity.

Considering the correlation matrix that resulted from the analysis, the overall correlation between the variables is moderate. The overall correlation ranges between -0.36262 and 0.51589 (Appendix D).

For further analysis of the impact of the explanatory variables on the dependent variable stock market performance, it has been decided to consider only variables that exhibit correlation coefficients above 0.05 and below -0.05, featuring no behavior of multicollinearity ($-0.07<x<0.07$).

Therefore, the following variables have been considered for the Random Effects Model:

Variable	**Correlation Coefficient**
Audit Committee Meetings	-0.1063620
Board Age Range	-0.0525489
Board Duration	-0.0842355
CEO on the Board	0.1530606

Dual Class Unequal Voting Rights - Common (Y/N)	-0.1446208
Executive Compensation Linked to ESG	-0.0620939
Percentage of Board Members that are Women	-0.1068657
Percentage of Independent Directors	0.0712569
Total Salaries Paid to CEO and Equivalent	-0.1617160
Total Bonuses Paid to Executives	-0.1886009
Years	-0.1403580

Figure 6: Correlation Coefficients of the Explanatory Variables on Stock Performance

4.2 Regression Results

This paper tests the null hypothesis of whether governance covenants of the DAX40 companies impact their stock price by applying the Random Effects Model to the data set. The respective methodology has been reviewed in Chapter 3.

Summary of Results

Methodology:	REM		
Date:	Mon, 08, May 2023		
Time:	12:53:09		
Panel Type:	Unbalanced	Chi-Square	0.00056848
Total Sum of Squares:	14.424	Residual Mean:	-0.00023
R-Square:	0.25988	Theta Mean:	0.25430
Adjusted R-Square	0.15415		

Coefficients:	Estimate	Std. Error	z-value	Pr(>|z|)
(Intercept)	0.4259	0.3244	1.3128	0.1892
Exec_Compensation_Linked_to_ESG	-0.0025	0.0664	-0.0386	0.9692
Percent_of_BM_Women	0.0016	0.0042	0.3825	0.7021
CEO_on_the_Board	0.1691	0.1443	1.1720	0.2411
Board_Age_Range	-0.0019	0.0050	-0.3868	0.6989
Percent_Independent_Directors	-0.0003	0.0012	-0.2601	0.7947
Board_Duration	-0.0034	0.0271	-0.1279	0.8982
sal_CEO	-0.0217	0.0506	-0.4302	0.6670
bonus_paid	-0.0056	0.0052	-1.0743	0.2826
Dual_Class_Unequal_Voting	0.0012	0.0802	0.0158	0.9873
Audit_Committee_Meetings	-0.0365	0.0194	-1.8803	0.0600*

*Significance Code: ***p<0.01, **p<0.05, *p<0.1*

Figure 7: Random Effects Regression Results

As previously discussed in Chapter 3, the Random Effects Model passes all statistical test assumptions. It does not show multicollinearity, heteroscedasticity, or autocorrelation. It

also presents the behavior of normality, even though the histogram exhibits broad tails, a typical characteristic of stock market data. It considers the impact of different years as separate factors, accounting for macroeconomic trends, thus increasing robustness. Additionally, the unitary significance results of the independent variables indicate that the model is not overfitting the data. Overfitting occurs when the model is too closely fitted to a limited set of data points and therefore will not be reliable under unforeseen circumstances.

The outcomes derived from the REM analysis indicate that, after accounting for autocorrelation, none of the ten independent variables considered exhibit a statistically significant impact on the dependent variable stock market performance at an alpha of 0.05.

It is important to remember that non-significant results do not imply that these values are not crucial for the stock market performance of the respective company but merely that an impact may not be statistically verified at an alpha level of 0.05. Specific values may exert a non-linear or a hurdle effect on stock market performance or may necessitate to be fitted with other covenants to inflict their impact statistically (Wooldridge 2010). This may indicate that the relationship between the chosen independent variables and their related stock market performance may be more complex than a linear model of this size can capture. Significantly increasing the observation duration may yield different findings.

Additionally, the general nature of the German stock market needs to be considered. Historically, Germany is a stock market controlled by its stakeholders, including banks, founding families and employee representatives, which focus their Corporate Governance efforts on maximizing long-term stakeholder value rather than shareholder value. Additionally, the private investor base in Germany historically exhibits relatively low degrees of shareholder activism, as outlined in the literature. The diminished need for shareholders to control governance in German companies, a function mainly assumed by other stakeholders, in

combination with the myriad factors influencing the stock market, may have prompted investors to de-emphasize the importance of governance in their investment decision historically. This may have decreased the influence of governance on the equity market in Germany below a statistically detectable threshold on a per-variable basis.

On the other hand, the R-Squared value of 0.26 highlights that the variables in the model are indeed explaining a part of the variation of the model. Twenty-six percent of the stock variation can be explained by the variables employed. This is not an unexpected result considering the nature of the stock market and the multitude of macro- and microeconomic factors influencing it.

Even though it cannot be statistically verified at a significance level of 0.05 that the employed independent variables inflict a statistically relevant impact on stock performance, they offer some insights into factors that may influence stock and the overall performance of a company. The analysis of the individual variables has been focused on the most prominent findings to stay within the constraints of the paper. The *Percentage of Women on the Board* carries a positive coefficient, indicating that a higher proportion of women on the board may positively impact stock performance. This may be due to diversity in decision-making and character traits. *Executive Compensation Linked to ESG* exhibits that linking compensation to ESG may not necessarily result in better stock performance, potentially driven by the fact that ESG initiatives may yield returns only over a more extended period or in the potential case of Germany that the market has yet to understand the importance of such measures. *Total Salaries Paid to CEO* and *Equivalent Total Bonuses Paid to Executives* negatively affect stock performance. Meaning if the bonus and salary of executives increase, the stock performance decreases. This highlights the inefficiency in companies' payment and incentive structures and outlines that companies with weak governance systems may pay higher salaries (Lucian, Martijn and Urs 2012). The number of *Audit Committee Meetings* also negatively impacts stock

performance since board audit meetings are more frequent in times of financial distress. With a p-value of 0.06 in the Random Effects Model, the variable can be considered significant at an alpha of 0.1, and the significance of the relationship may increase with a bigger sample size.

The theta value provided by the Random Effects Model ranged between 0.06 and 0.32 with a mean of 0.25, suggesting that the data sets exhibit a substantial variation between companies, thus underlining the importance of integrating company-specific effects such as business model, geographics, and customer loyalty when studying governance and stock market fluctuations. This goes in line with the disparity of governance's impact on the company's stock performance identified by the literature (Rogers and van der Laan Smith 2020, 155-176)

In conclusion, it can be stated that even though the employed independent variables in the Random Effects Model do not present a statistically relevant impact on stock performance at a p-value of 0.05, the considered data explains 26% of the stock price fluctuations allowing for some degree of indication. Nevertheless, it is impossible to reject this paper's null hypothesis merely based on the analysis results. The findings suggest that governance may impact stock performance; however, it cannot be statistically proven for the employed data set of the DAX40 between 2014 to 2022. The findings do not indicate that Corporate Governance is not important for the long-term success of a company in Germany but merely portray that shareholders historically were not willing to specifically pay a premium or penalize German companies' stock based on their Corporate Governance performace. These may be connected to the fact that the German capital markets were predominantly controlled by their stakeholders' alleviating shareholders of the duty to control a company's Corporate Governance. In other words, strong stakeholder focus, a well-balanced legal system, good company control measures and a unique shareholder structure may reduce the prominence of governance for investors in Germany. Consequently, this limited the comprehensive understanding of the importance of such measures for investors, resulting in diminished representation in the investment decision-

making process. Additionally, it is essential to acknowledge that historically accessing information on the company's governance posed significant hurdles. The publication of rankings and comprehensive governance statements by companies and ranking institutes is a relatively recent development compared to the longstanding practice of equity trading. Therefore, investors may yet not have fully incorporated Corporate Governance to the degree necessary in their investment decision-making process in a market such as Germany, where the topic of governance historically lacked prominence.

However, considering how the capital market in Germany evolved in recent years, decreasing banks' influence, and disrupting family-owned business structures while increasing (Schmidt 2003) shareholder awareness of governance through various scandals (Fockenbrock and Kewes 2020) and multifaceted literature, it is plausible that governance increases in importance for future investment decision-making of investors. Consequently, this may be facilitated by the increasing number of institutional and international investors entering the German capital markets (Du Plessis, et al. 2007).

4.3 Random Forest Regressor Machine Learning Model

To validate the robustness and complement the previous analysis using the Random Effects Model, it has been decided to re-run the data set using the Random Forest Regressor Machine Learning Model. As discussed in Chapter 3, the Random Forest Regressor Model is a machine learning tool used to assess the feature importance of independent variables in making predictions on the dependent variable. In other words, it helps to identify which independent variables have the most considerable effect on the dependent variable.

The Random Forest Regressor Machine Learning Model has been chosen to validate the findings of the Random Effects Model as it is highly flexible, non-parametric, and presumes an underlying data allocation, which makes it very adaptive to different regressions. Furthermore,

it can handle large data sets and is, due to its nature, less likely to be overfitted, making it a valuable robustness check (Breimann 2001), (Hastie, Tibshirani and Friedman 2009).

The Random Forest Regressor Machine Learning Model portrays a similar picture as the Random Effects Model, indicating that the independent governance covenants employed do not significantly impact the stock performance of the DAX40 members. The Random Forest Regressor Model indicates an R-Squared value of 0.0281, meaning that the employed variables explain about 3% of the stock performance variations of the DAX40 members in the given time span. This can be based on many exogenous and endogenous factors impacting a company's stock market performance, as explained in the previous chapter. In addition, it may indicate that German capital markets must yet fully grasp the importance of such governance covenants to integrate them into their purchasing behavior completely. The difference in the R-Square may result from the Random Forest Regressor Model's machine-learning capabilities, with implies a different methodology for handling data sets (James, et al. 2013).

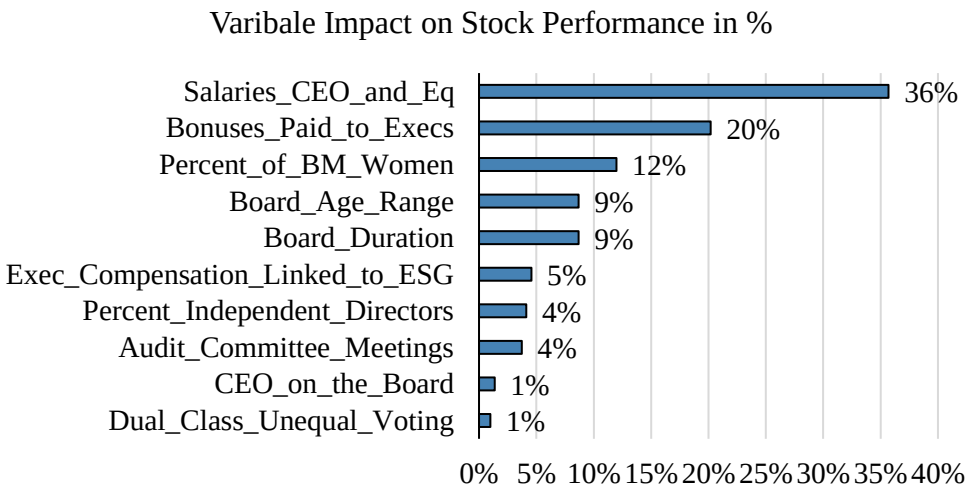

***Figure* 8: Variable *Impact* on Stock Performance in %**

As previously stated, the feature ranking of the Random Forest Regression Machine Learning Model provides a quantified view of which variables are to be considered most important when analyzing stock performance in Germany. The Random Forest Regression

Model does merely indicate the degree of importance of an independent variable for explaining the dependent variable. It does not evaluate whether the impact of the independent variable is negative or positive on the dependent one.

Total *Salaries Paid to the CEO* are considered the most relevant variables for explaining stock market performance, with a factor value of 35.69%. Even though it was not possible to detect a statistically relevant relationship in the REM model it indicates a negative correlation for the data set employed. This finding correlates with the overall literature that proves a significant negative influence of remuneration on stock performance (Tosi, et al. 2000).

Similar behavior is portrayed by the variable *Total Bonuses Paid to Executives*, which carries an impact factor on stock market performance, according to the outputs of the Random Forest Regression Model, of 20.19%. Literature verifies that outcome by stating that increasing bonuses may harm stock performance due to riskier behavior (Becker 1978), which is indicated by the correlation outputs of the REM model as well.

The *Percentage of Women on the Board* impacts the stock market performance by 11.98%, indicating that diversity affects stock market performance for the data set employed. The literature and the output of the Random Effects Model in this paper verify a potential impact of diversity on stock performance by indicating a positive correlation between diversity and stock market performance (Carter, Simkins and Simpson 2003, 33-52).

According to the Random Forest Regressor Model, the remaining independent variables present a decreasing degree of importance. However, it is essential to remember that even less influential features can still contribute to the overall model in the presence or absence of other features.

The Random Forest Regressor provides a valuable robustness check and complements the findings from the Random Effects Model. The Random Forest Regressor Model confirms

the potential impact of certain governance variables in determining stock performance in Germany. However, it also outlines that due to the nature of the market, the usual board structure, and the pursuit of stakeholder interests, governance has historically played a minor role for investors in Germany.

4.4 Comparison of Fixed Effect and Random Effects Model

As previously discussed in Chapter 3, it is necessary when dealing with Effects Models on panel data to run a Hausmann Test to assess whether the Fixed- or Random Effects Model is the appropriate model to be used. The Hausmann Test returned an alpha above 0.05, which allowed us to accept the H_0, implying the REM is the suitable model to apply to the data set.

In order to validate the outcome of the Hausmann Test, it has been decided to re-run the data set using the Fixed Effects Model and compare the findings with the output of the Random Effects Model (Appendix E). It needs to be considered as well that the Hausmann Test merely gives an indication of which model is making the correct assumptions about the data set employed. The Hausmann Test does not assess the predictive power or goodness-of-fit of the respective model, therefore this comparison could yield valuable insights on the goodness-of-fit of the methodology on the data set implied in this paper.

Summary of Results

Methodology:	REM and FEM	
Date:	Thu, 11, May 2023	
Time:	23:48:02	
Coefficients:	Fixed Effects Model	Random Effects Model
Exec_Compensation_Linked_to_ESG	-0.019 (0.097)	-0.003 (0.066)
Percent_of_BM_Women	0.007 (0.006)	0.002 (0.004)
CEO_on_the_Board	n/A	0.169 (0.144)

Board_Age_Range	-0.005 (0.007)	-0.002 (0.005)
Percent_Independent_Directors	-0.001 (0.002)	-0.0003 (0.001)
Board_Duration	0.012 (0.054)	-0.003 (0.027)
sal_CEO	-0.124 (0.106)	-0.022 (0.051)
bonus_paid	-0.004 (0.007)	0.001 (0.080)
Dual_Class_Unequal_Voting	0.007 (0.218)	0.001 (0.080)
Audit_Committee_Meetings	-0.071*** (0.026)	-0.37* (0.019)
Observations	145	145
R-Squared	0.296	0.260
Adjusted R-Squared	-0.004	0.154
F-Statistic	2.403***	44.045***

*Significance Code: ***p<0.01, **p<0.05, *p<0.1*

Figure 9: Results of Comparison between FEM and REM

Considering the results of the Fixed Effects Model and comparing them to the Random Effects Model, the overall goodness-of-fit, as well as the predictive power of the Random Effects Model is superior to the Fixed Effects Model. The Random Effects Model carries lower variable individual standard error terms indicating higher efficiency. The adjusted R-Square value is notably elevated, suggesting higher explanatory power. Moreover, the F-Statistic is 22 times higher than in the Fixed Effects Model, implicating a substantially higher statistical significance of the overall model. Therefore, the Random Effects Model is superior in terms of assumption biasedness as well as predictive power.

5 Limitations and Further Research

Using Corporate Governance risk assessments in sustainable finance and business valuation, especially in the context of stock price performance, underscores certain limitations that must be contemplated.

According to McKinsey (2022), ESG and particularly governance need to be measurable to a feasible extent. One limitation is the constrained standardization of Environmental, Social, and Governance risk assessments and variables for companies as well as rating agencies.

1. From a company's publication perspective: Governance scores can often not be measured accurately (McKinsey 2022). Additionally, there is no universally accepted approach to assessing governance risk, and companies may use different techniques and variables to report on their governance performance. As a result, governance risk assessments may be subjective.
2. From a rating and research agency perspective: Some difficulties emerge regarding selecting criteria and how they should be weighted from rating companies. The choice is subjective; likewise, individuals rate the relevance of different governance aspects differently, resulting in overweighting, underweighting, or the non-consideration of variables. This results in many different outcomes for mainstream rating agencies. While the ESG scores of S&P and Moody's are almost 99% correlated, many do not even exhibit a 50% correlation (McKinsey 2022)

The literature may extend the implication of this study by employing multiple governance risk ratings to yield a more comprehensive picture of companies' overall governance practice, including a multisided view from a publication and rating perspective.

The restricted accessibility of governance data in terms of duration and interval poses a formidable challenge to this study. There is an opportunity for incremental research building on a larger sample size to improve observations as well as increase statistical relevance. Additionally, considering monthly governance ratings for the analysis may yield valuable implications of the impact of governance on short-term stock performance. Considering technological advancements, further research could use an artificial intelligence data-gathering tool to increase efficiency.

The methodology in this paper focused on Random- and Fixed Effects Models. Both possess their specific limitations. As the REM presupposes that a common distribution imposes individual effects, it presents certain analytical deficiencies for data sets exhibiting substantial disparities among groups/individuals not captured by a single distribution. Conversely, the FEM assumes the uniqueness of individuals, thereby posing certain limitations in the case when dealing with data sets that are extremely large. Additional scholarly endeavors may build on the methodology applied in this paper by adding a Mixed Effects Model, synthesizing the traits of both the REM and FEM. This approach would allow us to combine the unique individual effect captured by the FEM as well as the common distributional assumption by the REM.

Additionally, the theta value range of the Random Effects Model indicates that the data set exhibits a substantial variation between companies, thus underlining the importance of integrating company-specific effects such as business model, geographics, and customer loyalty when studying governance and stock market fluctuations. This may open the door for additional research using the Random Forest Regressor Machine Learning Model to understand the impact of company-specific variables on stock performance while comparing them to the respective impact of governance variables on stock performance.

Consequently, this study has initiated an exploration into the potential impact of a firm's Corporate Governance performance on its corresponding market performance in Germany. The research findings herein delve into the elucidation of the independent variables. To overcome the limitations inherent in this study, subsequent and complementary research could be performed to substantiate the findings presented herein. Additional research could establish the significance of governance while creating further momentum.

6 Conclusion and Managerial Implications

Corporate Governance has historically been of minor importance in Germany, first emerging around 1990 when the country faced severe economic difficulties (Du Plessis, et al. 2007). Over the previous two decades, the topic has gained increasing traction, propelled by forces of globalization and the vivid illustration of shortcomings in the German Corporate Governance landscape through scandals like the Wirecard fraud (Fockenbrock and Kewes 2020).

Therefore, this article aimed to assess the recent past by evaluating the impact of Corporate Governance on stock performance in Germany. The study employed a Random Effects Model to analyze panel data over nine years. The results revealed that the impact of governance on stock performance in Germany remains limited. The model could explain 26% of the stock price fluctuation within the observation duration. This indicates that Corporate Governance has some degree of impact on stock performance but ultimately portrays that governance still plays a minor role for investors in Germany when estimating the value of a publicly traded company.

Considering that, the results indicate contradictory implications for investors and companies. While the results of the analysis imply that investors may neglect Corporate Governance scores in favor of other metrics, such as financials, leverage, or stakeholder power, for maximizing shareholder value, they do not indicate that companies should neglect such in the pursuit of stakeholder value maximization. The characteristics of the German equity market suggest that historically, the responsibility of enforcing governance oversight in German companies rested primarily with stakeholders, which reduced the prominence and ultimately, the awareness of its importance among German investors. This may have led to the fact that the impact of governance on German equity markets was not statistically detectable in the analysis.

Governance can influence the company's reputation, stakeholder trust, and long-term success. To do that, stakeholders need to focus on governance measures that monitor, control, and provide transparency and accountability to the company. Embracing technology and digital tools such as board portals, collaboration platforms, and analytical tools may facilitate effective Corporate Governance.

In light of the research findings, stakeholders must flexibly adapt to dynamic market conditions. This adaptability includes using real-time data for informed decision-making and creating flexible governance structures that meet stake- and shareholders' diverse needs and expectations. In other words, to effectively manage the complex factors that influence stock performance, management and stakeholders must employ data-driven decision-making and adaptive governance structures while responding to unique market dynamics.

Considering that the results of the methodology indicated a strong variation between company type, industry, and other endogenous and exogenous factors, it is paramount for investors as well as companies to evaluate the impact of Corporate Governance on companies' stock performance by considering the individuality of the asset. No uniform solution fits every company, as no company is the same (Lawrence 1967, 1-47).

This research article's ultimate objective was to complement the current literature on governance and stock performance in Germany. This paper raises awareness governance for companies and investors, provides investors with valuable input for educated investment decision-making, and opens the foundation for subsequent research in this field. Ultimately the research indicated that investors in Germany were historically not willing to pay premiums for companies featuring best-in-class governance. Time will tell if scandals like the Wirecard Fraud, changing shareholder dynamics in Germany and growing worldwide consensus on the importance of governance may change the investors' approach.

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Appendix

Appendix A: Random Regression Model in R

---	
title: "Random Effects Model Code"	
output: html_document	
date: "09-05-2023"	
---	
1)	```{r setup, include=FALSE} #Load the necessary packages. install.packages("car") library(plm) library(tidyverse) library(skimr) library(stargazer) library(ggcorrplot) library(kableExtra) library(car) ```
Pre-processing of the data. To be able to input a new csv to test you need: 1. Remove everything that says "NA" 2. Remove spaces from headers 3. Change the commas (,) to dots (.) 4. Remove the percentages (%) 5. Remove the (-) 6. Export as a CSV file	
3)	```{r cars} #Upload the data sample. tb.dax <- read_delim("data10.csv", delim = ";") #Adjustments required for R to work properly. R needs small number to increase the quality of output. tb.dax<-tb.dax%>%mutate(stock = Stock_Performance/100, sal_CEO = Salaries_CEO_and_Eq/ 1000000, bonus_paid = Bonuses_Paid_to_Execs/ 1000000) tb.dax<-tb.dax%>%select(-Stock_Performance, -Salaries_CEO_and_Eq, -Bonuses_Paid_to_Execs) ```
4)	```{r} skim(tb.dax%>%drop_na()) ```ä
5)	```{r} #Creation of a Histogram for Normality check.

	#Install and load the 'ggplot2' package. if (!requireNamespace("ggplot2", quietly = TRUE)) { install.packages("ggplot2") } library(ggplot2) #Histogram. histrogram_plot <-ggplot(tb.dax, aes(x = stock)) + geom_histogram(fill = "steelblue", color = "black", bins = 60, alpha = 0.8) + theme_minimal() + labs(title = "Histogram of Stock", x = "Stock", y = "Frequency") + theme(plot.title = element_text(hjust = 0.5)) #Save the plot as an image. ggsave("histogram_plot.png", histrogram_plot, width = 10, height = 10, dpi = 300) #Print the plot. print(histrogram_plot) ```
6)	```{r} #Calculate descriptive statistics. mean_stock <- mean(tb.dax$stock, na.rm = TRUE) * 100 median_stock <- median(tb.dax$stock, na.rm = TRUE) * 100 sd_stock <- sd(tb.dax$stock, na.rm = TRUE) * 100 min_stock <- min(tb.dax$stock, na.rm = TRUE) * 100 max_stock <- max(tb.dax$stock, na.rm = TRUE) * 100 #Create a summary table. summary_table <- data.frame(Statistic = c("Mean", "Median", "Standard Deviation", "Minimum", "Maximum"), Value = c(mean_stock, median_stock, sd_stock, min_stock, max_stock)) #Format the value column as percentage. summary_table$Value <- sprintf("%.2f%%", summary_table$Value) #Display the summary table. summary_table ```
7)	```{r} #Dropping n/A rows. my_cor_matrix <- cor(tb.dax%>%drop_na()%>% select_if(is.numeric)%>%select(stock, everything()))

	library(ggplot2) library(ggcorrplot) library(RColorBrewer) #Create a correlation plot using 'ggcorrplot'. my_plot <- ggcorrplot(my_cor_matrix, type = "lower", hc.order = TRUE, outline.color = "white", colors = brewer.pal(-2, "RdGy"), #Using a more contrasting color palette title = "Correlation Matrix", ggtheme = ggplot2::theme_gray(base_size = 14)) + theme(plot.title = element_text(hjust = 0.5, size = 16, face = "bold")) #Save the plot as an image. ggsave("correlation_matrix_plot.png", my_plot, width = 10, height = 10, dpi = 300) #Print plot. print(my_plot) ```
8)	```{r} my_cor_matrix[upper.tri(my_cor_matrix)] <- NA print(my_cor_matrix, na.print = "")%>%kable() ```
9)	```{r pressure, echo=FALSE} #Create a panel data object. pdata <- pdata.frame(tb.dax%>%drop_na(), index = c('Company', 'Years')) ```
#Methodology: Using a Random Effects Regression with time dummies to estimate relationship between the target variable and the independent variables. This allows to control for time invariant unobserved factors that may affect the target variable. The time dummies are included in the model to account for time-specific effects that affect all individuals in the panel equally. This approach allows for the identification of the causal effect of the independent variables on the dependent variable by controlling for time-invariant unobserved factors and time-specific effects.	
10)	```{r pressure, echo=FALSE} #Run the Random Effects Regression with time dummies - with all the variables that have some kind of correlation to the target variable. In this case 5% correlation have been considered as sufficient. model <- pdata%>%plm(stock ~ Exec_Compensation_Linked_to_ESG + Percent_of_BM_Women + CEO_on_the_Board + Board_Age_Range + Percent_Independent_Directors + Board_Duration + sal_CEO + bonus_paid + Dual_Class_Unequal_Voting + Audit_Committee_Meetings + factor(Years) , data = ., index = c('Company'), model = "random") summary(model)

	``
11)	```{r} #Run the Fixed Effects Regression with time dummies. model_FIXED <- pdata%>%plm(stock ~ Exec_Compensation_Linked_to_ESG + Percent_of_BM_Women + CEO_on_the_Board + Board_Age_Range + Percent_Independent_Directors + Board_Duration + sal_CEO + bonus_paid + Dual_Class_Unequal_Voting + Audit_Committee_Meetings + factor(Years), data = ., index = c('entity_variable'), model = "within") #Run the Random Effects Regression with time dummies. model_RANDOM <-pdata%>%plm(stock ~ Exec_Compensation_Linked_to_ESG + Percent_of_BM_Women + CEO_on_the_Board +Board_Age_Range + Percent_Independent_Directors + Board_Duration + sal_CEO + bonus_paid + Dual_Class_Unequal_Voting + Audit_Committee_Meetings + factor(Years), data = ., index = c('entity_variable'), model = "random") summary(model_FIXED) ```
12)	```{r} #Verification whether Fixed or Random Effects Model is appropriate for the data employed data set. hausman_test <- phtest(model_FIXED,model_RANDOM) hausman_test #P-value > 0.05 = Random Effects Model #P-value < 0.05 = Fixed Effects Model ```
13)	```{r} #View the results - Fixed Effects vs. Random Effets. stargazer(model_FIXED, model_RANDOM, type = 'text', omit = 'Years') ```
14)	```{r} #Ensuring assumptions of regression analysis are met - Checking for serial correlation (autocorrelation) to guarantee that estimates are reliable and that the independent variables are not correlated. library(lmtest) bg_test <- bgtest(model) bg_test #P-value > 0.05, therefore H_0can be accepted, stating there is no serial correlation. ```
15)	```{r} #Ensuring assumptions of regression analysis are met: Checking for heteroskedastiticity to guarantee that estimates are reliable. library(lmtest) bp_test <- bptest(model) bp_test #P-value > 0.05, therefore H_0 can be accepted, meaning there is no heteroskedasticitiy. ```
16)	```{r} #VIF-Test: Checking for multicollinearity in the data set. vif(model_RANDOM)

	#Factor is 1 meaning no problem with multicollinearity in the independent variables. Year will always present higher degree of multicollinearity as it is a factor. ```

Appendix B: Python Code for Random Forest Regression Model

1)	#Import data modelling tools import openpyxl as openpyxl import pandas as pd import numpy as np import matplotlib.pyplot as plt #Import Statsmodels from statsmodels.tsa.api import VAR from statsmodels.tsa.stattools import adfuller from statsmodels.tools.eval_measures import rmse, aic
2)	#Import the sample data import pandas as pd filepath = r'C:\Users\User\OneDrive\Documents\Univeristy\1.2. Master_NovaSBE\1.5. Master Thesis\Data\R Model Final\data10_phyton.xlsx' sheet_name = 'data10' #Read the Excel file without parsing dates df = pd.read_excel(filepath, sheet_name=sheet_name) #Print the column names print("Column names in the dataset:") print(df.columns)
3)	#Running and implementing the Random Forest Regressor Model import numpy as np import pandas as pd from sklearn.ensemble import RandomForestRegressor from sklearn.model_selection import train_test_split, GridSearchCV from sklearn.metrics import mean_squared_error, r2_score import matplotlib.pyplot as plt #Assuming 'Stock_Returns' is the column representing stock performance target = 'Stock_Performance' #Prepare the dataset X = df.drop(target, axis=1) Y = df[target]

```
#Fill missing values with the mean of each column
X = X.apply(lambda x: x.fillna(x.mean()), axis=0)

#Replace positive and negative infinity with the largest finite positive/negative
values
X = X.replace([np.inf, -np.inf], [np.finfo(np.float32).max,
np.finfo(np.float32).min])

#Split the dataset into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
random_state=42)

param_grid = {
    'n_estimators': [100, 200, 300],
    'max_depth': [None, 5, 10],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}

#Create the Random Forest Regressor
rf = RandomForestRegressor(random_state=42)

#Perform grid search
grid_search = GridSearchCV(estimator=rf, param_grid=param_grid,
scoring='neg_mean_squared_error', cv=5)
grid_search.fit(X_train, y_train)

#Get the best model
best_model = grid_search.best_estimator_

#Make predictions on the test set using the best model
y_pred = best_model.predict(X_test)

#Evaluate the model
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)
print("Mean Squared Error:", mse)
print("R-squared:", r2)

#Analyze feature importances
importances = best_model.feature_importances_
indices = np.argsort(importances)[::-1]

#Print the feature ranking
print("Feature ranking:")
for f in range(X.shape[1]):
    print(f"{f + 1}. {X.columns[indices[f]]} ({importances[indices[f]]:.4f})")

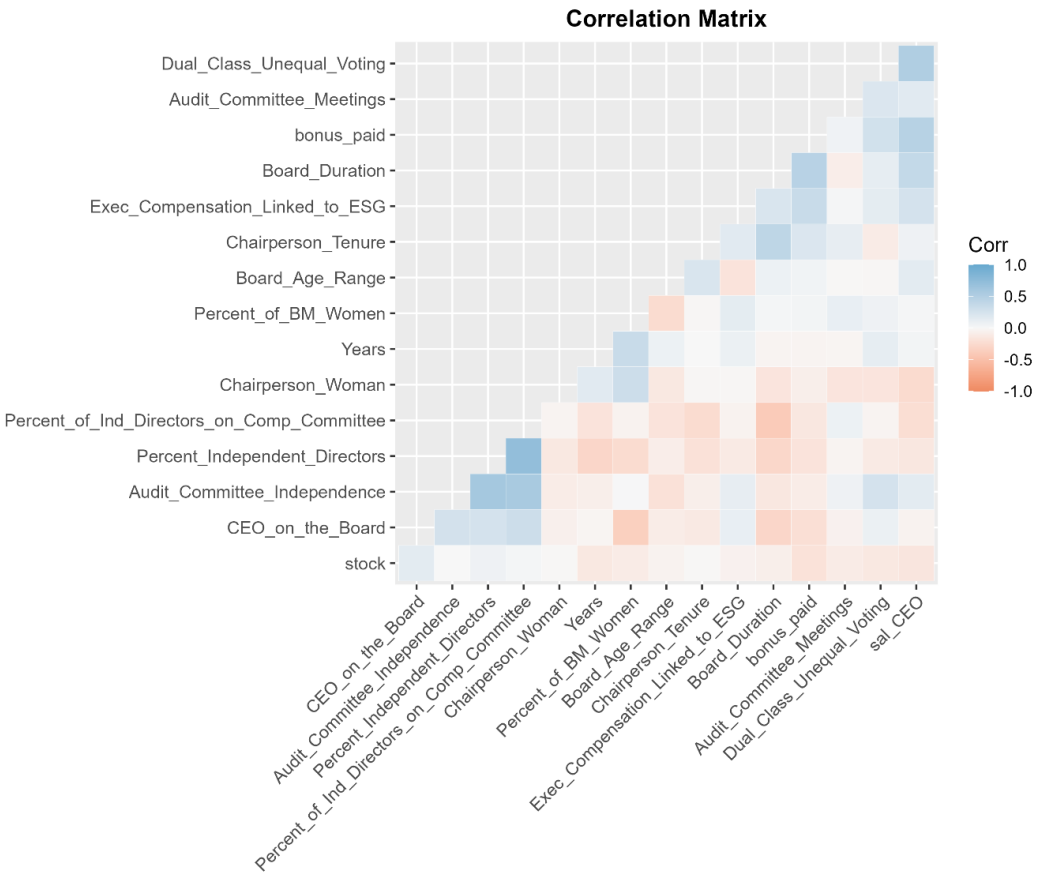
#Plot the feature importances
plt.figure()
```

```
plt.title("Feature Importances")
plt.bar(range(X.shape[1]), importances[indices], align='center')
plt.xticks(range(X.shape[1]), X.columns[indices], rotation=90)
plt.xlim([-1, X.shape[1]])
plt.show()
```

Appendix C: Statistic Evaluation on Stock Performance

Statistics <chr>	Value <chr>
Mean	10.44%
Median	5.40%
Standard Deviation	39.57%
Minimum	-100.00%
Maximum	257.70%

Appendix D: Correlation Matrix



Appendix E: Regression Output Fixed Effects Model

Summary of Regression Results

Method:	FEM		
Date:	Wed, 11, May 2023		
Time:	23:43:00		
Panel Type:	Unbalanced	Chi-square:	0.0025338
Total Sum of Squares:	11.724	Total Sum of Squares:	8.2586
R-Square:	0.2956		
Adjusted R-Square	-0.0042997		

Coefficients:	Estimate	Std. Error	z-value	Pr(>|z|)
Exec_Compensation_Linked_to_ESG	-0.0190	0.0973	-0.1961	0.8448
Percent_of_BM_Women	0.0072	0.0060	1.1966	0.8448
CEO_on_the_Board	n/A	n/A	n/A	n/A
Board_Age_Range	-0.0054	0.0067	-0.8074	0.4213
Percent_Independent_Directors	-0.0008	0.0021	-0.4167	0.6777
Board_Duration	0.0119	0.0544	0.2199	0.8263
sal_CEO	-0.1239	0.1063	-1.1648	0.2468
bonus_paid	-0.0041	0.0069	-0.5993	0.5502
Dual_Class_Unequal_Voting	0.0066	0.2176	0.0303	0.9758
Audit_Committee_Meetings	-0.0705	0.0256	-2.7475	0.0071**

*Significance Code: ***p<0.01, **p<0.05, *p<0.1*

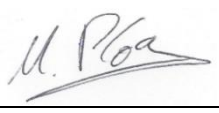
Declaration of Authorship of an Academic Paper

We hereby declare that we have written this paper by ourselves and used no other sources or resources than those indicated, have clearly marked verbatim quotations as such, and clearly indicated the source of all paraphrased references, and have observed the General Study and Examination Regulations of Nova School of Business and Economics.

Neither this paper nor any part of this paper is a part of any other material presented for examination at this or any other institution.

Lisbon, May 17, 2023

Ben Julius Völter



Moritz Plog