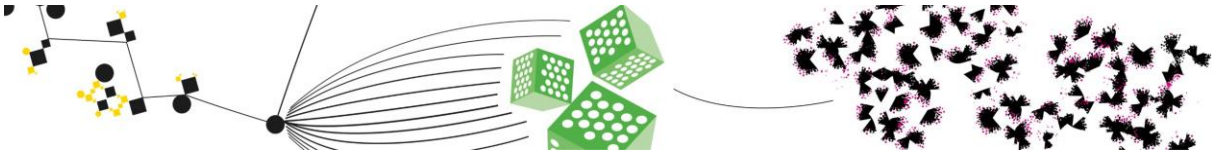

Master Thesis

The impact of board characteristics on firm performance in Germany

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Acknowledgements

This thesis is the last assignment to finalize the Master of Science in Business Administration with the specialization track Financial Management at the University of Twente.

I would like to thank my family for their support during my study. I also would like to thank my supervisors for their help during the process of the thesis.

Emre Kazan

March, 2022

Abstract

This study examines the impact of board characteristics on firm performance for German listed firms. Previous literature presents different findings on the impact of board characteristics on firm performance. Four important theories, namely the agency theory, stewardship theory, resource dependence theory and human capital theory are described. Three main board characteristics are analyzed, namely board size, independence and gender diversity. Performance is measured based on two accounting-based (ROA and ROE) and a market-based measure (Tobin's Q). The relationship between the board characteristics and firm performance is tested by conducting an OLS regression analysis, using data from a sample of 89 German firms from the Frankfurt Stock Exchange for the period of 2017 to 2019. The results show a negative significant relationship between board size and firm performance. There is a negative significant relationship between board independence and the accounting-based measures, whereas the relationship with Tobin's Q is significant and positive. Gender diversity has no significant impact on ROA and ROE, and a significant negative impact on Tobin's Q.

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1. Introduction

There are several key factors playing a role in the success of a firm and good corporate governance is a major one of them. Corporate governance is important because it deals with the procedures and processes according to which firms are directed and controlled by the board of directors, the CEO and management (Martinez and Alvarez, 2019). Research shows that firms with good corporate governance have better performance compared to firms with poor corporate governance (Makhlouf, Laili, Basah and Ramli, 2017; Kao, Hodgkinson and Jaafar, 2019). Being such an important element for firm success, corporate governance and its mechanisms have been the focus point of many studies. An important mechanism that ensures good corporate governance is the board of directors of a firm.

The board of directors is assigned to take on crucial tasks concerning the firm. They are responsible for guiding and authorizing the firm's strategic decisions, including mergers and acquisitions, capital structures, and hiring or firing executives (Terjesen, Couto and Francisco, 2016). In turn, these issues have an impact on the firm's financial performance. In addition, Martinez and Alvarez (2019) describe that the board of directors is a highly effective corporate governance mechanism because it fulfills two important functions, namely the supervision of executive management while representing the shareholders, and providing business resources. It is their responsibility to monitor firm performance and the behavior of executive managers.

The separation between management and owners is the most interesting and popular issue to pay attention to. The possible conflicts of interest that may arise from this separation are referred to as the agency problem (Kao et al., 2019; Martinez and Alvarez, 2019). According to the agency theory, the board of directors is an essential element and acts as a control mechanism to ensure that the problems resulting from the principal and agent relationship are controlled (Martinez and Alvarez, 2019). For the shareholders and investors of a firm the board of directors are a sort of insurance, because their task is to align the interests of managers with those shareholders who are not managing the firm directly (Martin and Herrero, 2018).

Interest in board of directors has been increasing in recent years due to corporate fraud, scandals in multinationals and negligence of shareholders (Martinez and Alvarez, 2019; Terjesen et al., 2016). Previous literature present different findings on the topic, which is understandable since governance can differ from country to country. Therefore it is even more interesting to do research on this topic with a specific focus country. In this study the focus will be on three major board characteristics: the size, independence and gender diversity. Discussions on the ideal board size and the impact of independence have been very important for firms and research over the years and the ideas have been mixed. Gender diversity has especially been a focus point in recent years in literature and society. Unlike most other studies, this paper will thus include three different board characteristics and do research to their impact on firm performance. Different from other studies, in this research there will be accounting-based and market-based performance measures. Including multiple performance measures will make the results of this study more valuable, and form a more clear idea in practice for firms.

The focus in this study will be on German listed firms. Germany is the largest economy in Europe and the results of this research can present an idea whether the board of directors has an impact on the performance of German listed firms. Different from other countries, Germany has a two-tier board structure which will make it interesting to analyze. A two-tier board structure is divided in a management board and a supervisory board. Another factor that separates Germany from other countries is codetermination on the supervisory board, which makes relations on German boards even more complex and interesting to study. Many previous studies focus on countries with a one-tier board, or studies on Germany tend to choose either the management or supervisory board to do research on. This study will analyze both the management and supervisory board of German firms and present new and valuable findings on the topic from an important European country with a different structure and law. Another important factor separating this study from most German studies is the in 2016 introduced gender quota that is applicable for German supervisory boards. Results in this study are valuable in this sense since the gender quota is quite recent and many previous studies do not present the effects of it on firm performance. Findings in this study can act as an example for future research in the field of board of directors for firms adapting a two-tier structure, making this study very interesting. This leads to the research question of this study:

What is the impact of the board of directors' characteristics on the firm performance of firms listed in Germany?

The main objective of this study is to find an answer to the research question, thereby contributing to the literature written on this topic. In addition to contributing to literature, the findings can be valuable in practice as well.

1.1. Outline of the Study

The remainder of this study consists of six chapters where subsections are also included. Chapter 2 is the literature review where four main theories are presented in the theoretical perspectives. Next to this, Chapter 2 describes the board of directors, presents the German board structure with the separation between the management and supervisory board. The three main board characteristics of this study and their implementation in German boards are explained in this chapter as well. Chapter 2 concludes with empirical findings from previous studies and hypotheses development based on the theories and empirical findings. Chapter 3 describes the research methodology. First, several models from comparable studies are explained, then the model for this study is formed. This chapter ends with defining the dependent, independent and control variables and their measurements. Chapter 4 presents the sample and data collection process of this study, and it describes the industry classification of the sample firms. Chapter 5 presents the results of the research. First the descriptive statistics are describes, followed by the correlation analysis and multicollinearity test. The chapters end with an analysis on the regression results. Finally, Chapter 6 gives the conclusion of the study and in Chapter 7 the limitations and recommendations are described.

2. Literature Review

This section of the paper presents the literature review and is divided in six subsections. First the theoretical perspective is presented, which includes four important theories on the topic. Then, there is a description on the board of directors and the German board structure is explained. The chapter continues with the three board characteristics and their implementation in German boards. Subsection 5 presents the empirical findings from previous studies. This chapter ends with a hypotheses development, where the theoretical perspectives and empirical findings are referred to in forming hypotheses.

2.1. Theoretical Perspectives

This chapter will further describe four important theories, namely the agency theory, stewardship theory, resource dependence theory and human capital theory. These theories are commonly used throughout literature on the topic of board of characteristics. They help in understanding the principal and agent relationship in corporate governance. In addition, these theories describe how individuals can be valuable and beneficial for firms.

2.1.1. Agency theory

The most important and most used theory in studies regarding corporate governance is the agency theory. The core of the agency theory is the separation between ownership and control and explaining the fundamentals of the relationship between the two parties in the firm (Martinez and Alvarez, 2019). The two parties are commonly referred to as the principal and the agent, and the agency theory can help understand the potential problems that arise between these two parties. The principal are the owners and shareholders of a firm and the agent stands for the managers who are hired by the owners. The problems between these parties arise when the principal employs the agent to create value for the firm (Bosse and Phillips, 2016). Hereby, the main goal of the principal is to maximize firm value and performance, and therefore this task is delegated to the agent (Martinez and Alvarez, 2019). By delegating the task to the agent, the principal demands the agent to work in the benefit of the owners (Panda and Leepsa, 2017).

However, in reality the managers are more interested in their own compensation and interests. The opposite goals and interests of the principal and the agent define the agency problem, which eventually results in agency costs for the firm (Panda and Leepsa, 2017). Besides the divergent interests, Bosse and Phillips (2016) add another factor that cause problems, namely that the agent has better information than the principal often referred to as information asymmetry. These conditions create the possibility that the agent will not act in the best interests of the principal, resulting in poor firm performance. By addressing the problems between the principal and the agent using the agency theory, it is possible to find solutions and reduce these problems. This theory can be helpful in implementing governance mechanisms to control, supervise and monitor managers (Panda and Leepsa, 2017). With a proper governance system the agency conflict can be minimized and eventually result in reduced agency costs.

Hereby, the board of directors plays an important role because the board is considered as an institution to mitigate agency problems between the owners and the managers (Kao et al., 2019). According to agency theory, the board of directors is an essential element of the

control mechanism to ensure that problems resulting from the principal and agent relationship are controlled (Martinez and Alvarez, 2019). The board is responsible to present governance that maximizes the firm's outcomes by aligning owner and manager interests and minimizing agency costs (Bosse and Phillips, 2016). The board of directors acts as an internal governance mechanism by speaking with managers and monitoring them on behalf of the owners (Bosse and Phillips, 2016; Kao et al., 2019). The main objective is to reduce the agency problem between owners and managers and improve firm performance.

2.1.2. Stewardship Theory

Stewardship theory is commonly used as an alternative and complementary approach when focusing on the principal and agent relationship. This theory emphasizes on cooperation and collaboration, and provides a non-economic premise for explaining principal and agent relationships (Keay, 2017). The theory describes that the managers act as stewards for the company they work for. Contrary to the agency theory, stewardship theory assumes that managers do not behave selfish and act on the best interest of the principal (Schillemans and Bjurstrom, 2020). Keay (2017) describes that the agent who acts a steward will not be concerned about their own economic interests, but will act in the best interests of their company, this approach will eventually lead to a better firm performance and in turn the personal interests of the manager are also fulfilled. Thus, stewardship theory points out the idea of service for others and not self-interest where non-financial factors such as intrinsic satisfaction from achievement, respect, reputation and trust are key factors for the managers (Duru et al., 2016; Keay, 2017).

Alignment of principal and agent interests is also important in the stewardship theory, but this theory assumes that interests are already aligned. The managers already work towards the objectives of their principal, and they are viewed as loyal to the company (Keay, 2017). The composition, structure and characteristics of the board of directors is used as an important indicator of stewardship (Schillemans and Bjorstrom, 2020). Contrary to the roles of the board of directors with the agency theory, the primary function of the board in the stewardship theory is to lend support, give advice and share experience with managers (Glinkowska and Kaczmarek, 2015). Thus, the board does not focus on aligning principal and agent interests but rather on facilitative and empowering structures within the firm (Donaldson and Davis, 1991). This theory is very helpful in analyzing the board of directors, their expected functions and how they handle their relationships with managers. A common example for this theory on boards is that it assumes that insider dominated boards will boost firm performance (Ramdani and Witteloostuijn, 2010).

2.1.3. Resource Dependence Theory

The key perspective in resource dependence theory is considering the role of external resources needed by the firm and how these affect firm behavior (Terjesen et al., 2016). This theory explains the organizational behavior in terms of those critical external resources a firm must have in order to function and create value. The resource dependence theory assumes that dependence on critical and important resources influences the actions of organizations and that organizational decisions and actions can be explained depending on the particular dependence situation (Nienhuser, 2008). Therefore, the core of this theory is thus the flow of resources between firms (Johnson, 1995). In order to form an organization

providing the critical external resources, an effective corporate system is needed, resulting in a better firm performance.

The role of the board of directors is very important in this aspect of the resource dependence theory. According to Martinez and Alvarez (2019) the board of directors help firms improve their performance by reducing their dependence on the external environment. Resource dependency theory describes that boards have to be considered as an asset to the firm since they are providers of resources that are not otherwise available (Pugliese, Minichilli and Zattoni, 2014). The board is also able to adjust their behavior to the needs of the firm, hereby securing access to valuable resources and supporting the managers in making decisions about future directions aiming to increase firm performance (Pugliese et al., 2014). This makes the board of directors an essential link between the firm and the required external resources to maximize performance (Martinez and Alvarez, 2019).

Resource dependence theory is also important in the sense that it affects the composition, size and different characteristics of the board of directors. It suggests for example that a larger board can provide access to a wider range of resources which influences firm performance positively (Bennouri et al., 2018). Terjesen et al. (2016) present another example by explaining that independent directors have access to valuable knowledge and expertise on the firm and therefore are able to expand their firms' boundaries with links to external resources.

2.1.4. Human Capital Theory

Human capital theory focuses on the individual and the qualities he or she has that makes them unique and valuable such as knowledge and personal experience. This theory can be considered as a support for the resource dependence theory because it focuses on what individuals can bring and add to organizations. Human capital is typically developed through investments in education, training and various experiences (Kor, 2008). Hereby, education and experience are considered as the main characteristics of human capital, and the knowledge it brings creates a competitive advantage for the individual (Dimov and Shepherd, 2005). Having these individuals representing the firm makes is a key factor for its performance and can make the difference with competing firms in the market (Dimov and Shepherd, 2005; Gillies, 2015). Human capital theory makes a distinction between skills and knowledge gained from team-level, firm-level and industry-level experiences (Kor, 2008). According to Valenti and Horner (2020) extensive experiences in those specific levels impact decision making and increases the likelihood of positive outcomes.

Human capital theory also states that individuals with more qualities are able to achieve higher performance for their firms (Dimov and Shepherd, 2005). Each board member brings a unique set of human capital. Therefore, it is important for firms to form their boards with individuals who can provide critical resources through their knowledge, expertise and personal experiences (Terjesen, Singh and Vinnicombe, 2008). It is possible to gain a competitive advantage by having these individuals representing the board of the firm, here also lies the link between human capital theory and firm performance (Dimov and Shepherd, 2005). However, it is also important to keep in mind that qualitative aspects of human capital are more important than quantitative aspects, meaning that firms should not solely

focus on attracting as many board members but focus on quality (Dimov and Shepherd, 2005).

2.2. Board of Directors

The board of directors has been the focus point of many studies regarding corporate governance since many years. Throughout these studies, the board of directors has been described as a crucial governance mechanism for firms to implement in order to realize firm success. Studies on the board of directors conclude that the board is the most important and effective internal governance mechanism (Martinez and Alvarez, 2019; Kao et al., 2019; Naciti, 2019). Generally, the board of directors of a firm is the body that determines policies for management and has the ability to make decisions on major company issues. The board of directors is considered necessary, as the separation of corporate control from ownership potentially gives managers space to pursue their own interests, at the expense of the owners of the firm (Bezemer, Peij, de Kruijs and Maassen, 2014). With this, the main responsibility of the board of directors is protecting the interests of the firm's stakeholders through directing operations and supporting the decision-making process (Naciti, 2019). Together with this responsibility, the board of directors are given many authorities within the firm such as hiring and firing executive directors, set CEO compensation, and be involved in financial statements (Bezemer et al., 2014).

Next to the responsibility towards the owners of the firm, according to Martinez and Alvarez (2019) the board of directors has two main functions in companies. These are the supervision of executive management and providing resources to the company. In the supervisory role, the board use their resources to monitor firm performance and the behavior of managers. By conducting the supervisory role in a good way, the board is even able to reduce agency problems between the owners and managers of a firm, which eventually can improve firm performance (Kao et al., 2019). The importance of the supervisory role of the board can also be seen by international scandals involving major organizations where the boards fail or struggle to supervise management in a proper manner (Bezemer et al., 2014). A strong board of directors has shown to reduce agency problems and encourage managers to operate properly and in the best interest of the owners (Naciti, 2019).

The main functions and tasks given to the board of directors make it an interesting topic for previous studies researching the impact of board characteristics on firm performance. Many previous studies describe that several board characteristics have to be analyzed in order to be able to present results whether these have an impact on firm performance or not. Hereby, research is done on the characteristics such as the size of the board, independence of the board, diversity on the board etc., more on this in the next subsections (Naciti, 2019; El-Faitouri, 2014). How the board of directors and the different characteristics are formed also depends on the structure of the board. Since the focus in this study is on German boards, next section describes their structure further in detail.

2.3. German Board Structure

Studies on corporate governance and the board of directors define two different board structures, namely the one-tier and the two-tier structures. In one-tier board structures the

board consists of both executive and non-executive directors, where the decision-management and decision-control are integrated in one organizational body (Bezemer et al., 2014; Bozhinov, Joecks and Scharfenkamp, 2021). This structure is commonly used in countries as the US and the UK. Contrary to the one-tier structure are thus the two-tier boards, which is also the structure used by German firms. Since this thesis focuses on German listed firms, the structure which will be described further in detail will be the two-tier structure used in Germany.

According to the German Stock Corporation Act, it is mandatory for German firms to have the two-tier board structure (Jungmann, 2007). The main idea of two-tier boards is that there is a separation between decision-management and decision-control. In two-tier board structures there is a formal separation between the two roles of the boards. The executive directors who are responsible for the daily operations of the firm are part of the management board, and the non-executive directors who are responsible for the supervision of executive directors are part of the supervisory board (Bezemer et al., 2014). There is a clear divide between the management board and the supervisory board since simultaneous membership on both boards is not permitted (Jungmann, 2007).

2.3.1. The Management Board

The management board thus exists out of executive directors who are being hired, or fired when found necessary, by the members of the supervisory board. Within this two-tier structure, the executive directors in the management board are mainly responsible for the daily operations of the firm and managing and directing the business of the firm (du Plessis, 2004; Fauver and Fuerst, 2006; Block and Gerstner, 2016). They decide about the objectives of the company and implement the necessary measures to achieve those objectives.

Some specific tasks of the management board are described by Block and Gerstner (2016) as follows: providing the strategic direction of the company through careful planning of operations, managing the workforce, controlling the strategic planning of the company and maintaining the books of account. Next to managing the daily operations of the company, the management board also sets long term goals and guidelines. Hereby the main objective is running the business in a way that allows further development and increase financial performance (Jungmann, 2007).

An important aspect to successfully conduct these tasks is the information sharing between the members of the management board, this helps in creating an efficient decision-making process within the management board (Jungmann, 2007). The executive directors on the management board obtain all information that is necessary for their tasks directly from the contact with employees and junior management. This creates an additional task for the management board, which is to minimize the information asymmetry with the supervisory board. Since the management board is able to obtain all information from within the company it is their responsibility to share this with the supervisory board. All important information concerning firm strategy, future projects, business opportunities etc. lies in the hands of the management board (Jungmann, 2007). The management board must not withhold any crucial information from members of the supervisory board.

The management board is able to minimize the information asymmetry with the supervisory board by periodically reporting to them on specific matters (Block and Gerstner, 2016). The reports of the management board must contain all information needed to evaluate their work by including information concerning strategy and future directions (Jungmann, 2007). The specific matters that are important to report on are described by du Plessis (2004) as follows:

- The intended policy of the corporation and fundamental questions regarding the planning of the undertaking, in particular regarding finance and investments
- The profitability of the firm and the return on its own capital
- The performance of businesses and in particular their turnover and the financial state of the firm
- Transactions that are of vital importance for the corporation's profitability

It can be stated that it is important to report all issues regarding planning, business development and risk management. The matters the management board reports on also have specific periods of time in which the reports must be given to the supervisory board, making the flow of information sharing within the company efficient and effective (du Plessis, 2004).

2.3.2. The Supervisory Board

The supervisory board within the two-tier board structure in Germany exists of non-executive directors. Members of the supervisory board usually are appointed during the annual meeting of the company. They can represent several different parties such as shareholders, employees, labor unions etc., and are given responsibilities and authorities to protect the interests of those parties. In Germany, there is an important aspect in forming the supervisory board, referred to as codetermination. With codetermination laws, employees are given the right to choose or vote to appoint members to the supervisory board (Block and Gerstner, 2016). The number of employee representatives on the supervisory board depends on the total number of employees a firm has. For German firms who have between 500 and 2000 employees, it is required to have one-third employee representatives on the supervisory board. For companies with more than 2000 employees, it is required that half of the supervisory board members are formed by employee representatives (Bozhinov et al., 2021). The supervisory board members are thus formed and chosen by different parties and are being directly elected by the shareholders or employees.

The main responsibilities of the supervisory board, as the name refers to is to supervise, monitor and evaluate the management board´s decisions and their performance. The supervisory board is given the authority to form the management board by appointing or removing executives (Fauver and Fuerst, 2006). Appointing executives by the supervisory board to the management board is usually done through establishing nominating committees. These committees identify potential candidates for executive positions on the management board and propose them to the supervisory board who are thus given the authority to make the final decision (Bozhinov et al., 2021). This makes the members of the supervisory board the final decision makers regarding the question of whom will be running the daily operations of the company.

The supervisory board is able to evaluate and review the management board by inspecting the books, reviewing the annual report and overseeing the work of an external auditor (Block and Gerstner, 2016). In addition, Fauver and Fuerst (2006) describe some specific tasks within the supervisory board, namely reviewing the executive's performance, selecting a chief executive officer, setting executives' salaries and long-term strategic planning. It is not possible for the supervisory board to directly interfere with the management of the firm, but they can address some actions that can only be performed with their permission. Other ways of influencing management could for example be setting incentives through remuneration or provide regular advise on strategic decisions (Block and Gerstner, 2016). Reviewing the responsibilities and tasks of the supervisory board it can be stated that the focus of the supervisory board is shifting towards advising, controlling and supervising the management board in order to achieve better firm performance.

A key factor to accomplish abovementioned tasks and responsibilities is the communication with the management board. As mentioned in the previous subsection, there is a situation of information asymmetry between the supervisory and management board because the supervisory board is not permitted to collect information from employees or junior management on their own (Jungmann, 2007). A possible problem arising from this is the lack of insider knowledge by the supervisory board since employees do not have the obligation to report directly to the supervisory board (Fauver and Fuerst, 2006; Block and Gerstner, 2016). This makes the communication and information sharing with the management board even more important because the members of the supervisory board receive all necessary information on the firm from the executives on the management board (Fauver and Fuerst, 2006; Jungmann, 2007).

The supervisory board usually has several options to reduce the information asymmetry. They, for example can choose to hire former members of the management board that will report to them, but in this case there is a limited number of former members allowed. Another option is to inspect all reports and documents from the management board in person or define which data to collect or when exactly the management should deliver their reports. Yet another option is simply request the members of the management board to join the board meetings set by the supervisory board to inform them on important subjects (Block and Gerstner, 2016).

2.4. Board Characteristics

2.4.1. Board Size

Board size is a major characteristic of the board of directors, and determining the optimal size is an important task for companies (Graf and Stiglbauer, 2009). Board size refers to the total number of members on the board of directors, who are either involved in the daily operations of the firm or in the supervisory role. From a corporate governance perspective, it has been an ongoing question what the ideal board size is for a firm, and since its importance, the relationship between board size and firm performance has been a focus point of many studies (Fiss, 2006; Bermig and Frick, 2010; Darmadi, 2011). Previous research present mixed findings of companies with large and small boards and the reasoning for the choice of a larger or smaller board also varies (van Ees, Postma and Sterken, 2003; Hidayat

and Utama, 2016). This makes it even more difficult for researchers and companies to come to a conclusion on whether larger or smaller boards are better for firm performance.

The covered theories regarding corporate governance can present different insights or approaches to board size, depending on the interpretation. For instance, agency theory mainly describes that smaller boards should be considered over larger boards, since the increase in board members causes an increase in the agency costs and efficiency of the board declines which eventually results in poor firm performance (Li, Lu, Mittoo and Zhang, 2015). The smaller number of board members also decreases information asymmetry and reduces conflicts between members contrary to larger boards which can experience greater levels of conflict (O'Connell and Cramer, 2010). On the contrary, resource dependence theory insists that the more members on a board the more available resources for the company. According to this theory, larger board size can increase firm performance through sharing of knowledge and experience in the decision-making process (Latif, Kamardin, Mohd and Adam, 2013). Stewardship theory also supports this view, since the focus of this theory is that every manager or employer is a good steward of the company meaning their interests are aligned with those of the owners. So it will not matter how many member there are on the board, they all will act with loyalty and professionalism towards the company. Having these mixed ideas from different theories makes the decision on a specific board size even more difficult for companies.

Adding to this, in Germany as mentioned there is the separation between a management board and a supervisory board, meaning that German firms have to decide on the number of members for both boards. For the supervisory board, there are some legal rules and regulations that determine the size and influence the formation of the board (Graf and Stiglbauer, 2009). In Germany it is required that the supervisory board has a minimum of three members and the maximum is up to 21 members, the total number eventually depends on firm size and number of employees (Boneberg, 2010; Block and Gerstner, 2016). It is common for German firms with fewer than 2000 employees to have 6 supervisory board members, 12 members for firms with between 2000 and 10000 employees, and over 16 up to 21 members for firms with more than 10000 employees (Fiss, 2006). Adding a rule to the formation is that when one-third of the supervisory board members is elected by the employees through codetermination, it is required that the total number on the supervisory board is dividable by three (Boneberg, 2010).

In the case of the management board there is no maximum or minimum amount of members allowed or required according to law or agreements. The size of the management board usually depends on the decision of the owners and supervisory board who are in charge when forming the management board. Thus, it depends on supervisory directors' and firm's characteristics (Bermig and Frick, 2010).

2.4.2. Board Independence

The independence of a board usually refers to the non-executive directors on the board, who are mainly formed by outsiders of the company. According to Jungmann (2007) a director is considered independent if there exists no relationship or circumstance which could affect the director's judgement. These directors can be considered as a control mechanism because they are more objective than managers and can provide new

viewpoints focused on firm performance (Martinez and Alvarez, 2019). Independent directors can be better in achieving the supervising task and prevent misuse of company resources and hereby improve performance (Makhlouf et al., 2017). The presence of independent board members is also important in aligning the interests of the owners and managers, which is the core function of the board of directors. There has always been some kind of fear or mistrust from the owners towards the managers, that they would chase their own interests rather than that of their firm. Owners believe that independent directors are able to align their interests with the firm, making the appointment of independent directors on the board a crucial aspect of this internal governance mechanism.

Because of their independence and objectiveness, independent directors are considered to be better at assessing firm's management and are more likely to make better decisions that are beneficial for firm performance (Kao et al., 2019). Independent directors make this possible because control is exerted through someone who is independent from the daily operations of the firm. In the two-tier structure these directors are members of the supervisory board. In the German two-tier board structure there is thus the clear separation between the executive directors on the management board and the non-executives on the supervisory board. However, within the supervisory board of German firms it is not possible to refer to every non-executive member as independent. The reason for this is the codetermination law that can apply for German firms, where employee representatives obtain a place on the supervisory board. These directors are usually chosen from within the company, and thus cannot be considered as outsiders or independent from the firm (Block and Gerstner, 2016). As previously mentioned, the number of these members on the supervisory board depend on the total number of employees of a firm. Therefore, independence in this study refers to the non-executive directors on the supervisory board that are no employee representatives.

The characteristic of board independence can also be analyzed using the theoretical perspectives. According to the agency theory, independent directors will promote better firm performance by effective monitoring of executives and making sure that interests between management and shareholders are aligned, resulting in reduced agency costs (Ramdani and Witteloostuijn, 2010; Kao et al., 2019). A supporting view is given by the resource dependence theory which claims that independent directors can increase value creating activities with their knowledge outside the firm and improve performance through strategic decision-making (Martinez and Alvarez, 2019).

2.4.3. Gender Diversity

Gender diversity on the board of directors has especially been a relevant topic in recent years and the focus point of many studies. The argument whether more female directors should be involved in firm strategies got the attention in public debates, academic research and corporate strategy (Marinova, Plantenga and Remery, 2010). For many years the debate around gender diversity on boards was considered only as a social issue, but nowadays it is more perceived as an aspect of increasing value for corporate governance and firm strategies (Marinova et al., 2010). In general it is believed that the presence of female directors on boards bring a fresh viewpoint and new perspectives, which could be beneficial for firm performance (Bennouri et al., 2018; Terjesen et al., 2016).

Having more gender diverse boards could be an advantage for firms because women may be better in understanding particular market conditions than men, this may bring more creativity and quality to board decision-making (Shukeri, Shin and Shaari, 2012). Increasing the number of female directors on the board makes it possible to take decisions considering a wider range of alternatives (Marinova et al., 2010). According to Martinez and Alvarez (2019) women are able to have a better impact on decision-making when there is more than one woman present on the board, since this makes them feel stronger and encourages them to have a stronger voice within the board. In addition to this, having a higher presence of women on boards also benefits the public image of the firm, which eventually can result in better firm performance (Marinova et al., 2010).

Theories concerning corporate governance also present ideas on gender diversity on the board of directors, which are usually positive towards increasing the number of female directors. Agency theory for instance states that female directors on boards contribute a wider range of perspectives in decision-making and they can act as a mechanism of control for board activities (Martinez and Alvarez, 2019). This is mainly because female directors are more likely to ask questions, debate issues and hold their firm to higher ethical standards compared to men (Terjesen et al., 2016). These characteristics make the presence of female directors especially on the supervisory board more important. Having more gender diverse boards is from the resource dependence and human capital theory perspectives also beneficial to firm performance. Female directors contribute new skills and valuable resources, therefore they have to be considered as an essential link between the firm and external resources, and compared to male directors they have more diverse networks (Terjesen et al., 2016; Martinez and Alvarez, 2019).

In accordance with the public debate on gender diversity, the topic got the necessary attention in Germany. The country introduced an act in 2016 which requires that at least 30% of the supervisory board members of publicly listed firms has to be formed by female directors (Bozhinov, Koch and Schank, 2017). Since the introduction of this gender quota, the effects have showed, namely the presence of women on supervisory boards increased from 3% to 28% in 2018 for the largest companies (Weidler, 2020). Similar to the characteristic of board size, there is no specific law that determines the number of female directors on the management board. Again, this depends solely on the characteristics of the firm and the supervisory board. Whether this attention on the topic and the necessary changes in the formation of the board has an impact on firm performance is a question that has to be answered.

2.5. Empirical Findings

This section will include a look on empirical findings on the board characteristics and firm performance. It is valuable to have a look at different studies since findings can be mixed throughout different researches. Since this study focuses on German listed firms that use a two-tier board structure, findings will focus on Germany and other countries that adapt a two-tier structure. This will be helpful in forming the hypotheses for the different board characteristics by analyzing results from countries with a similar corporate system.

2.5.1. Board Size and Firm Performance

An important study regarding the characteristic of board size is conducted by Bermig and Frick (2010) who focused on supervisory board size in German listed firms and firm performance. For their sample of 294 firms in the period of 1998-2007 they analyzed supervisory board size with both market-based and operating performance measures. Contrary to their expectations, they find a significantly positive relation between board size and Tobin's Q, and a non-significant result for their operating performance measures. Another study conducted by Martinez and Alvarez (2019) focused on a wider scale by conducting an international study with firms from 34 countries, including Germany, in their research. They believe that these results will give a great mix of the different corporate governance systems and provide a general view on board size and its influence on firm performance. In their analysis they conclude that board size has a positive influence on firm performance, meaning that larger boards are beneficial for firms. Martinez and Alvarez (2019) believe this is explainable with resource dependence and human capital theory since having more board members results in greater knowledge, expertise and more available resources.

Contrary to the positive relation between board size and firm performance, there are also studies that find negative relations. An example is the study conducted by Graf and Stiglbauer (2009), who focus on the size of the German management boards. Analyzing data from over 100 German firms and their management boards, they conclude that board size has a negative relation with firm performance. The main reason they present is that increasing the size of the board lowers efficiency and reduces decision quality because there are more ideas and perspectives, which makes it take longer to reach consensus. Supporting these findings is the study of Hidayat and Utama (2016) who focus on Indonesia, which is another country with the two-tier structure. They conclude that firm performance decreases as board size increases. Van Ees et al. (2003) focus specifically on the supervisory boards of Dutch listed firms and observe that size has a negative impact on firm performance. They believe that the main reason for this is the increasing number of outsiders on the supervisory board that do not obtain the necessary information on the firm. Yet another country with the two-tier system is Taiwan where Kao et al. (2019) present findings of a negative relation between board size and firm performance. Contrary to their hypothesis, firm performance decreases as board size increases, mainly due to the inefficiency of decision making and the lack of consensus within the larger boards.

2.5.2. Board Independence and Firm Performance

In their research, Martinez and Alvarez (2019) conclude that a higher presence of independent directors on the board has a positive impact on firm performance. The monitoring and supervising abilities of independent directors is in their opinion the main reason for this positive impact. In line with these findings and the importance of monitoring, Kao et al. (2019) show that firm performance increases significantly after an increase in the proportion of independent directors. Another country specific study of Abidin and Jusoff (2009) also shows that as the percentage of independent non-executive directors on the board increase, the performance of Malaysian firms increases as well. Next to the monitoring and supervising benefits of independent directors, Abidin and Jusoff (2009) point out that these directors also increase the total resources of the firm which eventually results in greater performance.

The Indonesian study conducted by Hidayat and Utama (2016) also finds a significant positive correlation in the proportion of independent directors to the performance measures of Tobin's Q, return on equity and return on assets. This study focuses on the supervisory role and interest alignment tasks of the independent directors as well. An interesting finding is that independent directors who served the company less than nine years show a higher positive significance. According to the study, this indicated that directors cannot be considered as independent when they served the company for longer than nine years or were once employees of the company (Hidayat and Utama, 2016). A different approach is taken by Gani and Jermias (2006) who studied the international manufacturing industry by categorizing firms according to their strategy, and interesting findings have been presented. Firms pursuing a strategy of cost efficiency show a positive relation between board independence and performance. Again, this is a result of the benefits of the monitoring and supervising tasks of independent directors.

On the contrary, Gani and Jermias (2006) conclude that firms with the main objective of innovation show a negative relation with board independence and performance. These firms require the strategic management roles of their directors rather than a monitoring or supervising role which independent directors mostly provide. This shows that all firms can have different relations between board independence and performance depending on their strategies. Ammari, Kadria and Ellouze (2014) investigated a sample of French firms and present a negative impact of board independence on return on assets and Tobin's Q.

2.5.3. Gender Diversity and Firm Performance

Joecks, Pull and Vetter (2012) conducted a valuable research to the gender diversity on the supervisory boards of German firms. They find that gender diversity on the board enhances firm performance when at least 10 percent is formed by female directors, and boards with more than 30 percent female representation even perform better than male dominant boards. They also conclude that when female representation is lower than 10 percent it might even be associated with reduced firm performance. The international study conducted by Martinez and Alvarez (2019) find that a higher presence of female directors on the board increases firm value and performance. They explain this positive relation with the perspectives of the agency and resource dependence theory, mentioning that female directors can provide different resources and skills compared to their male colleagues. This is supported by Green and Homroy (2017) who studied the largest European firms and conclude that greater female representation on the board, especially when it is integrated in the governance mechanism of the firm, results in greater firm profitability.

A country specific study conducted by Smith, Smith and Verner (2005) did research on a sample of 2500 Danish firms presenting findings of a positive relation between gender diversity and firm performance. Smith et al. (2005) point out a very important factor, mentioning this positive relation exists when the female directors on the board are elected by the staff without any ties to the owners of the firm. With another country specific study, Lückerath-Rovers (2013) examined the link between female directors and return on equity in the Netherlands. The findings in the study show that companies with female directors on the board have greater firm performance compared to companies without female directors. Lückerath-Rovers (2013) mentions that involving female directors on the board is beneficial

because companies then make use of the whole talent pool for competent directors. This is also motivating for other female employees at the company, because they see and believe that they also can reach the top.

Darmadi (2011) presents other findings in the research to gender diversity and firm performance in Indonesia. The researcher concludes that a higher proportion of female board members is associated with lower firm performance. Similar negative findings are presented by Soare, Detilleux and Deschacht (2021), who focused on Belgium firms in their research. Both researches describe several factors that could cause these negative impacts. Firstly, a higher proportion of female directors could lead to over monitoring which can have an impact on reaching consensus and slow down the decision-making process (Darmadi, 2011). Secondly, female directors tend to focus more on the long term performance of their firms rather than short term results, therefore it is important to consider the effects of female directors on long term firm performance. Lastly, women are often still the minority on the board of directors, and in order to reap the benefits of gender diversity a change in company culture and mentality is required which will take some time (Soare et al., 2021).

2.6. Hypothesis Development

In this section the hypotheses on the board characteristics for this study will be formed. This will be done based on the described theories and the empirical findings.

2.6.1. Board Size

When studying the theories it is possible to say that they present different perspectives on board size and its impact on performance. This makes it not easy to predict whether smaller or larger boards will be beneficial for firms because all theories are valuable and should be considered when forming hypotheses. For instance, according to the agency theory, larger boards increase agency costs and the problem of free riding among the many board members arises which eventually will negatively affect firm performance (Kao et al., 2019). In addition, larger boards can reduce efficiency and performance since agreeing on decision becomes more difficult. On the other hand, resource dependence theory present another view on board size, considering that larger boards bring more professionals with great resources thanks to their backgrounds (Makhlouf et al., 2017). Therefore, it is possible that more members are able to contribute their knowledge which can improve firm performance (Martinez and Alvarez, 2019).

Previous findings present mixed findings as well, some researches are in favor of the agency theory while other studies find support for resource dependence or human capital theory. However, it is possible to say that previous studies are mostly in favor of the agency theory, presenting results that smaller boards have a positive impact on firm performance. The primary reasons that smaller boards perform better compared to larger boards are that decision making, communication, interaction and coordination becomes more efficient (Graf and Stiglbaur, 2009; Makhlouf et al., 2017; Kao et al., 2019). Regarding the resource dependence and human capital theory, even if the board is smaller it is expected from the present board members to be capable individuals with resources beneficial for the firm. Therefore, the disadvantages of the agency theory for larger boards outweigh the resource dependence and human capital perspectives in this case. Considering the theories and findings from previous studies Hypothesis 1A is formed as follows:

Hypothesis 1A: smaller board size has a positive impact on firm performance

Based on this main hypothesis for board size, it will also be interesting to do research on the management and supervisory boards separately, therefore the next hypotheses have been formed:

Hypothesis 1B: smaller management board size has a positive impact on firm performance
Hypothesis 1C: smaller supervisory board size has a positive impact on firm performance

2.6.2. Board Independence

Independence is a difficult board characteristic to make a prediction on whether it will be positively or negatively linked with firm performance. There are different opinions on independence, some are in favor of increasing the number of independent directors and some have opposing ideas. In theory, independent directors are mostly considered for the supervisory task within the board because they are not directly linked with management. Owners tend to have the idea that there is a need for independent directors that have their best interests in mind, which is in line with the agency theory (Makhlouf et al., 2017). Since these directors are outsiders of the company they can add valuable resources that other directors do not have access to (Martinez and Alvarez, 2019). On the contrary, it is discussed that independent directors are not able to add value in terms of resources because they are outsiders and possibly do not own all information, expertise or knowledge on the daily operations and needs of the firm (Ammari et al., 2014).

Evidence from previous research mainly supports the positive impact of board independence on firm performance. The foremost reasons are in line with the theories, suggesting that independent directors have a positive impact on firm performance because of their effective monitoring and supervising activities. Their access to valuable extra resources is also a positive factor. This leads to the next hypothesis on board independence:

Hypothesis 2: greater proportion of independent directors on boards has a positive impact on firm performance

2.6.3. Gender Diversity

In general all theories have positive perspectives on gender diversity on boards and describe that it can have a positive impact on firm performance. The agency theory's focus is mainly aligning the interests between managers and owners by delegating the monitoring and supervising tasks to board members. According to the agency theory, female directors can be highly valuable in this task since they can act as a control mechanism for the board because they hold other standards compared to men (Martinez and Alvarez, 2019; Terjesen et al., 2016). Also from the perspective of the resource dependence theory a greater proportion of female directors on boards has benefits for the firm. Female board members contribute valuable resources firms need with their diverse networks which their male colleagues cannot provide (Martinez and Alvarez, 2019). Supporting this view is the human capital theory, since this theory states that every individual should be considered as valuable to a firm since they all have different expertise, knowledge and backgrounds (Terjesen et al., 2016).

As presented in the previous section, many studies have findings in favor of gender diversity on boards (Joecks et al., 2012; Green and Homroy, 2017; Martinez and Alvarez, 2019). These studies describe the advantages of including more women on the board of directors and how this is impacting firm performance positively. These factors are all in line with the theories and focus on the increased resources, viewpoints and new perspectives with involving more female board members. With these results, female directors send a positive signal to the public and they should be considered as valuable members of the board. Considering the theoretical perspectives and previous findings, Hypothesis 3A is formed as follows:

Hypothesis 3A: greater proportion of female directors on boards has a positive impact on firm performance

As previously mentioned, Germany inducted an act in 2016 with a gender quota which states that at least thirty percent of the supervisory board of publicly listed firms should be formed by female directors. The management board on the other hand does not have a specific quota. It will be interesting to do research on whether this quota has its impact on performance in reality. Therefore, the next hypotheses have been formed:

Hypothesis 3B: greater proportion of female directors on the management board has a positive impact on firm performance
Hypothesis 3C: greater proportion of female directors on the supervisory board has a positive impact on firm performance

3. Research Methodology

The research method is a very important factor in a study, since it is the core of presenting results, form conclusions on the hypotheses and helps in answering the research question. In studies with multiple dependent, independent and control variables the most used method is a regression model. Similar studies doing research on the board characteristics and firm performance mainly use ordinary least square regression (OLS), fixed effects regression (FE), or two-stage least squares regression (2SLS). Some researchers even use two or more of the mentioned methods in their studies in order to present the most precise findings. First, these different regression methods from previous studies will be described, and then the method for this study will be chosen and the model will be presented. This section also presents the dependent, independent and control variables and describes their measurements.

3.1. Methods in Previous Studies

3.1.1. OLS Regression

The most popular method that is used in studies doing research on board characteristics and firm performance is the OLS regression method (Smith et al., 2005; Graf and Stiglbauer, 2009; Darmadi, 2011; Joecks et al., 2012; Lückerath-Rovers, 2013; Duru et al., 2016; Green and Homroy, 2017; Bennouri et al., 2018; Martinez and Alvarez, 2019; Soare et al., 2021). OLS regression estimates the relationship between one or more independent variables and a dependent variable, more on the variables of this study in the next sections. The estimated equation is calculated by determining the equation that minimizes the sum of the squared distances between the sample´s data points and the values predicted by the equation (Farahani, Rahiminezhad, Same and Immannezhad, 2010; Poston Jr., 2021). It is very useful as a multivariate model with multiple independent variables, a dependent variable and the possibility to add control variables. According to Graf and Stiglbauer (2009) OLS is a traditional method which delivers efficient, unbiased and consistent estimates. The statistical method of OLS regression requires some assumptions that should be met before conducting the regression analysis. These assumptions are linearity, random sampling of observations, no multicollinearity, homoscedasticity and no autocorrelation (Farahani et al., 2010; Albert Resources, 2020). These assumption can be checked prior to the regression.

3.1.2. Fixed Effects Regression

Another popular method used in prior studies is the fixed effects regression (Smith et al., 2005; Bermig and Frick, 2010; Hidayat and Utama, 2016; Green and Homroy, 2017; Makhlouf et al., 2017; Bennouri et al., 2018; Kao et al., 2019). FE is used to explore the relationship between independent and dependent variables within an entity, where each entity could influence the dependent variables (Torres-Reyna, 2007). FE regression is mostly used in studies with panel data which means that observations are collected over a specific time series for a specific sample (Best and Wolf, 2015). This regression method is used to reduce selection bias in the estimation of causal effects in data with a requirement that several assumptions are met (Best and Wolf, 2015; Mummolo and Peterson, 2018). According to Kao et al. (2019) the FE model assumes that the individual heterogeneity is associated with independent variables, different to the random effects model. An important test in determining whether FE regression is appropriate for the study is the Hausman test (Smith et al., 2005; Hidayat and Utama, 2016; Makhlouf et al., 2017).

3.1.3. 2SLS Regression

The 2SLS regression analysis is statistical method that is used in the analysis of structural equations. It can be seen as the extension of the OLS regression and is mainly used as a complementary method in studies (Kao et al., 2019; Marinova et al., 2019). Standard linear regressions assume that errors in the dependent variable are not correlated with the independent variables. However, this is not always the case and the 2SLS regression can then be used. Therefore, the 2SLS regression is mainly used when the dependent variable's error terms are correlated with the independent variables (Statistics Solutions, 2021). Because the computed values are based on variables that are not correlated with the errors, it is argued that the results of the 2SLS method are optimal.

Also similar to the OLS method there are some assumptions that should be met if the 2SLS regression will be used. First the model has to be correctly identified, the error variance of all variables should be equal, error terms have to be normally distributed, outliers need to be removed and observations should be independent (Statistics Solutions, 2021). The 2SLS regression can also be used in order to control for endogeneity issues between the variables (Kao et al., 2019).

3.2. Method in this Study

Similar to previous studies, this study includes multiple dependent, independent and control variables. Therefore a multivariate regression model will be the most appropriate method to test the hypotheses of this study. As mentioned in the previous section, the most used and popular model is the OLS regression. This method will also be used in this study because comparable studies researching different board characteristics and its impact on firm performance use this method as well. OLS regression presents results that are easy to understand and analyze. The hypotheses in this study are formed in order to test the impact of the total board or management and supervisory board separately. Therefore, depending on the hypothesis tested, either observations on total boards or management and supervisory boards will be used and included in the model. The model that will be used in this study is as follows:

$$PERF_{it} = \beta_1 BSIZE_{it} + \beta_2 BINDEP_{it} + \beta_3 FEMDIR_{it} + \beta_4 SIZE_{it} + \beta_5 LEV_{it} + \beta_6 AGE_{it} + \beta_7 YEAR_{it} + \beta_8 IND_{it} + \varepsilon_{it}$$

Table 1: Model Codes Descriptions

Code	Description
$PERF_{it}$	Performance of firm i in period t measured in ROA, ROE and Tobin's Q
$BSIZE_{it}$	Board size of firm i in period t
$BINDEP_{it}$	Board independence of firm i in period t
$FEMDIR_{it}$	Gender diversity (female directors) of firm i in period t
$SIZE_{it}$	Size of firm i in period t
LEV_{it}	Leverage of firm i in period t
AGE_{it}	Age of firm i in period t
$YEAR_{it}$	Year dummy

IND_{it}	Industry dummy
ε_{it}	Standard error

3.3. Variables

3.3.1. Dependent Variables

The aim of this study is to analyze the impact of different board characteristics on firm performance, which means that firm performance is the dependent variable in this study. There are different measures of performance used through literature, mainly divided in accounting-based and market-based measures. Performance in this study will be measured by using three measures, two accounting-based and one market-based. The first accounting-based measure that will be used in this study is return on assets, from now on referred to as ROA. This is a very popular performance measure and is used in many studies regarding this topic (Graf and Stiglbauer, 2009; Bermig and Frick, 2010; Kao et al., 2019). ROA is calculated as the ratio of net income divided by total assets (Darmadi, 2011; Green and Homroy, 2017; Makhlouf et al., 2017). The second accounting-based measure is another popular one used in many studies namely the return on equity, referred to as ROE (Graf and Stiglbauer 2009; Joekcs et al., 2012; Bennouri et al., 2018). The calculation for ROE is the ratio of net income divided by the average shareholders' equity (Lückerath-Rovers, 2013; Kao et al., 2019). The third and final performance indicator is a market-based measure which is used almost as the only market-based measure in existing literature namely Tobin's Q (Bermig and Frick, 2010; Marinova et al., 2010; Darmadi, 2011; Hidayat and Utama, 2016; Kao et al., 2019). Tobin's Q is calculated as market capitalization divided by total assets (Bermig and Frick, 2010; Marinova et al., 2010; Kao et al., 2019).

3.3.2. Independent Variables

The independent variables in this study are the board characteristics since their impact on firm performance will be analyzed. The first independent variable is board size of the German firms in the sample. In a previous German study conducted by Bermig and Frick (2010) board size is measured as the total members on the supervisory board, and the study by Graf and Stiglbauer (2009) measured this as the total members on the management board. This study will combine both the management and supervisory board since the aim is to analyze the impact of the total board size first and then the management and supervisory board separately. Therefore, board size is the sum of the total members from the management and the supervisory board, and as it speaks for itself the size of the management board and supervisory board are solely the members included in those specific boards.

The second independent variable is board independence. Martinez and Alvarez (2019) calculate board independence as the ratio between the total number of independent members on boards and the total number of board members. Kao et al. (2019) use the same approach, only difference is that in their study a director is considered independent when all criteria on independence as stated in the regulations of the country are met. Slightly different approach is taken by Gani and Jermias (2006) who use the ratio of external members to total members on the board of directors. In this study it should be considered that German supervisory boards are different compared to other countries with a two-tier

board structure because of the codetermination laws. As previously described, depending on the number of employees, German supervisory boards include employee representatives from within the firm. Block and Gerstner (2016) describe that these representatives cannot be considered as truly independent because of their ties with the company, therefore independence in this study refers to the members on the supervisory board who are no employee representatives. Board independence is thus measured as the ratio of supervisory board members who are no employee representatives to the total number of supervisory board members.

The third and final independent variable is gender diversity on the board of directors, which can be measured differently in previous studies. Marinova et al. (2010) use two approaches to measure gender diversity, the percentage of women on the board (management plus supervisory board) and the method of a dummy variable indicating whether there is at least one female director on the board or not. A similar dummy approach is used by Joecks et al. (2012) in their study to gender diversity on German boards, creating four dummy variables reflecting different group types ranging from no woman on boards to at least 40 percent women on boards. It should be mentioned that this study was prior to the gender quota of 30% female representation introduced in Germany in 2016. This particular measurement of gender diversity is not applicable for this study because every firm is required to have female representation on boards. The more recent studies focus on the method of proportion or percentage women on boards, using a ratio of the total number of female directors to the total number of board members (Lückerath-Rovers, 2013; Green and Homroy, 2017; Martinez and Alvarez, 2019). Therefore, gender diversity in this study is calculated as the ratio of female directors on the board (management and/or supervisory board) to the total number of board members (management plus supervisory board).

3.3.3. Control Variables

When analyzing whether the independent variables have an impact on performance it is important to consider other factors that can influence performance. These other factors are the control variables that must be included in the model. There are several control variables that are often being used in many studies regarding this topic. The first control variable is the size of the firm, because larger firms can easier generate funds and gain access to funds from external sources, which can impact performance positively (Kao et al., 2019). Firm size is measured as the natural logarithm of total assets (Bermig and Frick, 2010; Lückerath-Rovers, 2013; Hidayat and Utama, 2016; Martinez and Alvarez, 2019). The second control variable that is commonly used is leverage and is measured as the ratio of total debt to total assets (Bermig and Frick, 2010; Kao et al., 2019; Martinez and Alvarez, 2019). A firm with a high leverage ratio can negatively influence firm performance because they have more debt and less ability to repay debt, therefore it is important to include it as a control variable (Gani and Jermias, 2006; Kao et al., 2019; Martinez and Alvarez, 2019). The third control variable is the age of the firm, since it can play a role in the activities that influence performance. For instance, younger firms are new to the market, have less experience, and are building up a market position which could affect their earnings (Smith et al., 2005). Older firms on the other hand do have the experience, market position, and are better to obtain the necessary resources. Firm age is measured as the number of years the firm exists in the observation year (Marinova et al., 2010; Hidayat and Utama, 2016). The last two control

variables are year and industry dummies, which represent the observation year and firm industry (Martinez and Alvarez, 2019)

Table 2: Variable Definitions

Variable	Code	Definition	Sources
Dependent Variables			
Return on assets	ROA	Ratio of net income divided by total assets	Darmadi (2011); Green and Homroy (2017); Makhlouf et al. (2017)
Return on equity	ROE	Ratio of net income divided by the average shareholders' equity	Lückerath-Rovers (2013); Kao et al. (2019)
Tobin's Q	TOBQ	Market capitalization divided by total assets	Bermig and Frick (2010); Marinova et al. (2010); Kao et al. (2019)
Independent Variables			
Board size	BSIZE	Sum of total members from the management and supervisory board	Kao et al. (2019); Martinez and Alvarez (2019)
Management board size	MBSIZE	Number of directors on the management board	Graf and Stiglbauer (2009)
Supervisory board size	SBSIZE	Number of directors on the supervisory board	Bermig and Frick (2010)
Board independence	BIND	Ratio of supervisory board members who are no employee representatives to the total number of supervisory board members	Block and Gerstner (2016); Kao et al. (2019)
Gender diversity	FEMDIR	Ratio of female directors on the board to the total number of board members	Lückerath-Rovers (2013); Green and Homroy (2017); Martinez and Alvarez (2019)
Management board gender diversity	MBFEMDIR	Ratio of female directors on the management board to the total members on the management board	Lückerath-Rovers (2013); Green and Homroy (2017); Martinez and Alvarez (2019)
Supervisory board gender diversity	SBFEMDIR	Ratio of female directors on the supervisory board to the total members on the supervisory board	Lückerath-Rovers (2013); Green and Homroy (2017); Martinez and Alvarez (2019)
Control Variables			

Firm size	SIZE	Natural logarithm of total assets	Bermig and Frick (2010); Lückerath-Rovers (2013); Hidayat and Utama (2016); Martinez and Alvarez (2019)
Leverage	LEV	Ratio of total debt to total assets	Bermig and Frick (2010); Kao et al. (2019); Martinez and Alvarez (2019)
Firm age	AGE	Number of years the firm exists in the observation year	Marinova et al. (2010); Hidayat and Utama (2016)
Year	YEAR	Year dummy	Martinez and Alvarez (2019)
Industry	IND	Industry dummy	Martinez and Alvarez (2019)

4. Sample and Data

This chapter presents the sample of firms that is used in this study, and describes the process of collecting the data from those firms. It also describes the industry classification of the sample firms.

The sample in this research has been formed by making a selection of German public firms from the Frankfurt Stock Exchange. The Frankfurt Stock Exchange is the largest in Germany, and has been used in several previous studies (Bermig and Frick, 2010; Steger, 2017; Bozhinov et al., 2021). In order to make the selection of firms in this study, the Orbis database has been used. This database includes German firms from the four main indices of the Frankfurt Stock Exchange, namely DAX, MDAX, TecDAX and the German Entrepreneurial Index (GEX). The initial sample consisted of 104 German firms from the Frankfurt Stock Exchange that were in the indices above. From this initial sample, 38 companies where listed in DAX, 44 in MDAX, 9 in TecDAX and 13 companies in GEX. Data on these firms has been collected for a period of three years, from 2017 to 2019.

Two methods have been used in this study to collect the necessary data from the firms. The Orbis database has been used and the annual reports of all firms have been collected for the period of three years. Orbis provides information on many aspects of firms and is in this study used to collect data on several variables. Firstly, Orbis has been used to collect data on the dependent variables – the performance indicators ROA, ROE and Tobin's Q. ROA and ROE were calculated by using the net income and Tobin's Q by dividing the market capitalization by the total assets.

Information on the control variables of firm size, leverage ratio and age of the firm are also available in Orbis. Firm size is measured in total assets of the firm, which in Orbis was given in US dollars. Since this study focuses on German firms, the total assets were converted to Euro currency based on currency rates of the 31st of December of each sample year. For leverage, in addition to total assets data on total debt is collected from Orbis as well in order to calculate the ratio. The founding years of the firms are given in Orbis, this has been used to calculate the age for each sample year.

Additionally, in order to collect data on the independent variables of board characteristics, the annual reports of the selected firms are manually collected for the years 2017 to 2019. In each annual report a search has been made regarding the board characteristics. Every annual report was unique in the manner of disclosing information on their management and supervisory boards. Some firms used a very clear manner of presenting the members of the management and supervisory board by using pictures of the members next to their names. Other firms only presented the names of the board members without their pictures. The presence (if applicable) and number of employee representatives on supervisory boards were also given. For the independent variables board size and board independence this method of collecting data was very efficient. For the firms who did not present pictures of their board members in their annual reports, the board members' names have been searched on the internet to determine the gender. This approach was needed to collect the necessary data for the gender diversity variable.

During the data collection process several firms have been removed from the initial sample due to two reasons. In total 15 firms were removed from the sample, 11 companies due to missing information on the variables and 4 companies which were founded after 2017, causing a lack of data for the research period. Therefore, the final sample consists of 89 firms with data for three years.

4.1. Industry Classification

Industry dummies will be used as control variables in this study, therefore the firms in this sample are classified in the industries they operate in. The industry classification of the German firms in this sample is based on the NACE Rev. 2 codes. Initially there were 11 industries as presented in Table 3. Manufacturing is by far the largest industry with 45 firms which is 50.56% of the sample. The information and communication industry is the second largest with 12 firms, and the remaining firms are distributed over the other industries. Hereby the representation differs, some have just 1 firm others have 3 or 5 firms. For the analysis it is best to have industries with at least 10 firms each, therefore the firms are reclassified based on their industries. Combining industries resulted in 4 industries as presented in Table 3 that will be used to form the dummy variables in the analysis.

Table 3: Industry classifications

Industry	Number of firms	Reclassified industries
Manufacturing	45	45
Information and communication	12	12
Mining and quarrying	1	
Electricity, gas, steam and air conditioning	3	
Wholesale and retail trade	5	
Transportation and storage	5	14
Financial and insurance activities	4	
Professional, scientific and technical activities	6	
Other service activities	1	
Real estate activities	6	
Arts, entertainment and recreation	1	18
Total		89

5. Results

This section of the paper presents the results of the research. First the descriptive statistics will be given. Second, the correlation analysis will be presented followed by the multicollinearity test. Finally, the results of the regression analysis will be presented.

5.1. Descriptive Statistics

5.1.1. Dependent Variables

Looking at Table 4 for the accounting-based performance indicators, the average ROA in this sample is 3.18% with a median of 4.95%, and for ROE the mean is 9.62% with a median of 11.91%. This means that both accounting-based measures are skewed to the left. Graf and Stiglbauer (2009) have higher mean values for ROA and ROE in their study, with a mean ROA of 6.84% and a mean ROE of 15.48%. Not all firms in the sample show a positive ROA or ROE, the minimum ROA is -128.08% which is far from the mean value. This is also the case with ROE, which presents a minimum of -196.67%. The best performing firms on ROA and ROE have values of 26.03% and 58.51% respectively. Despite having firms with negative ROA and ROE, having positive mean and median values indicates that the majority of German firms in the sample have positive financial performances. The market-based measure Tobin's Q has a mean of 1.57 with a median of 0.93, indicating that this variable is skewed to the right. This can be explained by the maximum for Tobin's Q, which is 11.66 for a particular firm. The firm with the minimum value has a Tobin's Q of 0.09. Weidler (2018) used the same calculation for Tobin's Q, and has some differences in the findings for the sample period of 2012-2018 with a minimum Tobin's Q of 0.01, a maximum value of 6.66 and a mean of 0.89.

5.1.2. Independent Variables

Board size

For the total board size, the members of the management and supervisory boards are added together. German firms in this study have an average board size of 15.46 with a median of 15. Total board size is quite diverse in this sample, with the smallest board consisting of 5 members whereas the largest board has 33 members. Analyzing the values of the management and supervisory board will further explain how the total board size is composed. For the management board in this sample the minimum is 2 members, and firms with the largest management board have 10 members. On average, German firms in the sample have 4.38 management board members. Graf and Stiglbauer (2009) and Bozhinov et al. (2021) have similar findings in their study to German management boards, they find a maximum size of 11 and 12 respectively with means of 4.43 and 4.55. Supervisory boards are usually larger than the management boards, which is also the case in this study. The supervisory boards have a mean of 11.08 members with a median of 12. The firm with the smallest supervisory board has 3 members, and the largest supervisory board consists of 23 members. Bozhinov et al. (2021) have comparable findings for supervisory board size in their study of 95 German firms for the period of 2009-2016, showing a minimum of 6 and maximum of 21 members with a mean size of 13.48.

Board independence

For board independence it is important to have a look at the number of employee representatives on the supervisory board and what this means for the total composition of the supervisory board. Codetermination is not applicable for every firm in the sample,

therefore some firms have no employee representatives on the supervisory board at all. This was the case in 36% of the observations, as can be seen in Appendix B. On average the supervisory boards have 4.33 employee representatives, and the remaining members are considered as the independent members, which has a mean of 6.75 per supervisory board. The majority of the observations, with a percentage of 40.4 have 6 independent supervisory board members. The maximum representation of employees on a board is 12, and for the independent members the maximum amount is 13. As mentioned, not every board has employee representatives, therefore all supervisory board members on those specific cases are considered as independent members, 3 members is hereby the minimum.

Looking at the mean values of employee representatives and independent supervisory board members, it is possible to mention that on average the independent members on the supervisory board outweigh the employee representatives. The board independence ratio of 0.70 confirms this, because this is computed by the ratio of independent members to the total supervisory board. This means that in this study's sample, the supervisory boards consist of 70% independent members and 30% of employee representatives. This difference is thus explained by the firms where codetermination is not applicable and have no employee representatives on their supervisory boards. The minimum independence ratio is 0.48, meaning that supervisory boards are composed by half employee representatives and half independent members. This is mostly applicable for larger firms with over 2000 employees, for which codetermination laws require that half of the supervisory board is formed by employee representatives. As expected, the maximum board independence ratio is 1, caused by firms without employee representation.

Gender diversity

German firms in the sample have an average female representation of 3.58 members on their boards. Not all boards have women directors, and the firm with the highest representation has 10 female members on its board. The mean for gender diversity ratio is 0.20, thus for the average board only one fifth consists of female members. The most gender diverse board in the sample has a ratio of 0.43. Female representation on the management and supervisory board differ quite a bit. On average there are 0.39 female members on the management board, whereas the mean for the supervisory board is higher with a value of 3.19. Weidler (2018) has comparable findings for German supervisory boards for the period of 2012-2018 with a mean female representation of 3.49. Bozhinov et al. (2021) on the other hand present findings that show slightly lower female representation on the supervisory board with a mean of 2.36. The same study also shows lower female representation on the management board with a mean of 0.21.

For both the management and supervisory board there are firms without female representatives. Especially with the management board this percentage is quite high, namely 67.4% of the observations have no female members on their management boards at all. This value is rather lower for the supervisory board, with a percentage of 12.4%. The maximum representation of women on the management board is 2, which counts for 6.4% of the observations. The mean gender diversity ratio for the management board is 0.07, with a maximum ratio of 0.40. Supervisory boards have higher female representation with a mean gender diversity ratio of 0.26. This means that the gender quota of 30% female members that is required for the supervisory boards is not met, but the difference in this

sample is just 4%. The maximum female members on a supervisory board is 9, with a gender diversity ratio of 0.60. Weidler (2018) found a gender diversity ratio of 0.23. The higher value in this study could be a result of the gender quota which was introduced in 2016.

5.1.3. Control Variables

Next to the independent and dependent variables, this research also included several control variables. Looking at the total assets of the firms, it is possible to say that the sample exists of smaller firms and very large firms. This is because the minimum and maximum differ in a great amount. The smallest firm in the sample has total assets of €3.5 million, and the largest firm has an impressive total assets of €489 billion. The average total assets presents a value of €25.6 billion (median = €4.6 billion). The second control variable is the leverage ratio, which has a mean of 0.56 (median = 0.57). Another control variable is the age of the firm, this variable is also quite interesting. On average firms had an age of 58.19 years (median = 30), the oldest firms was 173 years and the youngest was 2 years old, meaning it was founded in 2015. These variables show the diversity of firms in the sample, making it more interesting to analyze.

Table 4: Descriptive Statistics

Variables	N	Mean	Median	Std. Deviation	Minimum	Maximum
Dependent variables						
ROA	267	3.18	4.95	12.68	-128.08	26.03
ROE	267	9.62	11.91	19.76	-196.67	58.51
Tobin's Q	267	1.57	0.93	1.74	0.09	11.66
Independent variables						
MB size	267	4.38	4	1.95	2	10
SB size	267	11.08	12	5.60	3	23
Total board size	267	15.46	15	6.86	5	33
SB employee representatives	267	4.33	6	3.85	0	12
SB independent members	267	6.75	6	2.29	3	13
Board independence ratio	267	0.70	0.52	0.23	0.48	1
MB female members	267	0.39	0	0.61	0	2
SB female members	267	3.19	3	2.27	0	9
Total female members	267	3.58	3	2.60	0	10
MB gender diversity ratio	267	0.07	0	0.10	0	0.40
SB gender diversity ratio	267	0.26	0.3	0.12	0	0.60
Total gender diversity ratio	267	0.20	0.22	0.01	0	0.43

Control variables						
Total assets	267	25,646	4,630	6,429	3.511	489,466
Leverage ratio	267	0.56	0.57	0.18	0.09	0.96
Firm age	267	58.19	30	50.94	2	173

5.2. Correlation Analysis

The correlation analysis is the step prior to the regression analysis, whereby the correlation coefficients indicate the strength of the relationship between two variables. A correlation coefficient greater than zero means that the relationship between the variables is positive, and a coefficient less than zero indicates a negative relationship (Gogtay and Thatte, 2017). Hereby especially attention has to be paid to the independent and control variables that will be put in the same model for the regression analysis. Highly correlated independent and control variables in the same regression model could be problematic for the analysis. Therefore a multicollinearity test will be conducted in the next section as well, paying close attention to strong significant correlations. For this study Pearson´s correlations has been used. The correlations of the variables are presented in Table 5. As shown in the table, the accounting-based dependent variables ROA and ROE have a high positive correlation at the 0.01 significance level. On the other hand, the third dependent variable – the market-based Tobin's Q – shows no significant correlation with both ROA and ROE.

ROA has no significant correlation with the total board size and the management board size. On the contrary, ROA shows a positive significant correlation with the supervisory board size at the 0.05 level, with a Pearson correlation of 0.128. This indicates that an increase in the number of supervisory board members leads to a greater ROA. Similarly, ROE also has a non-significant correlation with management board size. However, both the total board size as the supervisory board size show significant positive correlations, with values of 0.135 and 0.156. Thus, in the case of ROE both increases in members of the total board and supervisory board have a positive influence. The third dependent variable Tobin's Q has significant negative correlations with total board size, management board size and supervisory board size as well. All correlations are significant at the 0.01 level, indicating that larger boards cause a lower Tobin's Q value. Total board size has high positive correlations with the management and supervisory board, this is as expected since the total board size is formed by the management and supervisory boards. However, this strong correlation will not be problematic since these variables will not be put in the same model for the regressions. The management board size and supervisory board size also show positive significant correlations at the 0.01 level with a coefficient of 0.549. These will be put in the same model, therefore it is important to test for multicollinearity in the next section. In addition, total board size, management board size and supervisory board size all show significant positive correlations with firm size. This indicates that larger firms have more members on their boards. The same can be stated for the leverage ratio and the age of firms, since these correlations are all significant and positive for the board sizes as well.

Furthermore, both ROA and ROE show significant negative correlations with board independence ratio at the 0.01 level, with Pearson correlations of -0.211 and -0.222 respectively. This means that an increase in the independence ratio negatively influences

ROA and ROE, and vice versa. On the other hand, Tobin's Q has a significant positive correlation with board independence ratio at the 0.01 level with a value of 0.354. Interestingly, board independence ratio has negative significant correlations with the control variables. All correlations are significant at the 0.01 level, firm size has a Pearson correlation of -0.478. The Pearson correlations of leverage ratio and firm age are -0.226 and -0.399 respectively. This means that as firm size increases, the board independence ratio decreases and vice versa. It is also the case for leverage ratio and firm age.

Additionally, gender diversity ratio has positive significant correlations with ROA and ROE at the 0.01 level. This shows that greater gender diversity on boards has a positive impact on both accounting-based performance indicators. Tobin's Q has a significant correlation with gender diversity ratio as well, though this relationship is negative. Contrary to the total gender diversity ratio, the management board gender diversity does not have significant correlations with ROA and ROE. Tobin's Q again shows a negative significant correlation with the management board diversity. Indicating that an increase in the management board diversity causes a decrease in the Tobin's Q value and the other way around. Gender diversity ratio has positive significant correlations with management board diversity ratio and supervisory board gender diversity, this is as expected since gender diversity ratio is formed by management board diversity and supervisory board diversity. Management board diversity ratio and supervisory board diversity ratio show a positive correlation at the 0.05 level, and is yet another relationship that needs to be tested for multicollinearity in the next section. Furthermore, both gender diversity ratio and supervisory board gender diversity ratio have positive significant correlations with all three control variables at the 0.01 level. This indicates that larger firms, older firms and firms with higher leverage ratios tend to have more gender diverse board. On the other hand, management board diversity ratio has a positive correlation with firm size at the 0.01 level, and with leverage ratio at the 0.05 level. It does not have a significant correlation with firm age.

Lastly, even if the dependent variables do not have an effect on multicollinearity it is interesting to further analyze the correlations with the control variables. ROA and ROE have similar relationships with the control variables, both show positive significant correlations with firm size and firm age at the 0.01 level. This means that as firm size and firm age increases it positively affects the performance of the firm. Where these performance indicators differ is the correlation with leverage ratio. ROA shows no significance, whereas ROE is significant and has a Pearson correlation of 0.134 at the 0.05 level. On the contrary, Tobin's Q has negative significant correlations with all three control variables, for firm size and leverage ratio at the 0.01 level and for firm age at the 0.05 level.

Table 5: Correlations of Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13
(1) ROA	1												
(2) ROE	0.872**	1											
(3) Tobin´s Q	0.069	0.042	1										
(4) Total board size	0.100	0.135*	-0.410**	1									
(5) MB size	-0.013	0.028	-0.247**	0.732**	1								
(6) SB size	0.128*	0.156*	-0.417**	0.971**	0.549**	1							
(7) Board independence ratio	-0.211**	-0.222**	0.354**	-0.753**	-0.388**	-0.788**	1						
(8) Gender diversity ratio	0.159**	0.183**	-0.356**	0.619**	0.366**	0.632**	-0.598**	1					
(9) MB gender diversity	0.044	0.078	-0.217**	0.408**	0.500**	0.326**	-0.245**	0.429**	1				
(10) SB gender diversity	0.162**	0.165**	-0.285**	0.503**	0.311**	0.508**	-0.488**	0.927**	0.148*	1			
(11) Firm size	0.258**	0.246**	-0.351**	0.684**	0.630**	0.619**	-0.478**	0.538**	0.404**	0.485**	1		
(12) Leverage ratio	-0.020	0.134*	-0.441**	0.377**	0.196**	0.394**	-0.226**	0.246**	0.139*	0.195**	0.278**	1	
(13) Firm age	0.191**	0.179**	-0.150*	0.284**	0.254**	0.260**	-0.399**	0.207**	0.108	0.206**	0.277**	0.057	1

*Notes: ** correlation is significant at the 0.01 level (2-tailed); * correlation is significant at the 0.05 level (2-tailed)*

5.3. Multicollinearity Test

Multicollinearity can occur when two or more independent or control variables in the same regression model are significantly correlated with each other, whereby high multicollinearity will cause a problem for the results of the regression analysis (Daoud, 2017). Therefore, the significant correlations between the independent and control variables presented in the previous section indicate a potential multicollinearity problem when put in the same model. This means a multicollinearity test has to be conducted prior to the regression analysis. In the case of a strong significant correlation a consequence for multicollinearity is that the variance inflation factor (VIF) is inflated (Daoud, 2017). Variance inflation factor values of 5 or higher are considered as highly correlated and show signs of multicollinearity that is problematic for the regression models (Daoud, 2017).

Table 6 presents the collinearity test for the models that are used in this study, and give the variance inflation factors (VIF). For all variables it can be seen that the values are between 1 and 2. This means that there will not be a multicollinearity problem for all equations, since the VIF values are below 5.

Table 6: Multicollinearity Test

	Model 1	Model 2	Model 3	Model 4	Model 5
Total board size	2.068				
MB size		1.796			
SB size		1.931			
Board independence ratio			1.463		
Gender diversity ratio				1.436	
MB gender diversity ratio					1.201
SB gender diversity ratio					1.330
Firm size	1.909	2.050	1.368	1.516	1.651
Leverage ratio	1.171	1.193	1.101	1.100	1.092
Firm age	1.107	1.108	1.208	1.090	1.092

Notes: the variance inflation factors (VIF) are given.

5.4. Regression Analysis

This section presents the results of the regression analysis which will be helpful in answering the hypotheses of this study. The OLS regression is conducted for all three dependent variables, the accounting-based ROA and ROE, and the market-based Tobin's Q. Table 7 shows the results for ROA for all five models, Table 8 presents the regression results for ROE and Table 9 for Tobin's Q. These results will be analyzed for the independent and control

variables, whereby the results for the independent variables will either confirm or reject the hypotheses.

5.4.1. Board Size

The independent variable of board size was categorized in total board size, management board size and supervisory board size. Total board size represents Models 1 in the regression analyses, and management board size and supervisory board size are put in Model 2 for all performance indicators. Hypotheses 1A, 1B and 1C were formed for the variable of board size. These hypotheses stated that smaller boards will have a positive impact on firm performance, expecting a negative relationship between the dependent and independent variables. This means that it is anticipated that an increase in board size will decrease firm performance.

Looking at Model 1 in Table 7**,** total board size shows a negative significant relationship at the 0.05 significance level, with an unstandardized coefficient of -0.263 and a t-statistic of 1.675. This indicates that an increase in total board size decreases the accounting-based performance indicator ROA. Total board size has a negative significant relationship with the second accounting-based measure ROE as well. Hereby the unstandardized coefficient is -0.343 with a t-statistic of -1.406 and a significance at the 0.1 level. Therefore it can be stated that smaller boards have a positive impact on both ROA and ROE. Furthermore, total board size shows a negative significant relationship with Tobin´s Q at the 0.01 level with an unstandardized coefficient of -0.051 and a t-statistic of -2.256. The same can be stated for the market-based measure, that smaller boards increase the value of Tobin's Q which is favorable for firms. Total board size has negative significant relationships with all performance measures, whereby the significance level differs. This means that Hypothesis 1A is confirmed for ROA, ROE and Tobin's Q as well.

Similar to total board size, management board size shows a negative significant relationship with ROA as well, but with a stronger significance at the 0.01 level. The unstandardized coefficient is -2.252 with a t-statistic of -4.441. This indicates that increasing the members on the management board results in a lower ROA and that smaller management boards are more favorable. Thus, smaller management boards in this sample have a positive impact on ROA. The same conclusion can be drawn for the impact of management board size on ROE. Hereby the relationship is negative and significant at the 0.05 level, with an unstandardized coefficient of -2.682 and t-statistic of -3.355. Hypothesis 1B is confirmed for both accounting-based measures, meaning that smaller management boards have a positive impact on ROA and ROE. On the contrary, management board size has no significance with Tobin's Q meaning that it is not possible to confirm the hypothesis for the market-based performance measure.

Supervisory board size has different findings for ROA and ROE. The results in Model 2 for the supervisory board size show no significant relationship with both accounting-based measures. Therefore, Hypothesis 1C is rejected for ROA and ROE, meaning that the supervisory board size for firms in this sample do not have an impact on accounting-based performance. On the other hand, Tobin's Q does have a negative significant relationship with supervisory board size at the 0.01 level with a coefficient of -0.065 and t-statistic of -

2.842. Smaller supervisory boards in this sample have a positive impact on the market-based measure, thus Hypothesis 1C is confirmed for Tobin's Q.

5.4.2. Board Independence

Hypothesis 2 states that a greater proportion of independent directors on boards has a positive impact on firm performance. Model 3 in the regression tables represents the regression analysis of the independent variable board independence ratio. First, looking at Table 7 it can be concluded that board independence ratio has a negative significant relation with ROA at the 0.1 level. In addition, the relationship with ROE is negatively significant as well at the 0.05 level, with a coefficient of -10.611 and a t-statistic of -1.742. Thus an increase in the number of independent board members will negatively influence both ROA and ROE. The opposite was expected, therefore Hypothesis 2 is rejected for both accounting-based performance indicators. On the contrary, the market-based measure shows a significant positive relationship with board independence ratio at the 0.01 significance level. Hereby the unstandardized coefficient is 1.595 with a t-statistic of 3.327. For Tobin's Q it can be stated that increasing the independent board members results in better firm performance. Hypothesis 2 is confirmed for the market-based measure.

5.4.3. Gender Diversity

The independent variable gender diversity was categorized in gender diversity ratio, management board gender diversity ratio and supervisory board gender diversity ratio. Gender diversity ratio represents Model 4 in the regression analyses, and management board gender diversity and supervisory board gender diversity ratio are put in Model 5 for all performance indicators. Hypotheses 3A, 3B and 3C were formed for the variable of gender diversity. These hypotheses stated that greater proportion of female members on the boards will have a positive impact on firm performance, expecting a positive relationship between the dependent and independent variables. This means that it is anticipated that an increase in gender diversity ratio will increase firm performance.

The regression results show that gender diversity has a non-significant relationship with both accounting-based performance measures. This is the case for management board gender diversity and supervisory board gender diversity as well. This means that Hypotheses 3A, 3B and 3C are rejected for ROA and ROE. On the other hand, gender diversity ratio shows a negative significant relationship at the 0.01 level with Tobin's Q. Indicating that an increase in female board members decreases the Tobin's Q value. Next to this, management board gender diversity and supervisory board gender diversity have negative significant relationships with Tobin's Q as well, with significance levels of 0.1 and 0.05 respectively. Contrary to the expectation of the hypothesis, the results show that an increase in gender diversity ratio on the boards decreases Tobin´s Q and has a negative effect on performance. Therefore, Hypotheses 3A, 3B and 3C are rejected for the market-based performance measure as well.

Table 7: OLS Regression - ROA

	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-33.885***	-38.630***	-16.616*	-24.884**	-27.352**

	(-4.073)	(-4.736)	(-1.746)	(-3.269)	(-3.460)
Total board size	-0.263**				
	(-1.675)				
MB size		-2.252***			
		(-4.441)			
SB size		0.136			
		(0.753)			
Board independence ratio			-6.417*		
			(-1.634)		
Gender diversity ratio				7.249	
				(0.795)	
MB gender diversity ratio					-7.141
					(-0.889)
SB gender diversity ratio					5.756
					(0.822)
Firm size	1.879***	2.299***	1.263**	1.303**	1.433**
	(4.203)	(5.157)	(3.267)	(3.128)	(3.286)
Leverage ratio	-4.865	-6.539	-8.277*	-7.519*	-7.233
	(-1.036)	(-1.429)	(-1.817)	(-1.654)	(-1.597)
Firm age	0.044***	0.046***	0.034**	0.041**	0.040**
	(2.713)	(2.917)	(2.027)	(2.495)	(2.467)
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.089	0.142	0.088	0.081	0.081
Observations	267	267	267	267	267

*Notes: 1. Unstandardized coefficients are given. 2. t-statistics are reported in parentheses. 3. *** indicates significance at the 0.01 level, ** indicates significance at the 0.05 level and * indicates significance at the 0.1 level. 4. Firm size is expressed in the natural logarithm of total assets.*

Table 8: OLS Regression - ROE

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Constant	-49.602***	-55.183***	-23.505	-35.810***	-38.150**
	(-3.834)	(-4.291)	(-1.592)	(-3.036)	(-3.105)
Total board size	-0.343*				
	(-1.406)				

MB size		-2.682**			
		(-3.355)			
SB size		0.126			
		(0.442)			
Board independence ratio			-10.611**		
			(-1.742)		
Gender diversity ratio				17.074	
				(1.209)	
MB gender diversity ratio					-2.188
					(-0.175)
SB gender diversity ratio					10.250
					(0.941)
Firm size	2.453***	2.947***	1.583**	1.542**	1.681**
	(3.529)	(4.193)	(2.639)	(2.388)	(2.480)
Leverage ratio	11.170	9.202	6.315	7.287	7.884
	(1.530)	(1.275)	(0.893)	(1.034)	(1.120)
Firm age	0.066**	0.069**	0.051*	0.061**	0.061**
	(2.621)	(2.754)	(1.946)	(2.427)	(2.404)
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.092	0.121	0.096	0.090	0.085
Observations	267	267	267	267	267

*Notes: 1. Unstandardized coefficients are given. 2. t-statistics are reported in parentheses. 3. *** indicates significance at the 0.01 level, ** indicates significance at the 0.05 level and * indicates significance at the 0.1 level. 4. Firm size is expressed in the natural logarithm of total assets.*

Table 9: OLS Regression - Tobin's Q

	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	6.392***	6.556***	5.229***	6.852***	6.785***
	(6.242)	(6.341)	(4.498)	(7.378)	(6.981)
Total board size	-0.051***				
	(-2.656)				
MB size		0.017			
		(0.269)			
SB size		-0.065***			

		(-2.842)			
Board independence ratio			1.595***		
			(3.327)		
Gender diversity ratio				-3.412***	
				(-3.068)	
MB gender diversity ratio					-1.581*
					(-1.602)
SB gender diversity ratio					-1.787**
					(-2.075)
Firm size	-0.100*	-0.115**	-0.136***	-0.112**	-0.112**
	(-1.826)	(-2.034)	(-2.873)	(-2.198)	(-2.082)
Leverage ratio	-3.122***	-3.065***	-3.275***	-3.374***	-3.476***
	(-5.402)	(-5.283)	(-5.885)	(-6.082)	(-6.244)
Firm age	-0.002	-0.002	-0.001	-0.003	-0.003
	(-1.095)	(-1.129)	(-0.513)	(-1.304)	(-1.289)
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.266	0.267	0.277	0.273	0.262
Observations	267	267	267	267	267

*Notes: 1. Unstandardized coefficients are given. 2. t-statistics are reported in parentheses. 3. *** indicates significance at the 0.01 level, ** indicates significance at the 0.05 level and * indicates significance at the 0.1 level. 4. Firm size is expressed in the natural logarithm of total assets.*

6. Conclusion

This study examined the impact of board characteristics on firm performance for German listed firms. The relationship between the board characteristics and firm performance is tested by conducting an OLS regression analysis, using data from a sample of 89 German firms from the Frankfurt Stock Exchange. The main objective of this study was to find an answer to the research question and thereby contributing to the literature written on this topic. The research question of this study was formulated as follows:

What is the impact of the board of directors' characteristics on the firm performance of firms listed in Germany?

The German board structure is quite unique with the separation of the management and supervisory board and codetermination laws that can be applicable to firms. This unique structure made the analysis of the results even more interesting. In order to understand the potential impact of board characteristics, several theories and previous empirical studies have been researched. Theories that are important in the analysis of board characteristics and firm performance are agency theory, stewardship theory, resource dependence theory and human capital theory. These theories have been used throughout literature focusing on the topic of corporate governance and firm performance. Hypotheses have been formed based on these theories and previous empirical findings.

The OLS regression model has been formed to test the hypotheses and eventually provide an answer to the research question. The model included the dependent, independent and control variables. As dependent variables, two accounting-based measures (ROA and ROE) and one market-based measure (Tobin's Q) have been used. The independent variables were the board characteristics – board size, board independence and gender diversity. In addition, several control variables were included, these were firm size, leverage ratio, firm age, year and industry dummies.

The first board characteristic to be tested was the board size and its impact on firm performance. Board size in this study was classified in total board size, management board size and supervisory board size. According to agency theory, larger boards increase agency costs and the problem of free riding among the many board members arises which eventually has a negative effect on firm performance (Kao et al., 2019). Therefore, Hypothesis 1 stated that smaller boards have a positive impact on firm performance. This was tested for total board size, management board size and supervisory board size. Evidence in this study shows that there is a negative significant relationship between total board size and all three performance measures meaning that Hypothesis 1A is confirmed. In addition, Hypothesis 1B regarding the management board size is confirmed for both accounting-based performance measures. On the other hand, management board size has no significant relation with Tobin's Q, thus Hypothesis 1B is rejected for the market-based measure. Furthermore, supervisory board size has no significance with ROA and ROE, thus Hypothesis 1C is rejected for the accounting-based measures. However, supervisory board size does have a negative significance with Tobin's Q, which means that Hypothesis 1C is confirmed for the market-based measure.

The second board characteristic that was tested was board independence, which was defined as the ratio of supervisory board members who are no employee representatives to the total number of supervisory board members. Empirical literature provided mixed findings, however the main idea was that increasing the number of independent members positively affects firm performance because of their effective monitoring and supervising activities. Therefore, Hypothesis 2 stated that a greater proportion of independent directors on boards has a positive impact on firm performance. Opposed to the expected, ROA and ROE have a negative significant relationship meaning that Hypothesis 2 is rejected. However, for Tobin´s Q the relationship is significant and positive, thus Hypothesis 2 is confirmed for the market-based measure.

The third board characteristic was gender diversity, defined as the ratio of female board members to the total board, management board and supervisory board separately. Gender diversity and the board of directors have especially been relevant topics in recent years and received a lot of attention in public debates, academic research and corporate strategy (Marinova et al., 2010). All theories presented positive perspectives on gender diversity on boards and described that it can have a positive impact on firm performance. Hypothesis 3 stated that a greater proportion of female directors has positive impact on firm performance. This study finds no evidence that gender diversity has an impact on accounting-based performance since there is no significant relationship, causing a rejection of Hypotheses 3A, 3B and 3C for ROA and ROE. In addition, there is a significant negative relation between gender diversity and Tobin's Q. Thus, contrary to the expected, increased gender diversity has a negative impact on market-based performance causing a rejection of Hypotheses 3A, 3B and 3C.

Concluding, smaller boards in this study sample are more favorable for firm performance. Greater board independence has a negative impact on ROA and ROE, and is favorable for Tobin's Q. Gender diversity has no impact on accounting-based performance and a significant negative impact on Tobin's Q.

7. Limitations and Recommendations

This study provides relevant results on the impact of board characteristics on firm performance in Germany. However, there are some limitations that should be considered and recommendations for future research on the topic. First of all, the firms in this sample were chosen from the largest stock exchange and its indices, therefore the results should not be generalized for all German firms. In addition, the focus of this study was on German firms which have a unique board structure with the separation of management and supervisory board and codetermination law. This means that it is not possible to consider the results as a worldwide effect regarding the specific board characteristics and firm performance. For future studies on the impact of board characteristics on firm performance in Germany it is recommended to include a wider variety of firms. Furthermore, for future studies on board characteristics of two-tier board structures it is recommended to make a comparison of the same characteristics on different countries. This makes it possible to analyze whether the results are country or board structure specific.

Secondly, the research period of this study was from 2017 to 2019 in order to measure the impact of the in 2016 introduced gender quota for German supervisory boards. As the results show, the impact is not as expected resulting in rejecting Hypothesis 3. A reason for this could be that there is only one year between the introduction of the gender quota and the collection of data on gender diversity. Therefore it is possible that the potential positive effects are not established yet in this sample and research period. A recommendation would be to widen the range of the research period for this specific characteristic and compare the results of prior gender quota and after gender quota. This method could help in analyzing the effects of the gender quota, and whether there is a change in the impact, either positively or negatively.

Thirdly, in the OLS regression model choices have been made for defining and measuring specific dependent, independent and control variables. Previous studies on the topic played an important role in this process and method. A recommendation for future studies would be to consider different methods to control for the results of firm performance with other variables. Another point is that board independence in this study was defined as the ratio of no employee representatives on the supervisory board to the total supervisory board. Future studies on two-tier board structures could consider another definition for board independence.

References

Abidin, Z. Z., & Jusoff, K. (2009). Board Structure and Corporate Performance in Malaysia. *International Journal of Economics and Finance*, *1*(1), 150–164.

Albert Resources. (2020). Key Assumptions of OLS: Econometrics Review. https://www.albert.io/blog/key-assumptions-of-ols-econometrics-review/.

Ammari, A., Kadria, M., & Ellouze, A. (2014). Board Structure and Firm Performance: Evidence from French Firms Listed in SBF 120. *International Journal of Economics and Financial Issues*, *4*(3), 580–590.

Bennouri, M., Chtioui, T., Nagati, H., & Nekhili, M. (2018). Female board directorship and firm performance: What really matters? *Journal of Banking and Finance*, *88*, 267–291.

Bermig, A., & Frick, B. (2010). Board Size, Board Composition, and Firm Performance: Empirical Evidence from Germany. *SSRN Electronic Journal*, 1–42.

Best, H., & Wolf, C. (2015). Regression Analysis and Causal Inference. *SAGE*, 1–32.

Bezemer, P.-J., Peij, S., de Kruijs, L., & Maassen, G. (2014). How two-tier boards can be more effective. *Corporate Governance*, *14*(1), 15–31.

Block, D., & Gerstner, A.-M. (2016). One-Tier vs. Two-Tier Board Structure: A Comparison Between the United States and Germany. *Comparative Corporate Governance and Financial Regulation*.

Boneberg, F. (2010). The economic consequences of one-third co-determination in German supervisory boards: First evidence for the service sector from a new source of enterprise data. *EconStor*, 1–31.

Bosse, D. A., & Phillips, R. A. (2016). Agency Theory and Bounded Self-Interest. *Academy of Management Review*, *41*(2), 276–297.

Bozhinov, V., Joecks, J., & Scharfenkamp, K. (2021). Gender spillovers from supervisory boards to management boards. *Managerial and Decision Economics*, *42*(2), 1–15.

Bozhinov, V., Koch, C., & Schank, T. (n.d.). Has the Push for Equal Gender Representation Changed the Role of Women on German Supervisory Boards? *Schmalenbach Business Review*, *71*(3), 385–411.

Daoud, J. I. (2017). Multicollinearity and Regression Analysis. *Journal of Physics*, 1–7.

Darmadi, S. (2011). Board compensation, corporate governance, and firm performance in Indonesia. *SSRN Electronic Journal*, 1–45.

Darmadi, S. (2011). Board diversity and firm performance: the Indonesian evidence. *Corporate Ownership and Control Journal*, *8*, 1–39.

Dimov, D. P., & Shepherd, D. A. (2005). Human capital theory and venture capital firms: exploring ‘‘home runs’’ and ‘‘strike outs.’’ *Journal of Business Venturing*, *20*, 1–21.

Donaldson, L., & Davis, J. H. (1991). Stewardship Theory or Agency Theory: CEO Governance and Shareholder Returns. *Australian Journal of Management*, *16*(1), 49–65.

du Plessis, J. J. (2004). The German Two-Tier Board and the German Corporate Governance Code. *European Business Law Review*, 1139–1164.

Duru, A., Iyengar, J., & Zampelli, E. (2016). The dynamic relationship between CEO duality and firm performance: The moderating role of board independence. *Journal of Business Research*, 1–9.

Ees, H. van, Postma, T. J. B. M., & Sterken, E. (2003). Board Characteristics and Firm Performance in the Netherlands. *Eastern Economic Journal*, *29*(1), 41–58.

El-Faitouri, R. (2014). Board of Directors and Tobin’s Q: Evidence from U.K.Firms. *Journal of Finance and Accounting*, *2*(4), 82–99.

Farahani, H. A., Rahiminezhad, A., Same, L., & Immannezhad, K. (2010). A Comparison of Partial Least Squares (PLS) and Ordinary Least Squares (OLS) regressions in predicting of couples mental health based on their communicational patterns. *Procedia Social and Behavioral Sciences*, *5*, 1459–1463.

Fauver, L., & Fuerst, M. E. (2006). Does Good Corporate Governance Include Employee Representation? Evidence from German Corporate Boards. *Journal of Financial Economics*, *82*(3), 673–710.

Fiss, P. C. (2006). Social Influence Effects and Managerial Compensation Evidence From Germany. *Strategic Management Journal*, *27*, 1013–1031.

Gani, L., & Jermias, J. (2006). Investigating the effect of board independence on performance across different strategies. *The International Journal of Accounting*, *41*, 295–314.

Gillies, D. (2015). Human Capital Theory in Education. *Encyclopedia of Educational Philosophy and Theory,* 1–5.

Glinkowska, B., & Kaczmarek, B. (2015). Classical and modern concepts of corporate governance (Stewardship Theory and Agency Theory). *Management*, *19*(2), 84–92.

Gogtay, N. J., & Thatte, U. M. (2017). Principles of Correlation Analysis. *Journal of the Association of Physicians of India*, *65*, 78–81.

Graf, A., & Stiglbauer, M. (2009). Board Size and Firm Operating Performance: Evidence from Germany. *Corporate Board*, *5*(1), 37–47.

Green, C. P., & Homroy, S. (2017). Female Directors, Board Committees and Firm Performance. *SSRN Electronic Journal*, 1–52.

Hidayat, A. A., & Utama, S. (2016). Board Characteristics and Firm Performance: Evidence from Indonesia. *International Research Journal of Business Studies*, *8*(3), 137–154.

Joecks, J., Pull, K., & Vetter, K. (2012). Gender Diversity in the Boardroom and Firm Performance: What Exactly Constitutes a "Critical Mass"? *Journal of Business Ethics*, 1–23.

Johnson, B. L. (1995). Resource Dependence Theory:A Political Economy Model of Organizations, 1–21.

Jungmann, C. (2007). The Effectiveness of Corporate Governance in One-Tier and Two-Tier Board Systems - Evidence from the UK and Germany. *European Company and Financial Law Review*, *3*(4), 426–474.

Kao, M., Hodgkinson, L., & Jaafar, A. (2019). Ownership structure, board of directors and firm performance: Evidence from Taiwan. *Corporate Governance*, *19*(1), 189–216.

Keay, A. (2017). Stewardship Theory: Is Board Accountability Necessary? *International Journal of Law and Management*, *59*(6), 1292–1314.

Kor, Y. Y. (2008). Experience-Based Human Capital and Social Capital of Outside Directors. *Journal of Management*, 1–26.

Latif, R. A., Kamardin, H., Mohd, K. N. T., & Adam, N. C. (2013). Multiple Directorships, Board Characteristics and Firm Performance in Malaysia. *Management*, *3*(2), 105–111.

Li, K., Lu, L., Mittoo, U. R., & Zhang, Z. (2015). Board independence, ownership concentration and corporate performance—Chinese evidence. *International Review of Financial Analysis*, *41*, 162–175.

Lückerath-Rovers, M. (2013). Women on boards and firm performance. *Journal of Management and Governance*, *17*, 491–509.

Makhlouf, M., Laili, N., Basah, M., & Ramli, N. (2017). Board of Directors' Effectiveness and Firm Performance: Evidence from Jordan. *Research Journal of Finance and Accounting*, *8*(18), 23–34.

Marinova, J., Plantenga, J., & Remery, C. (2010). Gender Diversity and Firm Performance: Evidence from Dutch and Danish Boardrooms. *The International Journal of Human Resource Management*, 1–28.

Martin, C., & Herrero, B. (2018). Board of directors: Composition and effects on the performance of the firm. *Economic Research*, *31*(1), 1015–1041.

Martinez, M., & Alvarez, I. (2019). Do board characteristics drive firm performance? An international perspective. *Review of Managerial Science*, 1–47.

Mummolo, J., & Peterson, E. (2018). Improving the Interpretation of Fixed E ects Regression Results. *Semantic Scholar*, 1–15.

Naciti, V. (2019). Corporate governance and board of directors: The effect of a board composition on firm sustainability performance. *Journal of Cleaner Production*, *237*, 1–8.

Nienhüser, W. (2008). Resource dependence theory: How well does it explain behavior of organizations? *Management Revue*, *19*(1), 9–32.

O'Connell, V., & Cramer, N. (2010). The relationship between firm performance and board characteristics in Ireland. *European Management Journal*, *28*, 387–399.

Panda, B., & Leepsa, N. M. (2017). Agency theory: Review of Theory and Evidence on Problems and Perspectives. *Indian Journal of Corporate Governance*, *10*(1), 74–95.

Poston Jr, D. L. (2021). *Ordinary Least Squares Regression*. International Encyclopedia of the Social Sciences. https://www.encyclopedia.com/social-sciences/applied-and-social-sciences-magazines/ordinary-least-squares-regression.

Pugliese, A., Minichilli, A., & Zattoni, A. (2014). 0 Integrating Agency and Resource Dependence Theory: Firm Profitability, Industry Regulation, and Board Tasks Performance. *Journal of Business Research*, *67*(6), 1189–1200.

Ramdani, D., & Witteloostuijn, A. (2010). The Impact of Board Independence and CEO Duality on Firm Performance: A Quantile Regression Analysis for Indonesia, Malaysia, South Korea and Thailand. *British Journal of Management*, *21*, 607–626.

Schillemans, T., & Bjurstrøm, K. H. (2020). Trust and verification: balancing agency and stewardship theory in the governance of agencies. *International Public Management Journal*, *23*(5), 650–676.

Shukeri, S. N., Shin, O. W., & Shaari, M. S. (2012). Does Board of Director's Characteristics Affect Firm Performance? Evidence from Malaysian Public Listed Companies. *International Business Research*, *5*(9), 120–127.

Smith, N., Smith, V., & Verner, M. (2005). Do Women in Top Management Affect Firm Performance? A Panel Study of 2500 Danish Firms. *International Journal of Productivity and Performance Management*, *55*(7), 1–37.

Soare, T., Detilleux, C., & Deschacht, N. (2021). The impact of the gender composition of company boards on firm performance. *International Journal of Productivity and Performance Management*, 1–20.

Statistical Solutions. (2021). Two-Stage Least Squares (2SLS) Regression Analysis. https://www.statisticssolutions.com/free-resources/directory-of-statistical-analyses/two-stage-least-squares-2sls-regression-analysis/.

Steger, T. (2007). Internationality of Supervisory Boards and Firm Performance: Evidence From large listed German Companies. *SCMS Journal of Indian Management*, 5–19.

Terjesen, S., Couto, E., & Francisco, P. (2016). Does the presence of independent and female directors impact firm performance? A multi-country study of board diversity. *Journal of Management and Governance*, *20*, 447–483.

Terjesen, S., Singh, V., & Vinnicombe, S. (2008). Do women still lack the 'right' kind of human capital for directorships on the FTSE 100 corporate boards? *ResearchGate*, 152–164.

Torres-Reyna, O. (2007). Panel Data Analysis Fixed and Random Effects using Stata. *Princeton University*, 1–40.

Valenti, A., & Horner, S. (2020). THE HUMAN CAPITAL OF BOARDS OF DIRECTORS AND INNOVATION: AN EMPIRICAL EXAMINATION OF THE PHARMACEUTICAL INDUSTRY. *International Journal of Innovation Management*, *24*(6), 1–32.

Weidler, H. L. (2020). Does the gender quota make sense? Women on supervisory boards and firm performance. *Barcelona School of Management*, 1–39.

Appendices

Appendix A: List of sample firms

1&1 AG	Deutsche Post AG	Jenoptik AG	Serviceware SE
Adidas AG	Deutsche Telekom AG	Jungheinrich AG	Siemens AG
Aixtron SE	Deutsche Wohnen SE	K+S Aktiengesellschaft	Siltronic AG
Alstria Office Reit-AG	Duerr Aktiengesellschaft	Kion Group AG	SMA Solar Technology AG
Aurubis AG	E.ON SE	Knorr-Bremse AG	Software AG
Aves One AG	Eckert & Ziegler Strahlen- und Medizintechnik AG	Lanxess AG	Stroeer SE & Co. KGAA
Basf SE	Elumeo SE	LEG Immobielen SE	Symrise AG
Bayer AG	Evonik Industries AG	Merck KGAA	TAG Immobilien AG
Bayerische Motoren Werke AG	Evotec SE	Morphosys AG	Telefonica Deutschland Holding AG
Bechtle AG	Fraport AG	MTU Aero Engines AG	ThyssenKrupp AG
Beirsdorf AG	Freenet AG	Nagarro SE	Uniper SE
Brenntag SE	Fresenius Medical Care AG & Co.KGAA	Nemetschek SE	United Internet AG
Cancom SE	Fresenius SE & Co. KGAA	Nordex SE	VA-Q-TEC AG
Capsensixx AG	Fuchs Petrolub SE	Pfeiffer Vacuum Technology AG	Varta AG
Carl Zeiss Meditec AG	GEA Group AG	Porsche Automobil Holding SE	Volkswagen AG
Continental AG	Gerresheimer AG	Prosiebensat.1 Media SE	Voltabox AG
Covestro AG	Heidelbergcement AG	Puma SE	Vonovia SE
Creditshelf AG	Hella Gmbh & Co. KGAA	Rational AG	Wacker Chemie AG
CTS Eventim AG & Co. KGAA	Hellofresh SE	Rheinmetall AG	Zalando SE
Daimler AG	Henkel AG & Co.	RWE Aktiengesellschaft	Zooplus AG
Delivery Hero SE	Hugo Boss AG	SAP SE	
Dermapharm Holding SE	Hypoport AG	Sartorius AG	
Deutsche Lufthansa AG	Infineon Technologies AG	Scout24 AG	

Appendix B: Frequencies

Supervisory Board Employee Representatives

	Frequency	Percent	Cumulative Percent
0	96	36	36
1	4	1.5	37.5
2	17	6.4	43.8
3	6	2.2	46.1
6	66	24.7	70.8
7	2	0.7	71.5
8	32	12	83.5
9	10	3.7	87.3
10	30	11.2	98.5
11	3	1.1	99.6
12	1	0.4	100
Total	267	100	

Independent Supervisory Board Members

	Frequency	Percent	Cumulative Percent
3	21	7.9	7.9
4	21	7.9	15.7
5	17	6.4	22.1
6	108	40.4	62.5
7	9	3.4	65.9
8	35	13.1	79
9	9	3.4	82.4
10	26	9.7	92.1
11	15	5.6	97.8
12	5	1.9	99.6
13	1	0.4	100
Total	267	100	

Management Board Female Directors

	Frequency	Percent	Cumulative Percent
0	180	67.4	67.4
1	70	26.2	93.6
2	17	6.4	100
Total	267	100	

Supervisory Board Female Directors

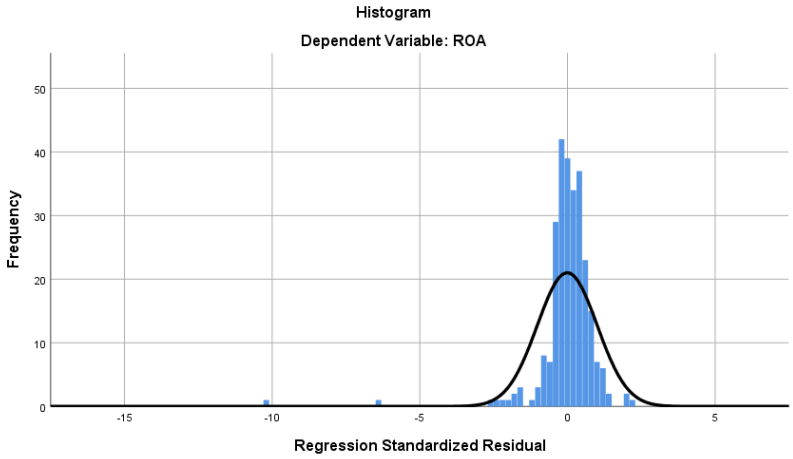
	Frequency	Percent	Cumulative Percent
0	33	12.4	12.4
1	49	18.4	30.7
2	37	13.9	44.6
3	18	6.7	51.3
4	57	21.3	72.7
5	21	7.9	80.5
6	32	12	92.5
7	11	4.1	96.6

8	7	2.6	99.3
9	2	7	100
Total	267	100	

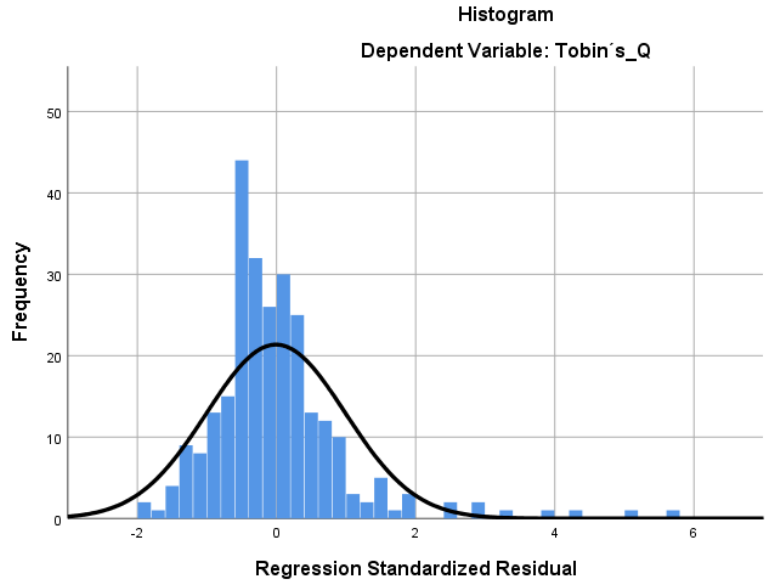
Appendix C: Regression Standardized Residual

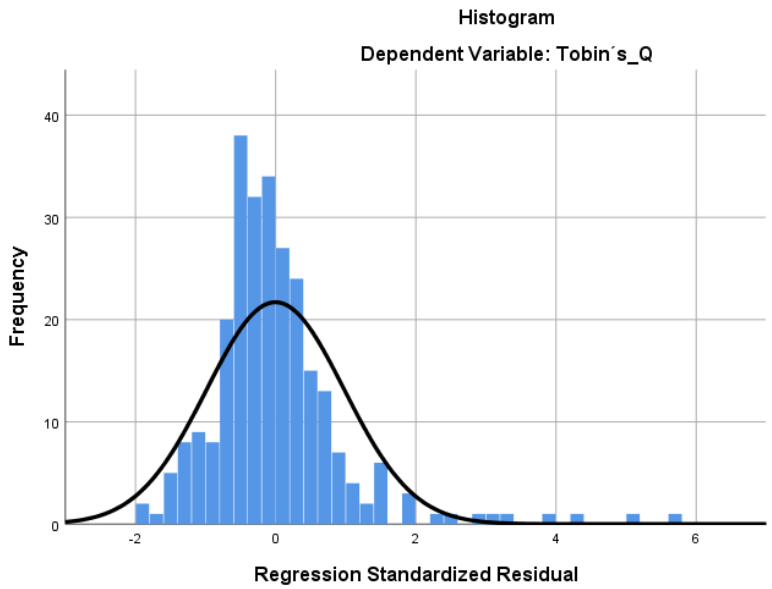
Regression standardized residual histograms of the models with a significance at the 0.01 level.

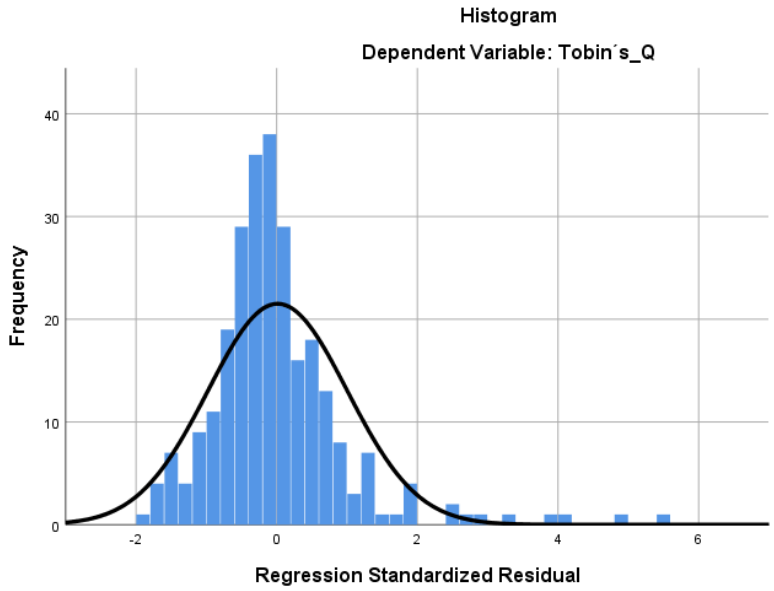
ROA Model 2

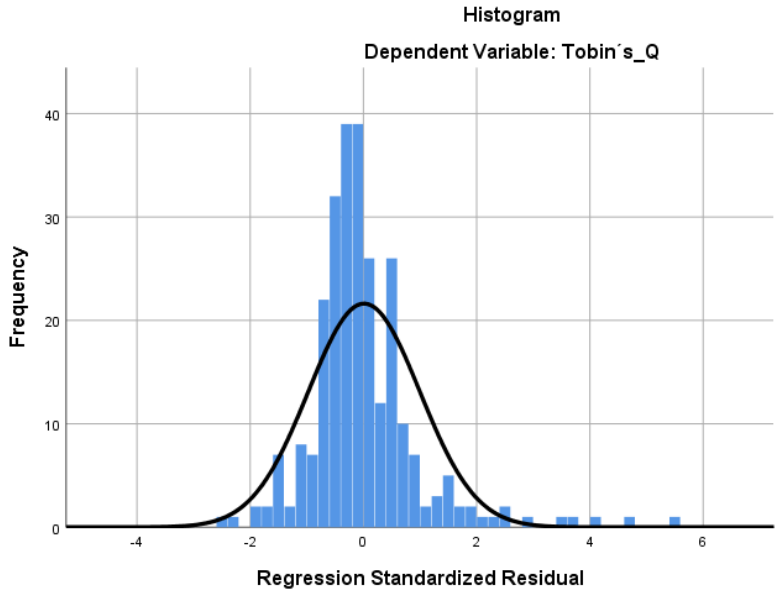


Tobin's Q Models 1 - 4



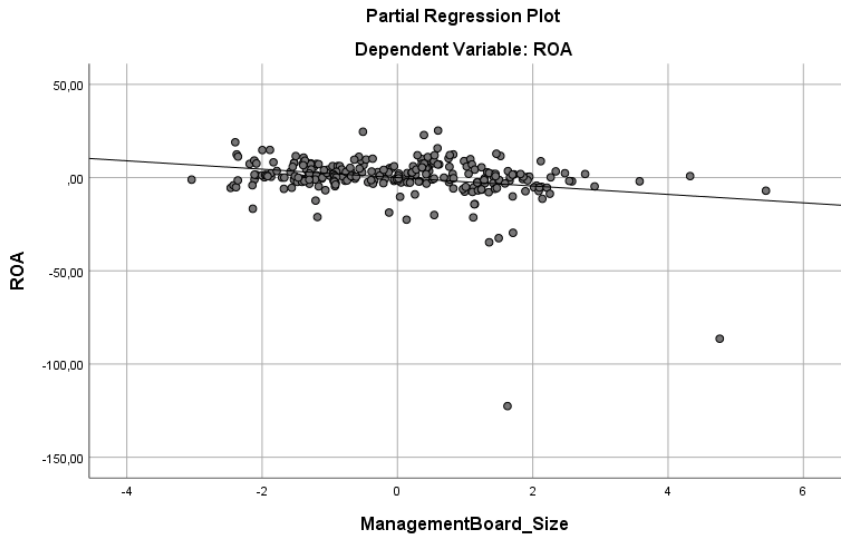

Histogram
Dependent Variable: Tobin´s_Q
Frequency
Regression Standardized Residual

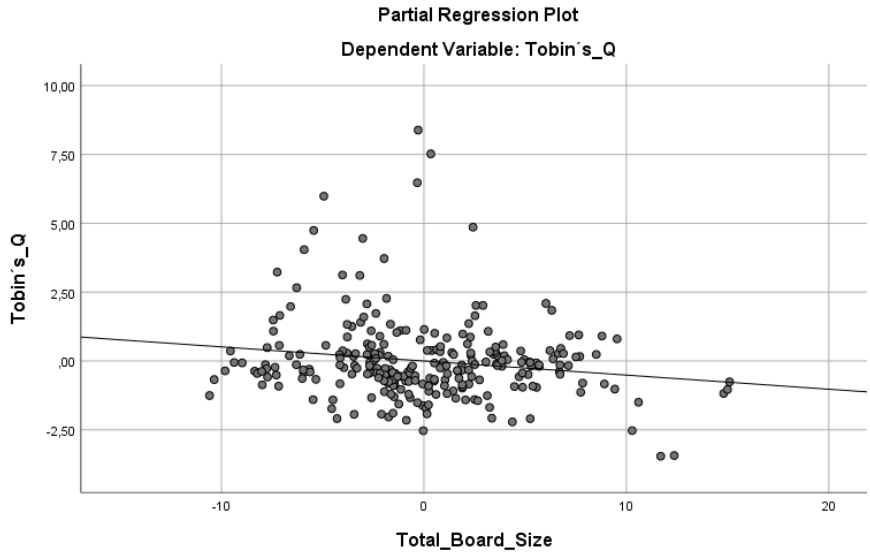

Histogram
Dependent Variable: Tobin´s_Q
Frequency
Regression Standardized Residual

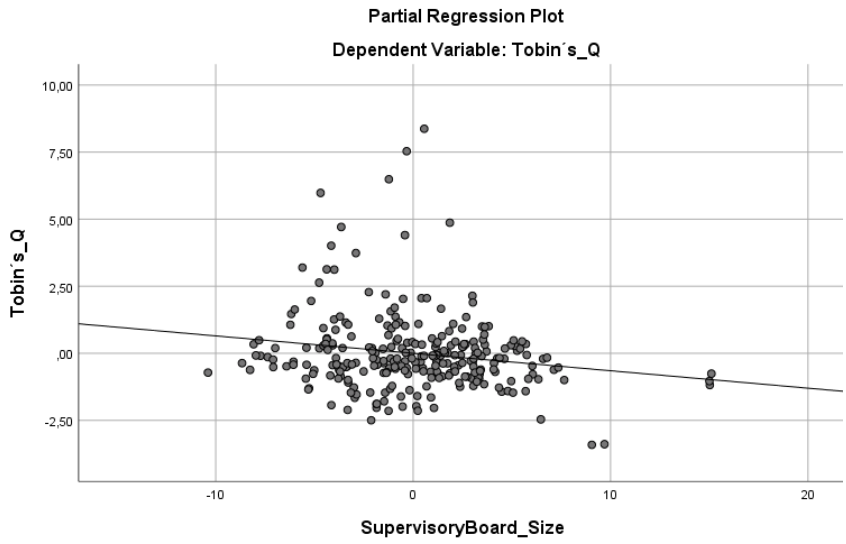

Histogram
Dependent Variable: Tobin´s_Q
Frequency
Regression Standardized Residual

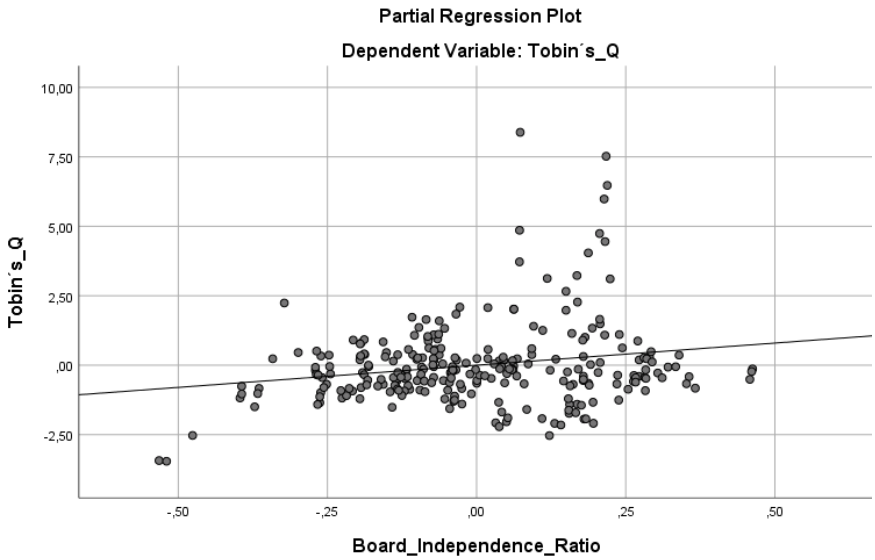
Appendix D: Regression Plots

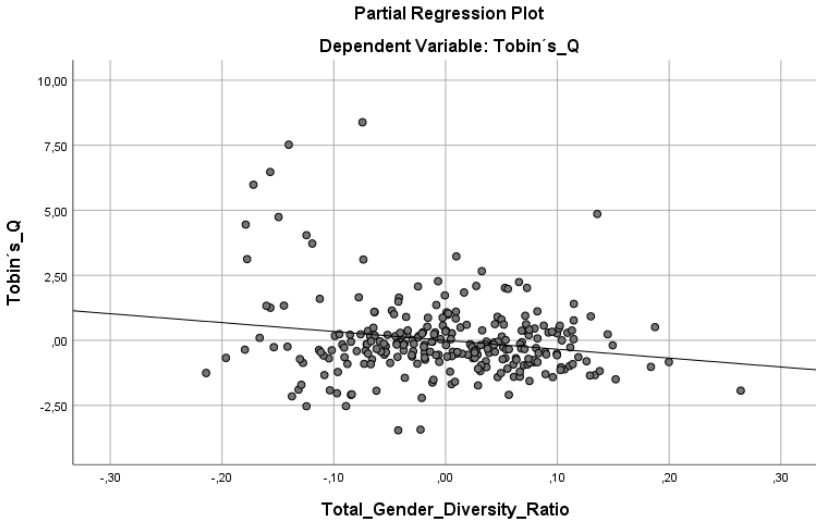
Regression plots of significant regression results at the 0.01 level.








Partial Regression Plot
Dependent Variable: Tobin´s_Q
Tobin´s_Q
10,00
7,50
5,00
2,50
,00
-2,50
-,50
-,25
,00
,25
,50
Board_Independence_Ratio


Partial Regression Plot
Dependent Variable: Tobin´s_Q
Tobin´s_Q
10,00
7,50
5,00
2,50
,00
-2,50
-,30
-,20
-,10
,00
,10
,20
,30
Total_Gender_Diversity_Ratio