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The Effect of Gender Quotas on Female Leadership in Corporate Positions

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Abstract

Women frequently face challenges trying to break through the glass ceiling and are often underrepresented in leadership positions. To tackle gender inequalities at the top of the hierarchy, several European countries have implemented national gender quotas. In 2016, Germany approved a 30%- gender quota for boardroom positions. Empirical contributions on the impact of gender quotas on female leadership remain superficial. Therefore, this study seeks to understand the impact of gender quotas by examining whether the German gender quota influences female representation in leadership such as board chair- or CEO positions. Furthermore, the effect of the gender quota is also examined in companies with more board interlock and companies active in male-dominated industries. By using a sample of 380 German listed companies in the period 2010-2020, companies subject to the quota are compared to companies not subject to the quota, using a difference-in-difference model. The difference-in-difference analyses suggest there is a significant relationship between gender quota and female representation on boards, however, the results are potentially subject to bias. Additionally, a probit regression model and a two-stage linear probability regression are used to estimate the effect of the quota on the probability of having a female CEO or -chair. Due to statistical insignificance, the results are not able to conclude whether the German gender quota results in more female leadership. Despite the limitations, this study fills an important gap in this area of research and lays a foundation for future studies on the effect of gender quotas on female leadership.

Keywords: Gender Quota, Difference-in-Difference, Germany, CEO, Chair.

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1. Introduction

On 25 September 2015, the United Nations General Assembly agreed to adopt the 2030 Agenda for Sustainable Development. This Agenda is the negotiated and agreed framework for achieving international development and therefore applies to all countries as opposed to goals exclusively being focused on developing countries (UN Women, n.d). By containing separate objectives on gender discrimination and the empowerment of both women and girls, the Agenda does not only emphasize problems such as poverty and education but is also largely centered around gender equality. Two of the central goals of this Agenda are to encourage women's involvement in politics and leadership roles to strengthen the economic position of women. Accordingly, women should have equal rights in all legal systems which should be enforced by legislation, including using proactive measures such as gender quotas. By devoting its goals on this Agenda to gender equality, the United Nations are dedicated to achieving women's equality and empowerment (UN Women, n.d.).

The need for these goals is evident in the slow progress of the proportion of women in top-level positions. In the last 15 years, efforts to minimize gender discrimination and strengthen the economic position of women have shown to result in increasingly more women in the workforce and politics (Haslam & Ryan, 2008; UN Women, n.d.). Still, there is low female representation in leadership positions and women tend to primarily occupy the lower and middle ranks within organizations (Haslam & Ryan, 2008). This phenomenon is often attributed to the 'glass ceiling' effect (Cook & Glass, 2014). Cotter, Hermsen, Ovadia, and Vanneman (2001) define this effect as the occurrence of gender- (or other) disadvantages being more prominent at the very top of the hierarchy as opposed to lower levels; and these disadvantages becoming more evident later on in ones' career. To illustrate, the 6th edition of Deloitte's Women in the Boardroom report (2019) examined the percentage of board seats occupied by women worldwide to raise awareness for gender diversity in these positions. Globally, women only held 16.9 percent of the board seat positions in 2019, while women accounted for no more than 5.3 percent of the chair positions and a mere 4.4 percent of them held chief executive officer (CEO) positions. Therefore, the fact that females remain severely underrepresented within boards- and leadership worldwide is certainly not a new phenomenon, but the pace of progress to reverse this trend remains slow.

To tackle gender inequalities at the top of the hierarchy, several European countries have already implemented national gender quotas. Recently, Germany approved two laws on establishing gender quotas for boardroom positions to increase the number of women on boards. As of January 2016, listed companies subject to the co-determination act[1] are required to have a minimum of 30% women on non-

[1] Companies with more than 2000 employees, require having employee representation for at least half of the supervisory board.

executive board seats (The Guardian, 2015). Building on this agreement, as of 1 January 2022 publicly traded private companies, which are co-determined, will have to appoint at least one woman and one man to their executive (management) board (Gesley, 2021). Similar to Germany, the Norwegian government introduced a 40% gender quota in 2005 for corporate board members to enhance gender equality in board positions (Wang & Kelan, 2013). Additionally, other European countries like France, Spain, and Iceland have also introduced quotas for female representation on corporate boards (Teigen, 2012). These statutory gender quotas for supervisory boards are closely related to the expectation that having more women in top positions will improve females' access to executive positions (Holst & Wrohlich, 2017). Enabling women to participate in boardrooms could ensure more equal opportunities to reach higher top positions, both in the boardroom as well as other positions within the company (Wang & Kelan, 2013).

There has been increasing debate about the underrepresentation of women in corporate boardrooms and gender quotas over the last few years. Not surprisingly, there are many studies examining the effect of gender quotas. A particular area of focus in many of these studies is the impact of gender quotas on corporate performance and females' involvement. For example, a study on the Norwegian gender quota in 2005 shows that the gender quota led to huge numbers of inexperienced women being appointed to board positions. As a result, some companies' stock performances were severely damaged (Ahern & Dittmar, 2012). Another effect was encountered in the study by De Paola, Scoppa, and Lombardo (2010), who found that gender quotas have a positive impact on women's involvement in political activities. The authors show that exposure to women in leadership roles helps to eliminate negative stereotypes about women. Central to this area of research are differences in gendered leadership styles and personal characteristics (Eagly & Johnson, 1990; Burke & Collins, 2001). For example, Burke and Collins (2001) found that women's leadership styles are positively associated with different successful management skills. Whereas Bennouri, Chtioui, Nagati and Nekhili (2018) suggest that female director traits negatively affect the relationship between female leadership and market-based performance of firms. Lastly, Wang and Kelan (2013) conducted a study on the effect of Norwegian gender quotas in boardrooms and the impact of gender quotas on the presence of women in leadership positions, such as CEOs and chairman. Their study found that women are encouraged to take up leadership positions by the gender quota. Nevertheless, research on gender quotas is still in its early stages, with a small but increasing number of contributions.

Although the effectiveness of gender quotas is often put up for discussion, previous research has focused primarily on leadership styles of women who make it to top positions or the effect of these quotas on firm performance. Since gender quotas are designed with the idea of women breaking the glass ceiling and allowing women to gain more access to executive positions (Holst & Wrohlich, 2017), it is interesting to see where these quotas work most effectively. In most cases gender quotas in corporate

boardrooms should primarily be reflected in the percentage of women in boardrooms, however, they might also affect the number of women in other (non)-executive positions. Therefore, this study seeks to understand the impact of gender quotas on women in leadership positions[2], by examining whether the German statutory gender quota requiring 30% women on supervisory boards shows an effect on female representation in CEO- or chair positions. In Germany, this gender quota has been effective as of January 1st, 2016, therefore this post-intervention period makes for an interesting study. This leads to the following research question:

What is the effect of the 30%-gender German quota in 2016 on female leadership in corporate positions for German companies?

By using a sample of 380 German listed companies in the period of 2010-2020, this study examines whether the statutory gender quota of 2016 shows an effect on female representation in leadership positions such as board chair- or CEO positions. Additionally, women in board positions are assessed in male dominated industries and in companies with board interlock after the introduction of the quota. German listed companies subject to the quota are compared to German listed companies which are not subject to the quota to estimate the effect of the German policy reform of the hard gender quota in 2016, using a difference-in-difference model. Lastly, a probit model and a two-stage linear probability regression are performed to estimate the effect of the quota on the probability of companies having a female CEO or -chair.

Answering this research question is relevant since recent developments in the field of gender quotas have led to a renewed interest in whether these quotas are effective in achieving more gender equality (e.g., the increasing number of national gender quota regulations in Europe and new EU proposals on gender quota regulations (Kleis, 2022)). While the subject of gender representation in corporate boardrooms and the involvement of women in top positions have increasingly come to the forefront of public debate, there a few to no empirical contributions on the impact of statutory gender quotas on female leadership. Therefore, the primary goal of this study is to assess the extent to which gender quotas result in more females in leadership positions rather than only in board positions.

In the first section, the theoretical framework provides an overview of previously conducted studies related to gender quotas and outlines the considered hypotheses. The second section on methodology and data discusses the datasets and presents the econometric methods applied for each of the hypotheses, including some robustness checks to ensure the validity of the results. Subsequently, the next section discusses the corresponding results, including some robustness checks. Following, the conclusion and

[2] Leadership positions in this study are defined as CEO- or chair positions.

discussion provide a summary of the findings and general conclusions of this study. The final section contains both limitations and recommendations for future research.

2. Theoretical Framework

This section reviews the existing literature on gender representation and gender quotas in boardrooms by identifying the barriers to women occupying leadership positions. By using research on gender quotas and studies on why women are less likely to make it into corporate boardrooms, this section aims to understand countries' decisions on whether to enact gender diversity laws in boardrooms. The first section consists of supply and demand explanations that attempt to clarify the low level of female representation on corporate boards. Subsequently, literature on gender quotas and the implementation of gender quotas in different countries is discussed. The final section provides an overview of board structures in Germany.

2.1 Explanatory factors for low female representation

To analyze whether gender quotas affect female leadership in corporate positions, it is important to understand possible explanatory factors for low female representation. As many companies deal with the under-representation of women in managerial positions, this has raised many questions in the current literature. A prominent focus within this area of research is the question of why women tend to hold lower and middle management positions. This area of research, for example, explores the barriers to women attaining CEO positions (Oakley, 2000) or examines how gender bias impedes women's ability to gain easy access to higher levels within companies (Heilman, 2001). Other research seeks explanations for the ever-existing wage gap and lack of women in senior leadership positions (Johns, 2013). Gabaldon et al. (2016) describe in their paper, that the underrepresentation of women in board seats may have both demand-side and supply-side explanations. Demand-side explanations may include companies maintaining certain barriers for women to access higher positions or being unwilling to hire more women. On the other hand, there may also be supply-side explanations. For example, women may not be interested in reaching top positions or may want to balance their work and family life, thereby reducing the pool of qualified women. For this reason, the following section divides the existing literature into supply- and demand-side explanations following the example of Gabaldon et al. (2016).

2.1.1 Demand-side explanations

Within boardroom studies, stereotypical perceptions of women are often examined to see how it relates to the underrepresentation of women in board positions. These stereotypical perceptions within the hierarchy of top management of companies may reduce the demand for women to fill these positions. In their paper, Eagly and Karau (2002) state this prejudice against women may exist in two forms. The first one is that women are generally less valued as leaders than men when choosing a candidate for a leadership role; and the second, is that actual leadership behavior in women is perceived as less favorable than in men, since this behavior is perceived as more masculine. Consequently, this prejudice creates bias against women, making it more difficult for women to (easily) reach leadership positions. The

stereotypical idea of masculine leadership thereby contributes to the segregation of gendered leadership positions, with men generally tending to occupy the positions of authority (Garcia-Retamero & López-Zafra, 2006).

In the general population, men and women differ in personal characteristics (Kirsch, 2018). Therefore, stereotypical perceptions about women in leadership positions are likely to reflect gender roles in everyday life. Due to these gender differences being present in the general population, women are not expected to exhibit the masculine characteristics considered to be important predictors of successful leadership (Garcia-Retamero & López-Zafra, 2006). However, given that female directors have already reached the boards of directors (or have the desire to reach this position), they might as well share more similarities with their male colleagues in comparable positions than with women in the general population (Kirsch, 2018). For this reason, some authors assess the difference between men and women in top-positions. For example, in a study on Norwegian firms, the authors find no overall differences in behavior between men and women in management positions (Nielsen & Huse, 2010). In fact, their results show that women perform no differently from men in certain tasks such as operational control. Another study by Adams and Funk (2012) shows that men and women in the boardroom differ in core values and risk aversion. However, they show that these differences are not comparable to those in the general population. Also, Schein (1973) examines the relationship between gender stereotypes and managerial characteristics. The findings suggest that the similarities between the characteristics of successful middle managers and men, in general, increase the probability of selecting a male for a managerial position rather than a female. These results indicate that male candidates are generally found to be more associated with leadership positions and women face biased treatment when seeking to reach a management position (Tabassum & Nayak, 2021). Since the majority of top-level positions are held by men, masculine behavior and traits are mostly used as the default (Chisholm-Burns et al., 2017; Dunn et al., 2014). For this reason, female candidates are often assessed against male characteristics, when hiring or promoting women into executive positions.

However, not only do the stereotypical perceptions of women hamper the progress of more gender equality on corporate boards. Central within the process of shaping the gender composition of boardrooms is the appointment process. An important notion to understand some of the difficulties women encounter when trying to gain access to leadership positions is the so-called “corporate elite” (Useem, 1986; Kirsch, 2018). Here, incumbent executives prevent outsiders from gaining access to the board of directors. Since board appointments are often influenced by the demand for diversity from the side of the selectors, having a masculine established corporate elite is likely to be problematic for women aspiring to enter the board or other top positions (Kirsch, 2018). Within the ‘old boy’s network, males tend to have a negative attitude toward women wanting to reach higher positions and prevent them to break through the glass ceiling (Baumgartner & Schneider, 2010). Indeed, Gregorič et al. (2017) suggest

by studying women's access to corporate boards that there is persisting resistance to diversity within boards of directors among the already established corporate elite. However, such resistance weakens as the rate of diversity increases. Building on a case study of the Netherlands, Heemskerk and Fennema (2014) argue that state-controlled firms were one of the first to allow female representation on boards. Over the last few decades, female representation has increased, but this is mainly due to the elites opening up their ranks and privileged positions, which is (mostly) the result of outside pressure (Heemskerk & Fennema, 2014).

Besides the old boys' network and the stereotypical gender differences, also meso-factors seem to have an influence on women reaching board positions. Factors such as type of industry, type of organization or -board tend to influence female representation on boards (Kirsch, 2018). For example, in Science, Technology, Engineering and Mathematics (STEM) sectors the proportion of women on boards is smaller compared to companies in other industries (Adams & Kirchmaier, 2016). Similarly, Engen (2012) finds the banking- and the finance sector to be mostly male dominated industries. Studies examining the effect of meso-factors on women in board positions also argue that the beneficial effects of women in board positions depend on the company itself. For example, if the desire of the firm is to have more control over their corporate boards, hiring women could be beneficial for the firm since more gender-diverse boards appear to have better monitoring capabilities (Adams & Ferreira, 2009). Additionally, for businesses in the retail industry it could also be beneficial to have more female representation in their boards as this makes their board more representative in terms of their employees and consumers, which are mostly women (Kirsch, 2018). This demonstrates that certain industries can also influence female representation in board positions.

2.1.2 Supply-side explanations

The aforementioned factors seem to create (discriminatory) barriers for women to reach corporate board- and leadership positions. However, there may also be supply-side issues that contribute to the underrepresentation of women in these positions. Two important explanations on the supply-side are the educational background of women and their choices to work a part-time or full-time job. By means of these choices, women can affect the pool of adequate female candidates for leadership- or boardroom positions. To illustrate, women's choices on human capital investment as well as their working hours affect their (future-) career. This can result in a limited pool of qualified female workers for corporate board positions (Gregory-Smith et al., 2014) or other executive positions, making it harder for companies to find women suitable for these positions (Elmuti, Jia & Davis, 2009). Yet it is uncertain whether the pool of qualified women is really that small since there is not much data available. In the past, Norway set up four national databases of women who were interested in board positions to make women's competence more visible (Ahern & Dittmar, 2012), meaning there possibly is an adequate number of women suitable for these positions; however, they may be difficult to find.

Another factor that causes this pool of qualified female workers to remain small is the willingness of women to achieve top positions. Some research shows women generally care much less about power and achievement than males (Gabaldon et al., 2016; Adam & Funk, 2012). For example, Schuh et al. (2014) find that women consistently reported lower power motivation than their male colleagues. However, a Catalyst study (2004) showed that men and women in executive positions have the same desire to reach CEO positions; 55% of the women and 57% of the men responded in the survey that they aspired to a senior leadership position. Therefore, women in executive positions are supposedly more power-orientated than women in the general population. Still, the unwillingness in the general population of women to attain top-level positions causes the pool to remain small.

Additionally, many women face trade-offs between family and work. Generally, women spend a greater proportion of their time on family responsibilities than men, but an equal amount of time on work activities (Gabaldon et al., 2016). The choice to devote more hours to family responsibilities can consequently slow down their career progress which again causes a supply-side issue within the problem of gender underrepresentation in top positions. By looking at time-diary studies, for example, in the United States in 2005 a married woman devotes on average 19 hours per week to housework, while married men devoted only 11 hours (Eagly & Carli, 2018). In addition to household chores, women might also have to deal with pregnancies and childcare. Many employers fear that pregnant (executive) women may work less hard, subsequently take paid maternity leave and never return to the office (Hughes, 1991). Women can therefore be portrayed as being uncommitted to their jobs when they decide or express their desire to become pregnant, despite their efforts and achievements (Lyness et al., 1999). In some cases, pregnant women are even demoted or do not receive the promotions they were promised (Hughes, 1991; Swiss & Walker, 1993; Lyness et al., 1999). These inconveniences can cause a delay in their career progress. Together, all these factors lead to reduced availability and unequal career opportunities (Vinnicombe & Singh, 2003). Therefore, additional family responsibilities and pregnancy may stand in the way of women reaching top positions.

Lastly, due to encountering many obstacles by trying to break through the glass ceiling, women might get disaffected with their work. A study done by Stroh, Brett and Reilly (1996) investigated differential turnover rates between male and female managers. By looking at a sample of 20 Fortune 500 corporations, they found that 26% of the female managers had left their positions after two years and only 14% of the male managers had left their position. In their paper, Haslam and Ryan (2008) describe this as women getting more disaffected with their work due to limited career opportunities. Indeed, also Merrit, Reskin and Fondell (1993) demonstrate that the reasons that women get stuck at the glass ceiling go beyond arguments such as family demands. With more women getting demotivated and disaffected with their work, the pool of women in leadership positions also gets smaller. As women's road to the

top consist of barriers such as stereotyping, lack of opportunities and other earlier mentioned factors, women ought to lose their drive and motivation to keep pushing to reach their desired position.

2.2 Gender quotas for women in board rooms and leadership positions

The awareness of the underrepresentation of women in these positions has led stakeholders to pressure companies into actively demonstrating their willingness to address the issue. Therefore, this has led to companies not only reviewing their policies and practices, but also having to actively show that they are responding to the underrepresentation of women in higher top-functions (Oakley, 2000). At national level, an increasing number of countries are using gender quotas for companies to correct the number of women in boardrooms. It is found that, globally, countries with higher gender quotas or strong enforcement mechanisms have more female representation (Sojo et al., 2016). Therefore, as a result of pressure from national regulations, women's representation on boards increases (Gregorič et al., 2017).

Within the research area of gender quotas, Wang and Kelan (2013) studied the effect of the Norwegian gender quotas in boardrooms and the impact on the presence of females in leadership positions, such as CEOs and chair positions. The results show that females are encouraged to take leadership positions due to the gender quota and show that the gender quota legislation in Norway has a consistent and positive effect on the presence of female leaders. Bertrand et al. (2019) also studied the mandating 40% female representation on boards in Norway and find no strong evidence to support the idea that the quota benefits women working in the companies affected by the policy. Seven years after the quota policy for boards of directors took full effect, they conclude that it has had hardly any observable impact on women in business, other than the direct effect on women entering boardrooms. Some other studies in this area are focused on whether more female representation in management positions impacts firm performance. Dezsö and Ross (2012), for example, find that having more women in top management positions does improve firm performance if the firm's strategy is focused on innovation. Moreover, Lückerath-Rovers (2013) shows that companies with female directors generally perform better than companies without women on their board of directors. However, research on the effect of gender quotas is still in its early stages.

2.2.1 Implementation of gender quotas in Germany

The growing awareness of gender underrepresentation and growing literature encourage an increasing number of countries to reflect on ways to control for overrepresented men in the top layers of a company. The first (European) country to impose a binding corporate board gender quota was Norway in 2003 (Smith, 2018). This mandatory quota stated that Norwegian firms had to comply with the new law by making sure that at least 40% of the corporate board members were female. Before the gender quota, in 2002, women made up less than 10% of the board of directors in Norwegian listed firms. The imposed

gender quota required these same firms to raise the percentage of women on their board of directors to 40% within a time span of 5 years. The quota reached it desired effect in 2008 as the proportion of women in Norwegian boardrooms made up more than the required 40% (Smith, 2018). Looking at these numbers, it is reasonable to think that the new legislation was a success. However, studies on the Norwegian gender quota show mixed results. For example, Ahern and Dittmar (2012) shows the Norwegian gender quota led to a negative effect on several economic performance variables. Whereas Nielsen and Huse (2010) show the presence of women in the board of directors in Norwegian firms to be positively related to board strategic control and effectiveness. There is no unambiguous answer as to whether these quotas are a success, however, gender quotas in corporate boardrooms are seen as a necessary step to make corporate boards more diverse. Consequently, Norway's gender quota for corporate boardrooms has led to debate about the implementation of these laws in other countries (Wang & Kelan, 2013).

At the supranational level, the European Commission acknowledged that the rate of progress for achieving gender equality was slow and therefore decided that legislative action was needed to ensure and encourage further change in the area of gender diversity. Hence, in 2012, it put forward a proposal for a Directive to make more rapid progress in improving gender diversity in corporate boards. The Commission's proposed Directive set a quantitative target of 40% of non-executive directors of listed companies to be of the underrepresented sex (Andreeva & Bertaud, 2012). Firms with a below-standard percentage should appoint their members based on a comparative analysis of candidates' qualifications using clear gender-neutral criteria. In the case of having two equally qualified candidates, the individual of the underrepresented sex will be given priority according to this Directive (Jourova, 2016). However, since the Council of Ministers has not managed to unanimously agree on the Directive, the European legislation on women in non-executive director seats has been postponed (Kirsch, 2018). Recently, in March 2022, the European Member states have given their first approval to the requirement that by 2027 companies' non-executive board seats should for at least 40% be held by women or 33% of all board positions should be held by women (Kleis, 2022). The European Commission has, however, not yet succeeded in implementing the Directive. Therefore, from an international perspective, there is still insufficient regulation regarding gender diversity, meaning that it mostly depends on domestic legislation.

In Germany, the opposition prevented the implementation of gender quotas until 2013. In April 2013, politicians in Germany's lower house of parliament (*the Bundestag*), rejected the proposals which would require companies to have at least 40% women in their corporate board rooms starting in 2023 (DW, 2013). In addition, Germany also joined other European countries in voting against the proposal of the European Commission to make more rapid progress in improving gender diversity in corporate boards. However, in September 2013, the Free Liberal party did not manage to get into the parliament after the general elections. With this, the greatest resistance against gender quotas disappeared from the

parliament (Oltermann & Neate, 2013). Therefore, in November 2013, new efforts were made to achieve more equality in the German boardroom. The federal elections resulted in a coalition among the Sozialdemokratische Partei Deutschlands (SPD), Christlich Demokratische Union Deutschlands (CDU) and the Christlich-Soziale Union (CSU). In their coalition agreement, the three parties announced they were going to make new efforts for female equality, for example through the introduction of a gender quota (CDU, CSU & SPD, 2013). Eventually, this resulted in the statutory 30%-quota in Germany as of 1 January 2016, meaning that all listed companies subject to the Co-Determination Act were now obliged to comply with a fixed quota of 30% female representatives on the supervisory board by January 2016 (Van de Sande & Schneider, 2022). In August 2021, the German Cabinet even agreed to adopt a second new gender quota to increase female participation in executive boards; starting August 1, 2022 (Library of Congress, 2021). With the second new gender quota, publicly traded private companies, which are co-determined, will have to appoint at least one woman and one man to their executive (management) board (Gesley, 2021).

2.3 Board structures in Germany

2.3.1 Germany

German stock-corporations require a two-tiered board structure. This mandatory two-tier board system consists of a management board ("Vorstand") and a supervisory board ("Aufsichtsrat"). In this system, the management board is appointed by the supervisory board and consists of natural persons. The supervisory board will mostly be elected by the shareholders' meeting and consists of at least 3 members. With regard to employee representatives, the One-Third Participation Act requires stock corporations with more than 500 employees to have at least one third employee representatives within the supervisory board. Companies with more than 2000 employees, require having employee representation for at least half of the supervisory board; this is called the Co-Determination Act. In the context of Germany's mandatory two-tiered board structure, the executive directors within the management board decide on the company's goals and objectives and execute the appropriate actions. Whereas, within the supervisory board the non-executive directors are responsible for supervising and monitoring these decisions on behalf of other stakeholders (Block & Gerstner, 2016).

Besides two-tiered board systems, there are also one-tiered board systems. Such one tiered-board systems are only allowed in Germany within a Societas Europea (SE). German SE companies can benefit from the EU company form and can adopt either a one-tier or two-tier board system (Official Journal of the European Communities, 2001). In the governance system of a one tier board, this board is called the administrative board ("Verwaltungsrat") and consists of non-executive and executive board members (Lehnert & Nase, 2021). Although German SEs are the only stock-corporations that are allowed to choose this one-tier governance system, most German SEs still choose to work with a two-tier board.

3. Hypotheses

The first hypotheses focus on the expected increase of female representation in corporate board positions and leadership positions, before and after the introduction of the gender quota in Germany. The hypotheses that follow focus on areas where the expected increase of female representation in corporate board positions after the quota is highest. These hypotheses therefore look at female representation in firms with more interlocking boards and firms in male-dominated industries.

3.1. Hypotheses 1: Women in board-, CEO- and chair positions after introduction of the gender quota

Gender quotas are closely related to the expectation that having more women in board positions will eventually result in having more women in other (non)-executive positions since this spillover effect will give women more access to higher leadership positions (Holst & Wrohlich, 2017). Following the introduction of the German 30%-gender quota in 2016, more women are expected to hold board positions as companies are required to comply with the new regulation. Additionally, it is interesting to examine whether the increase in female representation in board positions has also resulted in more women being appointed CEO- and chair positions. Matsa and Miller (2011) argue that a gender quota has more effect on corporate strategies when the board of directors has the opportunity to elect a new CEO after a recent increase in female representation on board positions. Therefore, more female representation in the board may impact the appointment of new (female) CEOs. In their study, Wang and Kelan (2013) use the similarity-attraction paradigm of Byrne and Griffit (1973) to predict that women prefer to work with other women. For this reason, the increased number of females in German board positions due to the quota is expected to also increase female representation in chair- and CEO positions. Therefore, the first hypotheses are as follows:

Hypothesis 1a: The gender quota increases the percentage of females in board positions in German companies that were subject to the quota relative to the German companies that were not subject to the quota.

Hypothesis 1b: The probability of having a female chair increases due to the 30%-statutory quota positions in German companies that were subject to the quota relative to the German companies that were not subject to the quota.

Hypothesis 1c: The probability of having a female CEO increases due to the 30%-statutory quota positions in German companies that were subject to the quota relative to the German companies that were not subject to the quota.

3.2. Hypotheses 2: Female CEOs as percentage of women on boards or female board independence rises

You (2019) found that the number of female directors significantly increases the likelihood of firms appointing a female CEO. Selecting the CEO is one of the most important tasks of the board of directors. For this reason, having more female representation in the boardroom can offer a potential solution to the lack of women in top positions. The similarity-attraction paradigm by Byrne and Griffit (1973) states that, generally, females prefer working with other women since there is gender similarity. Therefore, board rooms with a greater number of female members are expected to be more likely to appoint female CEOs relative to board rooms with less or no women. For this reason, the second hypothesis is:

Hypothesis 2a: The probability of having a female CEO increases as the percentage of female representatives on the board of directors rises (within German companies).

Overall, gender similarity is seen as an important tool for women to rise in management functions. This causes women to rise less frequently to management positions when they are active in a male dominated industry (Burgess & Tharenou, 2000). Therefore, it is interesting to see whether the probability of firms having a female CEO increases when there are more female non-executive directors. Essentially, the difference between executive and non-executive directors is that executive directors are involved in the day-to-day management of the company. Whereas non-executive directors are members of the board of the company and have a supervisory role. Non-executive directors are not employees for the company contrary to executive directors who are mostly employees of the company. For this reason, executive directors will occupy executive positions like CEO-positions, and one of the non-executive directors will occupy the position of chairman of the board (Surbhi, 2020). When a firm increases the percentage non-executive directors in their boards the overall board independence increases. Overall board independence is the proportion of non-executive directors on the board of directors (Wang & Kelan, 2012). Female board independence is thus the percentage of female non-executive directors on the board of directors. In a study on the Norwegian gender quota, Wang and Kelan (2012) find that the probability of having a female CEO increases as the of percentage of non-executive female directors rises. Also, a study by Frye and Pham (2018) find that female CEOs are associated with more independent boards. Since it is expected that more female non-executive directors increase the likelihood of a firm selecting a female CEO, the next hypothesis predicts the following:

Hypothesis 2b: The probability of having a female CEO increases as female board independence[3] rises (within German companies).

[3] Female board independence in this study is measured as female non-executive directors divided by the total number of board directors.

3.3. Hypothesis 3: Women in board positions with more board interlock after the gender quota

In general, network effects are a very helpful tool for companies to reduce uncertainty surrounding their external environment. Linkages with other firms can provide the ability to obtain information, communication and resources that can reduce some of these uncertainties (Hillman, Shropshire & Cannella, 2007). These links can, for example, be constituted through their directors and boards. Such an interlocking board is when a person serves a board position in two or more corporations, which provides interlock between these companies (Fich & White, 2005). Hillman et al. (2007) argue that interlocking boards can convey the valuable nature of gender diversity on boards as they can serve to provide additional information and access to more female directors. Firms with stronger networks have more access to scarce information, but most importantly, to more scarce resources (Hillman et al., 2007; Hultin & Szulkin, 1999; Simon & Warner, 1992). Since most boards of directors typically draw corporate board members from the top of their professional hierarchy, female qualified director candidates are scarce (Farrel & Hersch, 2005). Therefore, interlocking boards provide companies access to scarce resources, such as qualified female candidates. Previous studies indicate that the presence of more female directors in the network of interlocking directors results in the hiring of more female directors (Hillman et al., 2007, Kogut et al., 2014). It is expected that the gender quota will result in having more females in board positions, but also, that the quota will cause gender spillovers to other top positions. Consequently, this can mean that German companies with more interlocking boards will have access to more female candidates due to the new gender quota. Therefore, the gender quota may show a stronger effect on companies with more board interlock as these spillovers cause their pool of qualified female directors to increase; making it easier for these companies to gain more women on their boards. Since German firms with more interlocking boards are expected to exhibit more qualified females to fill board positions after the introduction of the gender quota, the third hypothesis is as follows:

Hypothesis 3: The percentage of females in board positions increases more after introduction of the quota in German companies with higher average board interlock that were subject to the quota relative to German companies that were not subject to the quota.

3.4. Hypothesis 4: Women in board positions in male-dominated industries after the gender quota

Empirical results show that female board representation is not uniformly spread across different types of industries, indicating that this can influence women's access to boards in certain industries (Kirsch, 2018). Consequently, some industries consist of more male-dominated companies which therefore also results in low female representation in board positions. To illustrate, Adams and Kirchmaier (2016) found the proportion of women on boards being smaller for companies in the STEM-industry than for companies in the non-STEM industry. Whereas, based on the resource dependence theory, businesses

in the retail industry have more female representation in their boards as this makes their board more representative in terms of their employees and consumers, which are mostly women (Kirsch, 2018). Therefore, women's access to board positions in more male dominated industries is considered lower relative to other industries. For this reason, it is expected that after the introduction of the gender quota, the effect of the quota on females in board positions in industries that are male dominated will be stronger since they suddenly must comply with the new regulation. Therefore, this effect is predicted to result in an increase in female representation in board positions in male-dominated companies affected by the quota relative to other companies. For this reason, the fourth hypothesis is as follows:

Hypothesis 4: The percentage of females in board positions increases more in male dominated industries after the introduction of the quota in German companies that were subject to the quota relative to the German companies that were not subject to the quota.

4. Data and methodology

This section describes the process of data collection, the employed dataset and selected variables. After giving an in-depth description of the control-, independent- and dependent variables, the descriptive statistics of the data are presented. The subsequent section elaborates on the used methodology to examine the formulated hypotheses and the research question. Lastly, some checks are performed to ensure the validity of the data and methodology.

4.1 Data description

To collect boardroom data on German listed firms, the database BoardEx is used. The database of BoardEx contains data on profiles of public, private, and non-profit organizations. The different datasets contain individual directors- and company information over the period 2010 until 2020. In this way, the dataset has a window of 6 years prior to the statutory quota and 4 years after the legislation. The dataset is an unbalanced panel-dataset since BoardEx was not able to follow all the companies in the sample for all the different years in which the data was collected. The retrieved datasets from BoardEx consist of two different levels: firm-level data and board-level data. After collecting all the data, the datasets are merged at firm-level and all the missing- and duplicate observations are deleted.

Based on data from Weckes (2015) and the Budnersministerium fur Familie, Senioren, Frauen und Jugend (2020), the lists of the companies which were (not) subject to the 30% statutory quota are presented in Appendix A. In Germany, publicly listed and parity co-determined companies with 2,000 or more employees are required to have at least 30% female representation in their supervisory boards by January 2016 (Ricchetti, 2020; Van de Sande & Schneider, 2022). The treatment group exposed to the policy intervention, therefore, consists of German listed companies subject to the Co-Determination Act. The 99 firms which were eligible to the gender quota during the studied period of 2016-2020 can be found in table A (Appendix A). In total, the dataset contains information on all 98 distinct German listed companies subject to the gender quota (1 company contains missing data on all periods). Of all the 99 companies, Boardex was able to follow 86 German companies subject to the statutory 30%-female quota during the whole studied period of 2016-2020 (Table M, Appendix E).

Besides the Co-Determination Act in Germany, there also is another regime of co-determination requiring companies with 500-2000 employees to have one-third codetermination (Wagner, 2011). To keep the control group as close to the treatment group as possible, the control group consists of publicly listed German companies which are not subject to full codetermination, but have more than 500 employees; making them subject to the one-third codetermination act. In this way, the control group firms are also listed on the stock market but do not fall under full co-determination because they either have under 2000 employees or because they are able to avoid the applicability of full co-determination

through the use of the "before-and-after principle" in which their co-determination status is locked in (Brems & Maurer, 2022). Therefore, all other publicly listed German companies with less than 500 employees are removed from the dataset. Missing data on the number of employees are manually added using BoardEx data or by retrieving company information from their websites/ the internet. By removing companies who do not meet these conditions, the data has a similar control- and treatment group. Furthermore, all companies that were only subject to the quota after 2016 are removed from the dataset to only include companies in the treatment group that were affected by the policy intervention at the start of 2016 (e.g., so no companies that were founded a few years after the introduction of the quota). Furthermore, companies that, according to Weckes (2015), were affected by the quota shortly before the introduction of the legal quota, but due to delisting/unknown reasons were no longer eligible after a few years, are also removed from the data if the year in which they no longer received treatment status is unknown. This will ensure that no control group companies are given treatment group status. Furthermore, Bremer Lagerhaus AG is not included in the treatment group because no data is available for this company. Tables B and C in Appendix A list all companies that are not included in the dataset but were subject to the quota at some point in time.

Lastly, the data dates to 2010, making 2010 a good pre-intervention period of 6 years prior to the German statutory 30%-quota as of 1 January 2016. Furthermore, BoardEx contains data which is collected in December. For this reason, it is possible to study a post-intervention period of 4 years, namely until 2020. In August 2021, the German Cabinet agreed to adopt a second new gender quota to increase female participation in executive boards; starting August 1, 2022 (Library of Congress, 2021). Therefore, 2021 and 2022 are not used in the analyses for the post-intervention period since the announcement in August 2021 may influence the number of females in board positions in Germany and in this way interfere with the effect of the first quota. The dataset therefore ranges from 2010 until 2020.

4.2 Variables

This section elaborates on all variables used in the analyses. Firstly, the variable *CompanyID* uniquely identifies all observations of the same company, there are a total of 380 unique companies in this sample and 2,706 observations. Overall, 32.63 percent of the companies are followed for the whole period of 2010-2020 (across all years).

Firstly, the dependent variable *Gender Ratio* is used in the first subset of hypotheses 1a, 3 and 4. This variable measures the proportion of female directors on the total number of directors on board per year in a given company. Furthermore, the dummy variable *treatment* makes a distinction between German listed companies affected by the quota (1), and German listed companies not affected by the quota (0). In addition, the *post-period* dummy indicates whether the observation falls in the post-quota period, taking value 1 if the observation falls in the 2016-2020 period and taking value 0 if the observation falls

in the 2010-2016 period. The interaction between the *treatment* dummy variable and *post-period* dummy variables shows the effect of the introduction of the 30%- quota in 2016 and, therefore, is the main variable of interest in this study.

The other subset of hypotheses 1b, 1c, 2a and, 2b use two dependent dummy variables. The dummy variable *Female CEO* indicates whether a company has a female CEO (1) or not (0) in that given year. Additionally, the dummy variable *Female Chair* is used to specify whether firms have a female chair (1) or not (0) in that given year. The CEO is the senior executive over management and the board chairman is the head of the board of directors (Price, 2019). Since the two positions differ in duties and responsibilities, most companies choose to separate the positions and employ two people to serve as CEO and chairman. However, there are also companies that allow the CEO to also fill the chairman role. For this reason, this study also includes the CEOs who simultaneously hold the chairman position to examine the effect on chairman and CEO positions.

Furthermore, another variable of interest in this study is the *Female Board Independence* variable. This variable is measured by dividing the number of female non-executive directors by the total number of directors, following the example of Wang and Kelan (2013). Moreover, the independent variable *male-dominated* is used to assess whether the effect of the quota was stronger in male dominated industries. This dummy variable indicates whether the sector in which the company operates is perceived as male dominated (1) or not (0) to estimate an interaction between the *male-dominated* dummy variable, the *treatment group* dummy variable and the *post-period* dummy. Additionally, the sectors of all listed German companies are divided into male dominated (1) and not (necessarily) male dominated industries (0), based on the paper of Roche et al. (2016). This paper defines male-dominated industries as industries where at least >70% of the employees are men, by looking at industries in the USA, Australia and Europe. The industries are particularly agriculture, construction, manufacturing, mining, transport and utilities. Additionally, some sectors were checked in available databases such as Eurostat (2022) to determine whether they are male dominated in all levels. For example, the finance sector has male-dominated executive levels, but had approximately 46 percent female employees in 2017 (Soldak, 2018), therefore being classified as not (necessarily) male dominated. In Table E, Appendix B, the sector divisions into both classifications are provided. Lastly, another variable of interest in this study is *Board Interlock*, which measures the average number of current directorships on other boards held per year in a given company, also following the example of Wang and Kelan (2013). By dividing the number by the total board size, a fair comparison between companies is allowed, showing the average number of current directorships on other boards per director.

Moreover, some control variables are included in the analyses to get a clear estimation of the relationship between the mandatory gender quota in Germany and female board representation and/or female

leadership. Firstly, the average tenure time of directors is controlled for and contains the *average time on board* for all the directors in a company. Moreover, the *nationality mix* variable controls for the proportion of directors coming from different countries within that given year. Other variables which are controlled for are: *the average age of directors* and *the average number of qualifications* of the board of directors. The control variables mentioned vary over time and will therefore not be captured by implementing company fixed effects. In order to control for time invariant differences, company fixed effects are introduced. Year fixed effects are not included in both regressions as they will perfectly align with the *post-period* dummy variable. Furthermore, the *network size* of the board directors will also be controlled for, which measures the average network size of all directors (numbers of overlaps through employment, other activities, and education). Since the values of the average network size variable have a skewed distribution (Figure E, Appendix D), the natural logarithm of the average network size variable is used in the analyses (Sundell, n.d.). Table 1 illustrates the descriptive statistics of all control variables.

Lastly, all company sectors are divided into 10 industries according to the Standard Industrial Classification (SIC). The SIC codes describe the primary business activities of a company. The following divisions of industries are used, namely: (1) Agriculture, Forestry & Fishing, (2) Mining, (3) Construction, (4) Manufacturing, (5) Transportation & Public Utilities, (6) Wholesale- & Retail Trade, (7) Finance, Insurance & Real Estate, (8) Services & Public Administration, (9) Information Technology, and other (10) (SICCODE.com, 2022). All the divisions are based on SIC codes, except for division 9 (Information Technology) since SIC codes do not (yet) recognize this industry classification. For this reason, by retrieving company information from their websites/ the internet companies active in information technology operations are divided into division 9. Furthermore, division 8 is a combination of two separate divisions which are combined into one division. The number of observations per sector can be found in the Appendix B in table D, with the highest number of observations being 936 for the manufacturing-sector and the lowest number of observations within a sector being 11 for the Agriculture, Forestry, Fishing sector.

4.3 Descriptive statistics

This section discusses and shows the descriptive statistics of the variables used in this study. The descriptive statistics are presented in Table 1. The information is split up in three parts: the first column contains information about the entire sample of German listed companies used in the analyses, the second column contains information for the companies affected by the quota (treatment group), and lastly, the third column contains the descriptive statistics for the control group companies.

In total, the data sample contains 380 distinct firms, 98 of which are in the treatment group and 282 which are in the control group. Furthermore, the sample contains 2,706 observations in total. The descriptive table shows that, in this sample, 13% of the board of directors consist of female board

members. In addition, the average percentage female board members on the board of directors is equal to 20% in the treatment group sample and 9% in the control group sample. In the sample, the minimum percentage of female directors is 0% and the maximum percentage is equal to 67%. Also, there is a small difference between the *average Board Interlock* in the treatment group and control group. In this sample, German companies which were affected by the quota have an average of 1.58 current directorships on other boards held per director, whereas companies not receiving treatment status have on average 1.45 current directorships on other boards held per director. The maximum number of average board interlock in the board of directors is equal to 9.5 in the control group, whereas the maximum average number of interlocking boards is 5.62 in the treatment group. Moreover, in this sample, the descriptive statistics on German companies affected by the quota contains higher averages for almost all the variables. However, the average number of qualifications and the average time serving on the board of directors are higher in control group sample.

Table 1: Descriptive statistics

	All companies	Companies affected by quota	Other companies
Gender ratio			
N	2,705	980	1,725
Mean	0.13	0.20	0.09
Std. dev	0.12	0.10	0.11
(Min, Max)	[0; 0.67]	[0, 0.48]	[0, 0.67]
Average age directors			
N	2,692	980	1,712
Mean	61.02	61.98	60.48
Std. dev	4.79	3.74	5.21
(Min, Max)	[43, 86]	[52.31, 72.43]	[43, 86]
Nationality mix			
N	2,538	977	1,561
Mean	0.23	0.27	0.21
Std. dev	0.24	0.20	0.25
(Min, Max)	[0, 0.8]	[0, 0.8]	[0, 0.8]
Network size (ln)			
N	2,705	980	1,725
Mean	5.80	6.11	5.62
Std. dev	1.01	0.78	1.09
(Min, Max)	[0, 8.04]	[4.04, 8.02]	[0, 8.04]
Number of qualifications			
N	2,706	980	1,726
Mean	1.49	1.44	1.52
Std. dev	0.54	0.45	0.58
(Min, Max)	[0, 4]	[0, 4]	[0, 3.22]
Average Board interlock			
N	2,706	980	1,725
Mean	1.50	1.58	1.45
Std. dev	0.63	0.55	0.66
(Min, Max)	[1, 9.5]	[1, 5.62]	[1, 9.5]
Female Independence			
N	2,705	980	1,726
Mean	0.17	0.23	0.13
Std. dev	0.14	0.12	0.14
(Min, Max)	[0, 1.43]	[0, 0.94]	[0, 1.43]
Average time in board			
N	2,706	980	1,726
Mean	6.18	5.99	6.29
Std. dev	2.99	1.93	3.45
(Min, Max)	[0, 18.67]	[0.1, 14.5]	[0, 18.67]
Total number of observations	2,706	980	1,726
Number of distinct firms	380	98	282

4.4 Methodology

This section elaborates on the methodology. By using a sample of German listed companies in the period of 2010-2020, this study examines whether statutory gender quota requiring 30% women on supervisory boards has an effect on female representation in leadership roles such as board-, chair- or CEO positions. Furthermore, the effect of the quota is examined in companies with more board interlock and in companies active in more male-dominated industries. The dataset contains two groups of German listed companies: companies which were affected by the quota in 2016 (treatment group) and companies which were not subject to the quota (control group). To examine the effect of the gender quota on German listed companies three different models are used to analyze the hypotheses. Hypotheses 1a, 3 and 4 use a difference-in-difference regression model, hypotheses 1b, 1c, and 2b use a probit (difference-in-difference) regression model and lastly, hypothesis 2a uses a two-stage linear probability regression with a linear probability model (LPM).

4.4.1. Hypotheses 1a, 3 and 4

To empirically test hypotheses 1a, 3 and 4 a difference-in-difference model is used. Through a difference-in-difference model, German listed companies that were subject to the quota are compared to German listed companies that were not subject to the quota to estimate the effect of the German 30% gender quota in 2016. This technique can account for time-invariant unobserved factors that differ between the treatment and control group. The difference-in-difference approach is particularly useful for estimating the impact of significant changes in government policies or other exogenous shocks (Angrist & Krueger, 1999). Therefore, this approach is frequently used in policy analyses in a natural experiment context. Such a natural experiment occurs when some actors are subjected to a policy intervention and other actors are not (Babu, Gajanan & Hallam, 2016). In this case, the natural experiment occurs by Germany approving the law of statutory gender quota in supervisory boards in 2016.

To obtain an unbiased estimate of the treatment effect in a difference-in-difference model, the parallel trend assumption needs to be satisfied. This assumption is necessary because the difference-in-difference technique requires time-varying factors in the treatment and control groups to be similar, meaning that the two groups must show parallel trends. In other words, there should be no time-varying factors influencing the outcome differently in the treatment group at the time the treatment starts. In the case of Germany, the parallel trend assumption is satisfied when the treatment group, which are all listed German companies subject to the 30%-quota, in the absence of the gender-quota follow a similar trend for the percentage of female board members as the control group (all other listed companies). The parallel trend assumption estimates are illustrated in Figure A and B, Appendix D. As can be seen in

Figure A and B, the trends in the pre-intervention period (before 2016) follow similar trends with overlapping 95% intervals. Therefore, the parallel trend assumption seems to be satisfied.

Another important assumption of a difference-in-difference model is the Stable Unit Treatment Value Assumption (SUTVA). This assumption implies that potential outcomes for each company are unrelated to the treatment status of other companies (Angrist, Imbens & Rubin, 1996). In this case, the SUTVA assumption would not be satisfied if, as a result of the introduction of the gender quota and its effect on firms affected by this, there would also be an effect on firms not subject to the quota. The policy intervention, and thus the change in treatment status of the treated group, is assumed to have no direct effect on the proportion of female directors in control group companies. However, the increase in the number of women in board positions could still cause a spillover effect to other companies, as many listed companies have linkages. Moreover, the supply of adequate female candidates may get lower due to treatment group companies taking up many women. Therefore, these factors could undermine the SUTVA assumption, and is therefore something to be cautious about. Still, control group companies are not expected to behave differently in terms of female representation in their board of directors after the introduction of the quota. All in all, as previously discussed, the parallel trend assumption (Appendix D, graph A and B) is satisfied, as the 95% confidence intervals of both the treatment group and the control group largely overlap over the entire period of interest. Additionally, the SUTVA assumption is also expected to be satisfied as the change in treatment status of listed German companies is not expected to affect other companies which are not subject to the quota. All in all, both assumptions are (expected) to be satisfied.

Subsequently, the following specifications demonstrate the applied difference-in-difference technique to examine the effect of the 30%-statutory quota. The first hypothesis examines a difference-in-difference interaction, and hypotheses 3 and 4 examine a triple-difference specification. Hypothesis 1 examines the effect of the German quota on the percentage of female board members. Therefore, the following regression is performed:

$$(\mathbf{1}) \qquad \boldsymbol{Y}(\boldsymbol{Gender\ ratio})_{\boldsymbol{i,t}} = \beta_0 + \beta_1\, d_{post-period_{i,t}} + \beta_2\, d_{treatment_{i,t}} + \delta_1\, d_{post-period_{i,t}} * d_{treatment_{i,t}} + \beta_K X_K + \alpha_i + u_{i,t}$$

Where the variable of interest is *gender ratio,* which measures the number of female directors on board divided by the total number of board members at firm i in period t. Furthermore, $d_{post-period}$ denotes the dummy variable indicating the period after the quota went into full effect (equal to 1 if the period is after 2016, 0 otherwise), $d_{treatment}$ denotes the dummy variable for the treatment group (equal to 1 for treatment group, 0 for control group). The coefficients of interest, $\delta 1$ multiply the interaction term; the dummy which indicates whether the quota was effective and the dummy indicating the treatment group.

Furthermore, X_k shows the set of control variables and α_i controls for firm fixed effects. Standard errors are clustered at firm level.

Next, hypothesis 3 studies whether the effect of the German quota on the percentage of female board members is stronger in affected firms with higher board interlock:

$$(2) \quad \boldsymbol{Y(Gender\ ratio)_{i,t}} = \beta_0 + \beta_1\, d_{post-period_{i,t}} + \beta_2\, d_{treatment_{i,t}} + \beta_3\, d_{Average\ BoardInterlock_{i,t}} + \delta_1\, d_{post-period_{i,t}} * d_{treatment_{i,t}} + \delta_2\, d_{Average\ BoardInterlock_{i,t}} * d_{treatment_{i,t}} + \delta_3\, d_{Average\ BoardInterlock_{i,t}} * d_{post-period_{i,t}} + \delta_4\, d_{Average\ BoardInterlock_{i,t}} * d_{treatment_{i,t}} * d_{post-period_{i,t}} + \beta_K X_K + \alpha_i + u_{i,t}$$

Here, again, the variable of interest is *gender ratio* at firm i in period t. The coefficients of interest, $\delta 4$ multiply the triple-interaction term; the *post-period* dummy which indicates whether the quota was effective, the *treatment* group dummy and the *average Board Interlock* variable indicating the average number of current boards the directors in a company serve on in a year. Furthermore, X_k shows the set of control variables and α_i controls for firm fixed effects. Standard errors are clustered at firm level.

Lastly, hypothesis 4 studies if the effect of the German quota on the percentage of female board members is stronger in affected firms operating in male dominated sectors:

$$(3) \quad \boldsymbol{Y(Gender\ ratio)_{i,t}} = \beta_0 + \beta_1\, d_{post-period_{i,t}} + \beta_2\, d_{treatment_i} + \beta_3\, d_{Maledominated_{i,t}} + \delta_1 d_{post-period_{i,t}} * d_{treatment_{i,t}} + \delta_2\, d_{Maledominated_{i,t}} * d_{treatment_{i,t}} + \delta_3\, d_{Maledominated_{i,t}} * d_{post-period_{i,t}} + \delta_4\, d_{Maledominated_{i,t}} * d_{treatment_{i,t}} * d_{post-period_{i,t}} + \beta_K X_K + \alpha_i + u_{i,t}$$

Additionally, in this difference-in-difference regression, again the variable of interest is *gender ratio* at firm i in period t. The coefficients of interest, $\delta 4$ multiply the triple-interaction term; the *post-period* dummy which indicates whether the quota was effective, the dummy indicating the treatment group and the dummy variable indicating the if the company operates in a male dominated sector (1) or not (0). Additionally, X_k shows the set of control variables and α_i controls for firm fixed effects. Standard errors are clustered at firm level.

4.4.2. Hypotheses 1b, 1c, 2a, and 2b

Hypotheses of 1b, 1c, 2a and 2b all examine the effect on a binary dependent variable. The aim of this set of hypotheses is to examine the probability of a company having a female CEO or female chair. Hereby, hypotheses 1b, 1c and 2b use a (difference-in-difference) probit regression approach to examine the effect of the gender-quota on female leadership. Lastly, hypothesis 2a examines the effect of gender ratio on the probability of having a female CEO, using a two-stage linear probability regression.

4.4.2.1 Probit-model (difference-in-difference) regression

There can be several statistical techniques which can be used to predict the relationship between the predictors (independent variables) and the predicted binary variable (dependent variable). An example of a simple linear regression model which can, unlike the standard linear regression model, have a binary dependent variable is the linear probability model (LPM). However, this method has its limitations as the LPM can cause the estimated probabilities to fall outside the 0-1 range (Horrace & Oaxaca, 2006). Therefore, models such as the probit- or logit model are more commonly used in the case of binary dependent variables. A logit model specifies the conditional mean of a discrete outcome variable as a logistic function of covariates. Such a logit model is comparable to a probit model, except that a probit model uses the cumulative normal instead of the logistic one (Breen, Karlson & Holm, 2018). Yet, there are also concerns regarding the use of logit and probit models since their use can result in the loss of properties that come with linear models (Hatfield & Zeldow, 2019). Ai and Norton (2003) were one of the first to point out that the cross-partial effect can be nonzero even when the interaction term of treatment group * post intervention period is equal to zero. In addition to this paper, Puhani (2012) showed that in the case of a non-linear difference-in-difference model, the treatment effect is not a simple cross difference, but a difference between cross-differences (*cross difference of the conditional expectation of the observed outcome minus the cross difference of the conditional expectation of the potential outcome without treatment*). The author showed that the interaction effect in a difference-in-difference model always has the same sign as the difference-in-difference effect. Accordingly, conclusions about the treatment effect can be drawn through the usual testing of the interaction parameter. Lastly, the paper of Karaca-Mandic, Norton, and Dowd (2012) combines both papers and shows how the difference-in-difference effect in a non-linear model can change as the linear predictor changes; and shows it can be safely interpreted.

Since the dependent variables from hypotheses 1b, 1c, and 2b involve binary outcomes (Female CEO (1), Male CEO (0); or Female chair (1) Male chair (0)) a probit[4] regression model is used by the example of Wang and Kelan (2012) who also study the effect of gender quotas on the presence of female CEOs and female chairs. Moreover, Wang and Kelan (2012) explain their choice of a probit regression model by the paper of Hoetker (2007), stating a probit regression model can generate a conditional probability that an observation falls into a category, given the values of the independent variables for the same observation. The probit technique does not require the independent variables to be multivariate normal and uses cumulative probability distributions (Wang & Kelan, 2012). Therefore, hypotheses 1b and 1c use a probit model and study the effect of the gender-quota in Germany by using the difference-in-difference technique. By calculating the average marginal effect, the probit model examines the effect of the 30%-statutory quota on the probability of having a female CEO/chair. Additionally, hypotheses

[4] Robustness check shows no difference in outcomes of logit regression model and probit regression model.

2b uses a standard probit regression model to examine the (marginal average) effect of board independence and female representativeness in boardrooms on the probability of having a female CEO. Subsequently, the following specifications demonstrates the applied probit regression models.

Hypothesis 1b and 1c examine the effect of the German quota on the probability of having a female CEO/chair in a difference-in-difference setting. Therefore, the following probit regressions are performed:

(5) $$\boldsymbol{Pr(Female\ Chair)_{i,t}} = \gamma_0 + \gamma_1\, d_{post-period_t} + \gamma_2\, d_{treatment_i} + \gamma_3\, d_{post-period_t} * d_{treatment_i} + \gamma_K X_K + u_{i,t}$$

(6) $$\boldsymbol{Pr(Female\ CEO)_{i,t}} = \gamma_0 + \gamma_1\, d_{post-period_t} + \gamma_2\, d_{treatment_i} + \gamma_3\, d_{post-period_t} * d_{treatment_i} + \gamma_K X_K + u_{i,t}$$

Here, the coefficients of interest, γ_3, multiply the interaction term; the dummy which indicates whether the quota was effective and the dummy indicating the treatment group. Furthermore, X_k shows the set of control variables. Standard errors are clustered at firm level.

Lastly, hypothesis 2b examines whether the probability of having a female CEO increases more as female board independence rises:

(7) $$\boldsymbol{Pr(Female\ CEO)_{i,t}} = \gamma_0 + \gamma_1\, d_{post-period_t} + \gamma_2\, d_{treatment_i} + \gamma_3\, d_{post-period_t} * d_{treatment_i} + \gamma_4\, d_{female\ board\ independence} + \gamma_K X_K + u_{i,t}$$

Here, the coefficients of interest, γ_4 is the variable female board independence, which is the number of female non-executive directors divided by all the directors on board. Again, X_k shows the set of control variables and standard errors are clustered at firm level.

4.4.2.2 Instrumental Variable Regression

Hypothesis 2a examines the effect of the percentage of female board directors on the binary variable *Female CEO*. In this regression, however, the independent variable *gender ratio* depends on other variables within the model. Presumably, there are many more reasons for companies to elect more female board members to their boards. Therefore, the variable gender ratio is considered to be an endogenous variable in the model, indicating that the predictor is most likely correlated with the error term. Accordingly, for hypothesis 2a, an instrumental variable (IV) regression is used. This method is also commonly known as the two-stage least squares method (Martens, 2006).

Additionally, a Durbin-Wu-Hausman is performed to test whether the independent variable of interest is in fact endogenous. The results of the test can be found in Table I (Appendix C). The p-value of the test is significant at 5% significance level, indicating there is endogeneity bias. Endogeneity refers to a where an independent variable correlates with the error term (Zaefarian et al., 2017). Consequently, the two-stage least squares method should be used to examine the effect of the percentage of female board members on the probability of having a female CEO. Since the value of *gender ratio* is expected to be influenced by the German gender quota, the endogenous gender ratio is instrumented by the (interaction between) dummy variables *post-period * treatment* indicating if the gender-quota was active (=1) or not (=0) and whether the firm was in the treatment group (=1) or not (=0).

For IV to hold, there are three main assumptions. The first assumption states that the IV should have a strong causal effect on the endogenous variable *gender ratio.* The relevance of the IV is tested in the first-stage regression, by performing an F-test. By using the threshold of 10 of a F-test-statistic by Stock and Yogo (2002), a result less than 10 is considered a weak instrumental variable. The results of the first stage regression can be found in Table J (Appendix C). The first stage regression is performed on a model without control variables and a model including control variables. As can be seen in the first stage regression, the instrument is very significant at a 1% level. Additionally, both the F-tests provide values larger than the threshold of 10, being 11.48 and 11.21 respectively. The second assumption is the validity assumption, which states the IV should be uncorrelated to the error term. However, this cannot be verified since the error term is unobserved. When looking at the correlation between the IVs and the observed variables, the highest reported correlation is -0.45, which is considered relatively low. Furthermore, the gender quota is most likely only changing the *gender ratio* variable and is not expected to be correlated with any unobserved determinants on the probability of having a female CEO. Therefore, it is probable that the validity assumption holds. Lastly, the third assumption states the IV should not have a direct effect on the outcome variable *Female CEO,* only an indirect effect through the *gender ratio* variable (Newhouse & McClellan, 1998). This assumption is satisfied, since the gender quota only affects the probability of having a female CEO through the percentage of female directors on board and is exogenous to firms' characteristics influencing the hiring of a female CEO. All in all, all three assumptions are expected to hold; allowing the endogenous gender ratio to be instrumented by the (interaction between) dummy variables *post-period * treatment.*

Additionally, hypothesis 2a studies the probability of having a female CEO as the percentage of female board increases by performing the following regressions:

(8) $Stage\ 1$: $$\boldsymbol{Y(Gender\ ratio)}_{i,t} = \beta_0 + \beta_1\, d_{post-period_{i,t}} + \beta_2\, d_{treatment_{i,t}} + \beta_3\, d_{post-period_{i,t}} *\, d_{treatment_{i,t}} + \beta_K X_K + u_{i,t}$$

(9) $Stage\ 2$: $$\boldsymbol{Pr(Female\ CEO)} = \gamma_0 + \gamma_1\, d_{gender\ ratio} + \gamma_K X_K + u_{i,t}$$

In the first stage, the variable gender ratio is estimated as a function of the interaction between *post period* and *treatment*. By using the first stage regression, the predicted values of gender ratio are used in the second stage regression. Both regressions are presented in specification 8 and 9. Furthermore, X_k shows the set of control variables and standard errors are clustered at firm level in the second stage. Moreover, since the dependent variable from the second stage involves a binary outcome (Female CEO (1), Male CEO (0)), this hypothesis uses an IV regression with an LPM.

4.4.3 Correlation Matrix

To increase robustness of the data, the correlation between the variables are inspected in a correlation matrix in table F in Appendix C. The correlation matrix allows for identification of potential concerns due to high correlations between variables which can cause multicollinearity problems. According to Green (1991), correlations higher than 0.8 are a potential cause for concern regarding multicollinearity. As can be seen in the correlation matrix, there are no correlations higher than 0.8. The variables *gender ratio* and *female board independence* show the highest correlation of 0.7, which is significant at a 1% significance level. This correlation is not unexpected since the *female board independence* variable captures the percentage of female non-executives in the board of directors, and therefore moves in the same direction and at almost the same rate as *gender ratio* which presents the percentage of female directors on the board of directors. These variables will, however, not be used in the same analyses. Therefore, no signs of multicollinearity problems occur when looking at the correlation matrix.

4.4.4 VIF test

Next, in this section a Variance Inflation Factor (VIF) test is performed to further analyze potential multicollinearity issues. Potential multicollinearity issues occur when VIFs values are greater than 5 (Daoud, 2017), whereas VIFs values greater than 10 indicate serious collinearity problems (Alin, 2010). The VIF table test results are provided in Appendix C table G. In this table the highest reported VIF value is 1.77 for the *average network size (ln)* variable, meaning there are no signs of multicollinearity issues. All in all, the correlation matrix and VIF test show no signs of multicollinearity problems since the reported values of the correlation matrix are under 0.7 and the highest reported VIF value is 1.77.

4.4.5 Clustered standard errors and fixed effects

Given that outcomes are compared over time, there may be autocorrelation in the variables and in the error term. Therefore, the autocorrelation test of Drukker (2003) is performed. The results can be found in Table H, Appendix C. According to the results from the autocorrelation test, the null hypothesis of no serial correlation can be rejected at a 1% significance level. For this reason, the model might suffer from serial correlation problems. In the case of autocorrelation, the standard errors can be underestimated, and this can be a serious problem in panel data analysis with difference-in-difference

models (Bertrand, Duflo & Mullainathan, 2004). A way to tackle possible autocorrelation in a difference-in-difference design is to compute clustered standard errors. For this reason, standard errors are clustered at firm level to account for heteroskedasticity across clusters of observations in the (difference-in-difference) models.

Moreover, to eliminate time-invariant firm characteristics that cannot be controlled for by the control variables; firm-fixed effects are also controlled for in the difference-in-difference model and the linear probability model. For the other subset of hypotheses (1b, 1c, and 2b), a probit model is used. Since a probit model generally gives inconsistent estimates by using fixed effects (Maddala, 1987), firm-fixed effects will not be controlled for. As already mentioned, year fixed effects are not included in both models as they will perfectly align with the *post-period* dummy variable.

4.4.6 Robustness check model

Lastly, a robustness check is performed by examining how the independent coefficient estimates of interest behave when the specification is modified by including and excluding control variables. Robustness of the model is necessary for valid causal inference (Lu & White, 2014). The results of the robustness check by excluding all control variables and checking whether the inclusion of clustered standard errors at firm level and company fixed effects yields different results, are presented in Table K, Appendix C. The variable of interest, which in the base model is the interaction between the *treatment* variable and the *post-period* variable, should not be sensitive to the adding or dropping of control variables (Lu & White, 2014). As can be seen in Table K, some observations are dropped when adding control variables due to missing values in the control variables. Therefore, this results in a smaller number of observations for the other models and does not allow for a fair comparison. Still, the coefficient of interest in the regression model excluding the controls, -standard errors and -company fixed effects does only differ slightly in the second decimal place from the base-model specification (1) coefficient. The significance level and sign of the coefficient do not differ between the two models. Therefore, there are no concerns of misspecification in the model. Furthermore, robustness checks by shortening the pre-intervention window show no difference in significance and sign of the coefficients in the base model. Only the average marginal effect of the gender quota on the probability of having a female chair (hypothesis 1b) loses its significance when the pre-intervention is shortened. This result should therefore be interpreted with caution.

5. Results

The subsequent section shows the regression results for the difference-in-difference regression, the probit (difference-in-difference) regression model and the two-stage LPM. Firstly, the trends of companies with a female CEO and/or chair are presented to intuitively see the changes in trends. Furthermore, Table 2 shows the regression results from the difference-in-difference analysis for hypotheses 1a, 3 and 4. The results of the probit regression model are shown in Table 3. The probit regression results are then used to calculate the average marginal effects of the probit regression models which are displayed in Table 4. Lastly, Table 5 presents the result of the two-stage LPM.

Firstly, the trends of both groups showing the percentage of companies with either a female chair and/or female CEO are analyzed. In Appendix E, Table N and O present the total number of companies with female CEOs- and chairs per year, respectively. Both the treatment group as well as the control group show a rise in number of female CEOs- and chairs relative to the starting point in 2010. The total number of female CEOs and -chairs in the treatment- and control group companies can, however, not be compared since the total number of distinct companies in both groups differ as can be seen in Table M (Appendix E). Since the numbers do not allow a fair comparison, the percentage of companies with female CEOs as well as female chairs within each group are visualized per year in Figure C and D (Appendix D). Here, the companies with female CEOs and -chairs are divided by the total number of firms in their respective group for each year.

Figure C shows that the two lines indicating the total number of female CEOs in the treatment group and control group per year follow a similar trend after 2014. After 2016, both lines show a slight increase in the percentage of companies with female CEOs after which they decrease again in 2017. Looking at Figure D in Appendix D, the percentage of treatment companies with female chairs appears to slightly increase after the quota and the distance with the line of the control group increases after 2017. This suggests that after the quota, the percentage of treatment companies with female chairs per year rises. Intuitively, the percentage of treatment group companies with female chairs seems to have risen after the mandatory gender quota in 2016, whereas the percentage of treatment group companies with a female CEO seems to have declined from 2017-2020.

5.1 Difference-in-difference model

The subsequent section examines the regression results for the difference-in-difference regression model. Table 2 shows the regression results from the difference-in-difference analyses for hypotheses 1a, 3 and 4.

Hypothesis 1a states that the gender quota increases the percentage of females in board positions in German companies that were subject to the quota relative to the German companies that were not subject to the quota. The results of hypothesis 1a are presented in the first column of Table 2. The results show that the gender quota increases the gender ratio with 0.053 in the treatment group compared to the control group, ceteris paribus. The results are statistically significant at a 1% significance level. Therefore, the interaction between the *treatment* group dummy and the *post-period* dummy can reject of the null hypothesis that there is no effect of the gender quota on the percentage of females in board positions in German companies that were subject to the quota relative to German companies that were not subject to the quota. This result is in line with the expectation of hypothesis 1a.

Additionally, column 2 in Table 2 presents the results for hypothesis 3. This hypothesis states that after the introduction of the gender quota the percentage of females in board positions increases more in German companies with higher average board interlock that were subject to the quota relative to the German companies that were not subject to the quota. The results of the triple interaction indicate that the effect of gender quota on gender ratio is weaker for treatment group firms with higher average board interlock, relative to the control group and the pre-intervention period, ceteris paribus. This effect is statistically significant at a 5% significance level. The triple interaction between the *board interlock* variable, the *treatment* group dummy and the *post-period* dummy can reject of the null hypothesis that there is no effect of the gender quota on the percentage of females in board positions in German companies with higher average board interlock that were subject to the quota relative to the German companies that were not subject to the quota. Nevertheless, since the result shows a negative sign, this finding in not in line with the expectation of hypothesis 3.

Lastly, column 3 contains the results of the triple interaction of hypothesis 4. This hypothesis states that after the introduction of the statutory quota, the percentage of female board members increases more in male dominated firms in treatment companies that were subject to the quota, relative to companies that were not subject to the quota. The results show that after the introduction of the gender quota the gender ratio increases more in treatment group firms active in a male dominated compared to non-male dominated industries, pre-period and control group companies, ceteris paribus. This effect is statistically significant at a 1% significance level. The interaction between the *male dominated industry* dummy, the *treatment* group dummy and the *post-period* dummy can reject of the null hypothesis that there is no effect of the gender quota on the percentage of females in board positions in German treatment group companies active in a male dominated industry relative to the German companies that were not subject to the quota and are not active in a male dominated industry. This result is in line with the expectation of hypothesis 4.

Table 2: Difference-in-Difference model

	Base model Difference-in-Difference		
Gender ratio	*(1) Hypothesis 1a*	*(2) Hypothesis 3*	*(3) Hypothesis 4*
Treatment	0.077***	0.108***	0.072**
	[0.024]	[0.037]	[0.031]
Post-period	0.015*	-0.010	0.026*
	[0.008]	[0.015]	[0.015]
*Treatment * Post-period*	0.053***	0.094***	0.012
	[0.012]	[0.025]	[0.021]
*Treatment * Average Board Interlock*		-0.022	
		[0.019]	
*Average Board Interlock * Post-period*		0.017**	
		[0.008]	
*Treatment * Post-period * Average Board Interlock*		-0.029**	
		[0.013]	
*Treatment * Male dominated industry*			
*Post-period * Male dominated industry*			-0.024
			[0.018]
*Treatment * Post-period * Male dominated industry*			0.067***
			[0.024]
Average age directors	-0.010***	-0.010***	-0.010***
	[0.001]	[0.001]	[0.001]
Nationality Mix	0.032	0.029	0.036
	[0.024]	[0.024]	[0.025]
Ln (average network size)	-0.016	-0.017*	-0.015
	[0.010]	[0.010]	[0.011]
Average time in board	0.001	0.001	0.002
	[0.002]	[0.002]	[0.002]
Number of qualifications	0.001	0.003	-0.001
	[0.014]	[0.013]	[0.015]
Average Board interlock	-0.001	-0.004	0.008
	[0.013]	[0.013]	[0.013]
Male dominated industry			0.004
			[0.031]
Constant	0.808***	0.805***	0.791***
	[0.093]	[0.092]	[0.097]
Observations	2,235	2,535	2,392
R-squared within	0.3976	0.4034	0.4075
R-squared between	1.0000	1.0000	1.0000
R-squared overall	0.7671	0.7693	0.7687
Company fixed effects	*Yes*	*Yes*	*Yes*

Standard errors are adjusted at firm level, are reported in parentheses.
*** p<0.01; ** p<;0.05; * p<0.1

5.2 Probit regression model

The regression results of the probit model are shown in Table 3 and the average marginal effects are presented in Table 4. Table 4 only displays the values of the variables which are important to answer the hypotheses.

Table 3: probit model regression

Probit model	***(1) Hypothesis 1b***	***(3) Hypothesis 1c and 2b***
	P(Female chair)	P(Female CEO)
Post-period	-0.074	-0.344
	[0.221]	[0.306]
Treatment	-0.044	-0.657*
	[0.367]	[0.381]
*Treatment * Post-period*	-0.426	0.611
	[0.358]	[0.423]
Average age directors	-0.024	-0.012
	[0.027]	[0.031]
Nationality Mix	0.200	0.670
	[0.539]	[0.516]
ln average network size	-0.123	0.250
	[0.172]	[0.191]
Average time in board	-0.022	0.057
	[0.043]	[0.046]
Number of qualifications	0.029	0.015
	[0.261]	[0.301]
Average Board interlock	-0.542**	-0.272
	[0.235]	[0.226]
Female Board Independence	5.718***	1.178
	[0.972]	[0.987]
Constant	0.471	-4.729**
	[1.877]	[2.184]
Observations	2,535	2,535

Standard errors are adjusted at firm level, are reported in parentheses.
*** p<0.01; ** p<;0.05; * p<0.1

Table 4: average marginal effects probit model

Average marginal effects	***(1) Hypothesis 1b***	***(2) Hypotheses 1c***	***(3) Hypothesis 2b***
Dependent variable	P(Female chair)	P(Female CEO)	P(Female CEO)
Post-period (1)			
Treatment (0)	-0.009	-0.021	
	[0.028]	[0.018]	
Treatment (1)	-0.059*	0.014	
	[0.036]	[0.017]	
Female Board Independence			0.067
			[0.056]
Observations	2,535	2,535	2,535

Standard errors are adjusted at firm level, are reported in parentheses.
*** p<0.01; ** p<;0.05; * p<0.1

Hypothesis 1b states that the probability of having a female chair increases due to the 30%-statutory quota in German companies that were subject to the quota relative to the German companies that were not subject to the quota. For hypothesis 1b, column 1 in Table 3 shows the results of the probit regression model. As can be seen in Table 3, on average in this sample, the gender quota has a negative effect but insignificant effect on the probability of having a female chair in the treatment group compared to the control group, ceteris paribus. This effect is not significant at a 10% significance level. Looking at the average marginal effect in Table 4, the average change in this sample in the probability of having a female chair when firms are in the treatment group, compared to control group and after the implementation of the 30% statutory gender quota, is a decrease of 5.9 percentage points, ceteris paribus. This effect is significant at a 10% significance level. The interaction between the *treatment* group dummy and the *post-period* dummy, can reject the null hypothesis that there is no effect on the probability of having a female chair in the treatment group after the 30%-statutory quota compared to the control group. The result is not in line with the expectation of hypothesis 1b, since it expected an increase in the probability of treatment firms selecting a female chair after the introduction of the gender quota compared to the control group. Nevertheless, the result should be interpreted with caution since the significance of the average marginal effect is only 10% and the significance is lost when the pre-intervention period is shortened by 1 (or more) years. Meaning that when the gender quota effect is tested on a shorter pre-intervention period, the result in this regression is not significant anymore.

The results of the probit model regression for hypothesis 1c, which states that the probability of having a female CEO increases due to the 30%-statutory quota in German companies that were subject to the quota relative to the German companies that were not subject to the quota, are presented in column 2 in Table 3. The results show that, on average in this sample, the gender quota has a positive- but insignificant effect on the probability of having a female CEO in the treatment group compared to the control group, ceteris paribus. This effect is not significant at a 10% significance level. Looking at the average marginal effect in Table 4, the average change in this sample in the probability of having a female CEO when firms are in the treatment group, compared to control group and after the implementation of the 30% statutory gender quota, is a decrease of 1.4 percentage points, ceteris paribus. This effect is also not significant at a 10% significance level. The interaction between the *treatment* group dummy and the *post-period* dummy, fails to reject the null hypothesis that there is no effect on the probability of having a female CEO in the treatment group due to the 30%-statutory quota compared to the control group.

Lastly, the results of the probit regression model of hypothesis 2b are displayed in the third column. This hypothesis states that the probability of having a female CEO increases as female board independence rises. In Table 3, the results show that, on average in this sample, female board independence has a positive- but insignificant effect on the probability of having a female CEO, ceteris

paribus. This effect is not significant at a 10% significance level. Furthermore, looking at the average marginal effect in Table 4, the average change in this sample in the probability of having a female CEO when doubling the non-executive female directors-to-total number of directors ratio (an increase by one unit) is an increase of 6.7 percentage points, ceteris paribus. However, this effect is insignificant at a 10% significance level. Therefore, the *Female Board Independence* variable fails to reject of the null hypothesis that there is no effect of female board independence on the probability of having a female CEO.

5.3 Instrumental Variable Regression

Hypothesis 2a is tested by using an instrumental variable regression with an LPM. This hypothesis states that the probability of having a female CEO increases as the percentage of female representatives on the board of directors rises. Therefore, the endogenous variable *gender ratio* is instrumented by the dummy variable *post-period* indicating if the gender-quota was active (=1) or not (=0) and the dummy variable *treatment* indicating whether the firm was in the treatment group (=1) or not (=0). The instrumental variable gender ratio is predicted through a full factorial of the *treatment* variable and the *post-period* variable (main effects for each variable and interaction between them).

Table 5: Instrumental variable LPM regression, second stage

	Hypothesis 2a
	P(Female CEO)
Gender ratio	*0.298*
	[0.220]
Average age directors	0.001
	[0.003]
Nationality Mix	0.022
	[0.034]
ln average network size	0.022
	[0.014]
Average time in board	0.003
	[0.003]
Number of qualifications	-0.016
	[0.018]
Average Board interlock	0.001
	[0.018]
Constant	-0.243
	[0.268]
Observations	2,535
R-squared within	0.0136
R-squared between	1.000
R-squared overall	0.6477
Company fixed effects	*Yes*

Standard errors are adjusted at firm level, are reported in parentheses.
*** p<0.01; ** p<;0.05; * p<0.1

Table 5 presents the result of the two-stage least squares linear probability model. The results show that *gender ratio* has a positive- but insignificant effect on the probability of having a female CEO, ceteris paribus. This effect is not significant at a 10% significance level. Therefore, the results fail to reject the

null hypothesis that there is no effect of the percentage of female representatives on the board of directors on the probability of having a female CEO.[5]

5.4 Robustness checks

5.4.1 Permutation tests

To check the robustness of the results in terms of the treatment and control group a permutation test is performed on the base model specification (1) regression. By permuting the data 100 times and recalculating the test statistic to build an approximation to our distribution, treatment assignment is permuted (Wilber, 2019). The results of the permutation test can be found in Appendix E, Table L. The results reject the null hypothesis that there is no effect of the gender quota on the percentage of females in board positions in German companies that were subject to the quota relative to the German companies that were not subject to the quota, according to the 0.000 P-value. The result is significant at a 1% significance level. This means that the treatment- and control group are well chosen.

5.4.2 Preexisting Trends

Another robustness check to verify the results of difference-in-difference analysis is by looking at preexisting trends prior to the policy intervention. As mentioned in chapter 2.2.1, the German opposition prevented the implementation of gender quotas until 2013. Only after the free Liberal party did not get into the parliament, the CDU, CSU and SPD announced new efforts to improve gender equality (CDU, CSU & SPD, 2013). Consequently, in March 2014 the proposal for a statutory gender quota was presented; and in December 2014 it passed the cabinet. The proposal was officially adopted by the parliament in March 2015 (Bozhinov, 2018). This resulted in the statutory 30%-quota in Germany as of 1 January 2016, meaning that all listed companies subject to the Co-Determination Act were obliged to comply with a fixed quota of 30% female representatives on the supervisory board by January 2016 (Van de Sande & Schneider, 2022).

In the past, the German parliament rejected many proposals for voluntary targets- and mandatory gender quotas in board rooms. Hence, the fact that the mandatory gender quota was passed by the Cabinet in March 2015 is expected to be a surprise for German public companies. Nevertheless, there could already be preexisting trends in gender ratios on the board of directors preceding the 30% statutory gender quota in 2016. Political focus on gender equality in board rooms already increased at the end of 2013, after the Free Liberal party did not get into the parliament due to the general elections. For this reason, publicly listed German companies could already anticipated on this after the new coalition agreement

[5] Robustness checks without controls, without company fixed effects and without clustering at firm level do not yield significantly different results.

in 2013, in which more efforts for gender equality were presented. In Figure A and B, in Appendix D, the line distances between the treatment- and control group extend slightly further over time prior to 2016. This may suggest that the increase of women in board rooms could also be due to other preexisting trends. To investigate the preexisting trends between 2013 and 2016, the first base specification (1) is estimated to see the interaction effect of the difference-in-difference model with a fake treatment effect (post-period after 2013). To test the fake treatment effect, only data is used before the treatment went into effect (2010-2016) to not capture the real treatment effect (Huntington-Klein, 2021).[6]

The estimates are presented in Table 5. Results of the preexisting trends analysis show that the estimates are statistically significant at a 5% level. This result indicates that there is an effect of the placebo post intervention period on the gender ratio within treatment group companies. This is a serious concern as this may indicate that the parallel trend assumption is violated and there are preexisting trends or omitted variables that affect the number of females in the board of directors in treatment group firms. Robustness checks with other fake placebo quota years all yield significant results for the treatment and post period interactions. For this reason, the difference-in-difference models should be interpreted with great caution as the results may not be accurate.

Table 5: Preexisting trends analysis

	Gender ratio
Treatment x Post 2013	.02423** [0.011]
Observations	1,255

Notes: This table tests the preexisting trends and examines the first base specification. The data which is used is from the pre-intervention period 2010-2016. The Post 2013 variable is a placebo treatment period. Standard errors are adjusted at firm level, are reported in parentheses.
*** p<0.01; ** p<;0.05; * p<0.1

[6] An analysis of preexisting trends using the entire sample period (2010-2020) following the example of Matsa and Miller (2013) yields almost the same results.

6. Conclusion & discussion

Using a sample of German listed companies in the period of 2010-2020, this study examines whether the German statutory gender quota of 2016 requiring 30% women on supervisory boards shows an effect on female representation in top positions such as board-, chair- or CEO positions. Additionally, the effect of the quota is examined in companies with more average board interlock and in companies active in more male-dominated industries. The introduction of the gender-quota in 2016 allows for a natural experiment in which the treatment group companies are subject to the policy intervention of 2016, whereas the control group companies are not. This study uses three different models to analyze the hypotheses. To test hypotheses 1a, 3 and 4 a difference-in-difference regression model is used. Additionally, hypotheses 1b, 1c, and 2b use a probit (difference-in-difference) regression model. Lastly, hypothesis 2a uses a two-stage linear probability model. All in all, the primary goal of this study is to assess the extent to which the 30%-gender quota results in an increase in the number of females in leadership positions rather than only in board positions.

By analyzing the interaction between the treatment group and the post intervention period, the results indicate that the gender quota increases the percentage of females in board positions in the treatment group compared to the control group. The result is in line with the expectation and with the findings of others that studied gender quotas and female board representation (Sojo et al., 2016; Smith, 2018). Moreover, the findings on the probability of having a female chair after the implementation of the 30% statutory gender quota in the treatment group compared to control group are only significant at a 10% level. The results indicate an average decreasing change in this sample in the probability of having a female chair after the implementation of the 30% statutory gender quota. Nevertheless, the result is not in line with the expectation that the probability of having a female chair increases due to the 30%-statutory quota within treatment-group companies. A potential explanation for the result is that treatment group companies are required to add female executive directors to their boards in order to satisfy the required 30% gender quota. Therefore, the gender quota may reduce the likelihood of treatment group firms selecting a female chair (non-executive director), as they would rather use these women to fill the mandatory gaps for their executive positions instead of their non-executive positions. Still, the result should be interpreted with caution as shortening the pre-intervention period removes its significance; and the result is only significant at a 10% level. For this reason, no real conclusion can be drawn from the result.

Furthermore, the findings show no significant effect of the gender quota on the probability of having a female CEO in the treatment group compared to the control group. A potential explanation for this is that the attainment of CEO positions depends on a great number of factors and capabilities. Research shows that education, number of children and the size of the company in terms of employees play a significant role in the likelihood of having a female CEO (Hurley & Choudhary, 2016). Also, the pool

of qualified women for these positions is likely to remain (almost) the same just after the introduction of the gender quota; since possessing these capabilities does not happen overnight and it might take several years for women to climb the corporate ladder. The findings of these results are in contrast with the findings of others that studied the effect of a Norwegian gender quota on the probability of a female board chair- and CEO (Wang & Kelan, 2013). However, the Norwegian context may be different from Germany.

Additionally, the finding on the probability of having a female CEO as the percentage of female representatives on the board of directors rises, shows an insignificant effect. This result is in line with the findings of Wang and Kelan (2013), who found the percentage of female directors to have no impact on the probability of having a female CEO. Nevertheless, the result is not in line with the expectation that the probability of having a female CEO increases as there are more female representatives on the board of directors. As already explained, the attainment of CEO positions depends on a great number of factors and capabilities. Therefore, having more female representatives on the board of directors might show no significant effect on the likelihood of a firm selecting a female CEO, as this depends on other factors rather than the mass of women in the board of directors.

Furthermore, by analyzing a triple interaction between board interlock, treatment group, and post intervention period the results indicate that the gender quota decreases the gender ratio more in treatment group firms with more board interlock. This result is, however, not in line with the expectation that the percentage of female board directors increases more after introduction of the quota in treatment group companies with more board interlock. A potential reason for this could be that firms with on average more board interlock might suffer from relatively more masculine interference. Board appointments are often influenced by the demand for diversity from the side of the selectors. Therefore, having a masculine established corporate elite is likely to be problematic for women aspiring to enter the board or other top positions (Kirsch, 2018). Consequently, firms with higher board interlock might also have a more (and larger) established 'old boys' network which may hamper the increase in the percentage of women directors on the board compared to companies with less board interlock. Another explanation might be that firms with higher board interlock may already exhibit a larger number of women on boards, resulting in a weaker gender quota effect in these companies. There are hardly any studies focusing on the effect of a gender quota on the gender ratio in the board of directors in (treatment) companies with more board interlock. The result is however in contrast with previous studies indicating that the presence of more female directors in the interlocking board network results in the hiring of more female directors (Hillman et al., 2007; Kogut et al., 2014). Nevertheless, these findings are not tested in the context of a gender quota. For this reason, this study is one of the first to show that there is a relationship between the gender quota and the percentage of female directors on boards and that this effect weakens when average board interlock increases (in the treatment group).

Lastly, the findings for the triple interaction between male-dominated industries, treatment group and post intervention period show that after the introduction of the gender quota, the gender ratio increases more in treatment group firms active in a male dominated industries compared to non-male dominated industries, pre-period and control group companies. This result is in line with the expectation that after the introduction of the statutory quota, the percentage of female board members increases more in male dominated firms in German companies that were subject to the quota, relative to companies that were not subject to the quota. Presumably, since male-dominated companies must fill in 30% of their board positions with women while having low female representation in their companies/boards, the effect of the gender quota is stronger for male-dominated companies. There are no other studies focusing on the effect of a gender quota on the gender ratio in the board of directors in (treatment) companies active in more male-dominated industries. Therefore, this study is one of the first to show that there is a relationship between the gender quota and the percentage of female directors on boards and that this effect is stronger for male-dominated companies (in the treatment group).

All in all, most analyses on the effect of the gender quota on females in leadership positions do not find significant results. Therefore, there is no clear indication whether the German mandatory 30%-gender quota in 2016 results in more females in leadership positions such as CEO- and/or chair-roles. The probit regression model and the two-stage linear probability model all find no significant result, except for the result of the gender quota on the probability of having a female chair within the treatment group. Nevertheless, shortening the pre-intervention period removed its significance; and the result is only significant at a 10% level. Therefore, no conclusions can be drawn based on these outcomes. The difference-in-difference regressions show highly significant results for the gender quota on the percentage of female board members in the treatment group. However, the robustness check with preexisting trends shows an effect of the placebo treatment period on gender ratio. These results may indicate that the parallel trend assumption is violated and there are preexisting trends or omitted variables that affect the number of females in the board of directors in treatment group firms. Furthermore, other fake placebo quota years all yield significant results for the treatment and post period interactions. Therefore, the difference-in-difference models should be interpreted with caution as the results may not be accurate.

The research question in this study was focused on the effect of the 30%-gender German quota in 2016 on female leadership in corporate positions for German companies. All in all, the analyses find a relationship between the gender quota and the percentage of females in board positions as well as effects in male-dominated industries and in companies with higher board interlock. This study is, however, not able to draw conclusions regarding the effect of the gender quota in Germany on females in leadership positions, due to statistical insignificance. Finally, this study is not able to find an unambiguous answer to the question on the effect of the 30%-gender German quota in 2016 on female leadership in corporate positions for German companies; therefore, additional research on this topic is required.

7. Limitations

There are several limitations to this study. Firstly, a potential limitation of this study is that this research cannot account for delisting companies in the dataset. The effect of countries delisting is difficult to capture since companies delist for different reasons. For example, the implementation of the gender quota might cause companies to delist to escape the quota-requirements. Since BoardEx does not possess data on non-listed companies, firms that delist at some moment in time are immediately removed from the dataset. Consequently, this can cause attrition bias and can cause a threat to the internal validity of this study. The delisted firms might be inherently different than firms staying in the control- and treatment group, which could affect the outcome of the study. Moreover, some companies may have delisted in the post-quota period, for instance, because they did not want to meet the quota requirements or because they feared that the gender quota rules might soon get extended to more companies. Due to this reason, pre-quota data may include more firms with lower female representation on average, and post-quota data may include more firms with higher female representation on the board of directors. As a result, there may be a selection bias, as the post-quota data may include companies with higher gender progressiveness compared to the pre-quota period.

Secondly, another concern in this study is the fact that Germany might adopt gender quotas since attitudes towards women in board- and executive positions are changing. The change in the treatment status of firms subject to the quota should not affect the control group, but this might be the case if there are changing attitudes towards gender equality. On top of that, there could also be spillover effects to the control group firms. For instance, linkages between control group companies and treatment group companies might also affect control group boards due to external pressure from treatment company boards. Additionally, there might be lower supply of female directors since treatment group companies possess many of the female candidates after the gender quota introduction. Furthermore, due to the gender quota, control group firms might also fear their own position as the German policy could be easily extended to listed firms with one-third codetermination. Consequently, control group firms may start anticipating on this expected policy intervention, therefore the increase in female (non)-executives may not reflect the causal impact of the quota on the treatment group only.

Another subsequent limitation in this research is the existence of pre-existing trends, which is tested in chapter 5.4.2. The results of the difference-in-difference analysis base specification using placebo quotas is a major concern as this indicates that the parallel trend assumption may be violated and there are preexisting trends or omitted variables that affect the number of females in the board of directors in treatment group firms. For this reason, German companies might already have changing attitudes to women in board- and executive roles as there are preexisting trends. All results must therefore be interpreted with great caution, as violation of the parallel trend assumption may lead to biased estimation of the causal effect.

Furthermore, the treatment group are listed firms which were subject to full co-determination (>2000 employees and publicly listed), whereas control group firms are subject to third co-determination (500-2000 employees and publicly listed). Therefore, control group firms are similar to treatment group firms as they are listed on the stock exchange but do not fall under full co-determination. However, one business entity is able to avoid the applicability of full co-determination through the use of the "before-and-after principle" in which their co-determination status is locked in (Brems & Maurer, 2022). The latter reason could lead to companies that originally should be part of the treated group to now be in the control group because they found a way to escape the gender quota obligations. Companies which are able to use the "before-and-after principle" are called SE's (Brems & Maurer, 2022). Since SE companies can circumvent the gender quota, the treatment group data contains almost no SE companies. To the extent that the SE companies are usually listed on the stock exchange and should be subject to full co-determination in terms of the number of employees, but may evade co-determination and thus the gender quota, these companies may still be inherently different from the rest.

Additionally, some company time-varying variables are not captured by this model which could potentially influence the outcome of the dependent variable. For example, data on financial company information and the number of employees is only available in BoardEx for one year (current year). Presumably, firms with more financial resources can potentially afford better recruitment processes and may thereby have more opportunities to find adequate female candidates for board- and leadership positions. Boardex, however, only has data on the current levels of revenue and employees. Therefore, these variables are not used in the analysis. Furthermore, the number of female CEOs and female chairs in the dataset is relatively low. Due to the small number of cases of firms having a female CEO/chair the probit model can suffer from potential bias as rare events require large sample sizes (Bergtold et al., 2018). Additionally, the results in this study only reflect short-term effects of the gender quota. Since the average length of terms on the board of directors is approximately 3 years (Peacy, 2021), a 4-year post-intervention period might be relatively short to see major changes. The real effect of the quota on women occupying (non)-executive positions might potentially take even longer to adjust to changes than the board of directors, where the quota is mandatory; meaning that a 4-year post intervention period might be too short to capture the effect on (non)-executive leadership positions.

Lastly, the representativeness of this study is limited. The focus of this study is solely publicly listed German companies since the scope of the German 30%-statutory quota is limited to only a portion of German listed companies. Therefore, the results of this study are only applicable to Germany as other countries might react differently to gender quotas. Countries may have different attitudes towards gender equality and gender quotas and therefore the external validity of this study is low.

8. Future research

The limitations of this study also create new areas for future research on the effect of gender quotas on the presence of women in board- and (non)-executive positions. As already mentioned, the number of female CEOs and female chairs is relatively low. Therefore, future studies should use cases where the number of women in executive positions is higher to accurately examine the aforementioned effects. Moreover, since this research was only able to focus on the short term's effects of the quota, it would also be interesting to see whether gender-quotas show a long-term effect. The average length of terms within the board of directors is approximately 3 years (Peacy, 2021). Therefore, the 4-year post-intervention period might be too short to see (major) changes. Due to the post-intervention period of 4 years, the real effect of the quota on women occupying (non)-executive positions might not be captured. Therefore, changes in gender compositions in (non)-executive positions, may potentially take even longer to adjust than positions in the board of directors. Future research implications are therefore to examine longer post-intervention periods since changes in the board of directors, and therefore also (non)-executive director positions, take time.

Furthermore, BoardEx does not contain data on board structures. Future research might also want to differentiate between one- and two-tier board structures since it can be interesting to examine whether these structures also play a role in the percentage of female directors on boards and the number of female (non)-executives. Moreover, as mentioned in the limitations, BoardEx does not contain multiple year financial information. Future research should therefore gather more firm level data to control for companies' revenue over time and other financial factors which could influence the number of female board members or female CEO/chairs. Moreover, future studies should find a way to control for the problem of delisting companies being removed from the dataset as this may bias- and lower the representativeness of the results.

Also, the preexisting trend robustness check in this study implies the significant effects in the difference-in-difference model are not completely valid and should be interpreted with caution. Future research should choose an adequate regression model to safely interpret the results of the gender quota on the percentage of female directors. Also, mapping out the preexisting trends and seeing when these trends started happening and why yields a more complete image of the effect of the gender quota and the (potentially) changing attitudes of German companies towards more women in leadership positions.

Lastly, the representativeness of this study is low since the scope of this research is limited to Germany. Nevertheless, there are multiple countries enacting gender quotas in board rooms. Consequently, studying other countries within this area of research may be interesting for future studies. Unfortunately, this study was unable to find significant effects of the gender quota on women occupying leadership

positions. Therefore, it is interesting for future research to focus on similar issues as in this study, since the goal of gender-quotas is not only to have more women in the board of directors, but also eventually cause spillovers to other top-level positions. Lastly, this study uses German listed companies with headquarters in Germany. Thereby, this study neglects the fact that companies can have multiple locations throughout the world which are being exposed to different attitudes and cultures on topics such as gender equality. The number of other countries a company is active in, is therefore also an interesting area of future research, as linkages in many other countries could also influence the number of women on the board of directors.

Despite the limitations, this study fills an important gap in this area of research since limited studies are available on the impact of gender quotas on women occupying (non)-executive positions. Most previously conducted studies examine the effectiveness of gender quotas on the board of directors or focus on the impact of quotas on firm performance. Considering, however, that gender quotas are designed with the idea that women will have greater access to top-level positions, it is interesting for future research to examine whether quotas work at the desired level as well as other levels. Recent developments in the field of gender quotas have led to a renewed interest in whether these quotas are effective in achieving more equality in the board of directors. However, empirical contributions on the impact of statutory gender quotas on women in leadership roles remain superficial. Therefore, this study lays a good foundation for future research to examine the effect of gender quotas on female leadership in corporate positions**.**

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Appendix A

Table A: Companies which had to comply with the quota during the period of 2016-2020

No	Company Name	No	Company Name
1	Adidas AG	51	Infineon Technologies AG
2	Adler Modemärkte AG	52	JENOPTIK AG
3	Allianz SE	53	Jungheinrich AG [VA]
4	Amadeus FiRe AG	54	K+S AG
5	Audi AG	55	Kion Group AG
6	Aurubis AG	56	Koenig & Bauer AG
7	BASF SE	57	Krones AG
8	Bauer AG	58	KSB AG
9	Bayer AG	59	KUKA AG
10	BayWa AG [Vink. NA]	60	Lanxess AG
11	Bechtle AG	61	Leoni AG [St.]
12	Beiersdorf AG	62	Mainova AG
13	Bilfinger SE	63	MAN SE
14	BMW AG	64	Maternus-Kliniken AG
15	Bremer Lagerhaus AG	65	Mediclin AG
16	Ceconomy AG	66	Merck KGaA
17	CEWE Stiftung & Co. KGaA	67	MTU Aero Engines Holding AG
18	Commerzbank AG	68	Münchener Rück AG
19	Continental AG	69	MVV Energie AG
20	Daimler AG	70	OSRAM Licht AG
21	Deutsche Bank AG	71	Rheinmetall AG
22	Deutsche Lufthansa AG	72	Rhön-Klinikum AG [StA]
23	Deutsche Post AG	73	RWE AG [StA]
24	Deutsche Telekom AG	74	Salzgitter AG
25	Deutz AG	75	SAP SE
26	DMG MORI SEIKI AG	76	Sartorius AG
27	Drägewerk AG & Co KGaA	77	Schaeffler AG
28	Dürr AG	78	SCHULER AG
29	E.ON SE	79	SGL CARBON SE
30	ElringKlinger AG [NA]	80	Siemens AG
31	EnBW Energie AG	81	SMA Solar Technology AG
32	Evonik Industries AG	82	STO SE & Co. KGaA
33	Fielmann AG	83	Südzucker AG [StA]
34	Fraport AG	84	Symrise AG
35	Freenet AG	85	Talanx AG
36	FRESENIUS SE & Co. KGaA	86	Telefonica Deutschland H. AG
37	GEA Group AG	87	ThyssenKrupp AG
38	Gerresheimer AG	88	TUI AG [NA]
39	Gerry Weber AG	89	ÜSTRA Hannov. Verkehrsbetr. AG
40	Grammer AG	90	Villeroy & Boch AG
41	Hamburger Hafen und Logistik AG	91	Volkswagen AG [VZ]
42	Hapag Lloyd Aktiengesellschaft	92	Wacker Chemie AG
43	Heidelberg Cement AG	93	Wasgau Produktions & Handels AG
44	Heidelberger Druckmaschinen AG	94	Wüstenrot & Württenbergische AG
45	Hella KGaA	95	RENK AG
46	HENKEL AG & CO KGAA [VZ]	96	McKesson Europe AG
47	Hochtief AG	97	Linde (de-listed 2019)
48	Hornbach Naumarkt AG	98	Oldenburgische Landesbank AG (OLB) (de-listed 2018)
49	HSBC Trinkaus & Burkhardt AG	99	Diebold Nixdorf AG (Wincor Nixdorf AG prior to
50	Hugo Boss AG [VA]		12/2016) (de-listed 2019)

Table B: companies that were only eligible for the quota after 2016

Company	Year in which it had to comply with quota
Covestro AG	2017
Deutsche Boerse AG	2018
Indus Holding AG	2018
Innogy SE	2016 (listed on 2016, delisted 2020)
Knorr-Bremse AG	2018
Siltronic AG	2017
Tom Tailor Holding AG	2017
Uniper SE	2016 (was founded in 2016)

Table C: Companies subject to the quota in 2015 but delisted/ are not eligible for the quota anymore

Company	Reason
Deutsche Postbank	Deutsche Bank sold its entire stake in Postbank just before 2016
Kabel Deutschland	Unknown when company was not in treatment group anymore (removed from the dataset)
Nurnberger Beteilungs-AG	Unknown when company was not in treatment group anymore (removed from the dataset)
Paul Hartmann AG	Unknown when company was not in treatment group anymore (removed from the dataset)
Porsche Automobil Holding SE	Not subject to Co-Determination Act
Sanacorp Pharmaholding AG (Sanacorp Pharmahandel AG prior to 2007)	De-listed 2019 (removed from the dataset since dataset only contains data in 2017 and 2018)
Homag group	Unknown when company was not in treatment group anymore (removed from the dataset)
Linde	De-listed 2019 (kept in the dataset)
Oldenburgische Landesbank AG (OLB)	De-listed 2018 (kept in the dataset)
Software AG (Software AG Darmstadt prior to 06/2002)	Not subject to Co-Determination Act, unknown when company was not in treatment group anymore (removed from the dataset)
Diebold Nixdorf AG (Wincor Nixdorf AG prior to 12/2016)	De-listed 2019 (kept in the dataset)

Appendix B

Table D: sectors

Sector	Number of observations
Agriculture, Forestry, Fishing	11
Mining	37
Construction	117
Manufacturing	936
Transportation & Public Utilities	262
Wholesale Trade & Retail trade	303
Finance, Insurance, Real Estate	245
Information Technology	313
Services & Public Administration	482

Table E: male dominated industries

Male-dominated industries (>70% male employees)	Others
Diversified Industrials	Pharmaceuticals and Biotechnology
Electronic & Electrical Equipment	Real Estate
Engineering & Machinery	Health
Aerospace & Defence	Business Services
Transport	Consumer Services
Diversified Industrials	Media & Entertainment
Information Technology Hardware	Telecommunication Services
Software & Computer Services	Publishing
Renewable Energy	Trade Association
Oil & Gas	Regulators
Electricity	Chamber of Commerce
Utilities - Other	Blank Check / Shell Companies
Mining	Education
Steel	Leisure Goods
Steel & Other Metals	Clothing & Personal Products
Construction & Building Materials	Legal
Containers & Packaging	Wholesale Trade
Chemicals	Beverages
Forestry & Paper	Food & Drug Retailers
Automobiles & Parts	Tobacco
	Banks
	Investment Companies
	Insurance
	Private Equity
	Sovereign Wealth Fund
	Speciality & Other Finance
	Life Assurance

Appendix C

Table F: Correlation matrix

	Gender ratio	Average board interlock	Average age directors	Nationality mix	Average time in board	Number of qualifications	Independence	Average network size (ln)	Sector	Treatment	Post-intervention
Gender ratio	1										
Average Board interlock	0.0606	1									
Age	-0.1772	0.0696	1								
Nationality mix	0.1304	0.1153	-0.0902	1							
Average time in board	-0.1181	-0.0238	0.3223	-0.2344	1						
Number of qualifications	0.0246	0.1926	-0.0190	0.1451	-0.0743	1					
Independence	0.7077	0.2814	-0.1857	0.1558	-0.1036	0.0029	1				
Average network size (ln)	0.2219	0.2403	0.0117	0.3656	-0.2249	0.5165	0.1852	1			
Sector	-0.0145	-0.0719	-0.0998	0.0937	0.0535	0.0903	-0.0100	0.1448	1		
Treatment	0.4331	0.0978	0.1517	0.1216	-0.0469	-0.0752	0.3185	0.2336	-0.2095	1	
Post-intervention	0.2895	-0.0330	-0.4510	0.0120	0.0737	0.0231	0.1801	-0.0532	-0.0146	-0.0752	1

Table G: VIF test

	VIF	1/VIF
Average network size (ln)	1.77	0.565958
Average age directors	1.66	0.603728
Number of qualifications	1.42	0.704040
Quota	1.41	0.707259
Treatment	1.35	0.738170
Female independence	1.34	0.748716
Time in board	1.33	0.753205
Nationality mix	1.21	0.828905
Average board interlock	1.18	0.844314
Sector	1.18	0.847475
Mean VIF	1.38	

Table H: Autocorrelation test by Drukker (2003)

F(1, 216)	67.606
Prob > F	0.0000

Table I: Durbin Wu Hausman test for endogeneity

chi2(1)	4.15
Prob > chi2	0.0425

Table J: IV regression first stage

Variables	**1**	**2**
	Gender ratio	*Gender ratio*
Post-period	0.047***	0.015***
	[0.004]	[0.004]
Treatment		
*Treatment * Post-period*	0.073***	0.054***
	[0.006]	[0.005]
Average age directors		-0.010***
		[0.001]
Nationality Mix		0.032***
		[0.011]
ln average network size		-0.017***
		[0.005]
Average time in board		0.001
		[0.001]
Number of qualifications		-0.000
		[0.000]
Board interlock		0.001***
		[0.000]
Constant	0.096***	0.829***
	[0.002]	[0.046]
Fixed effects	*Yes*	*Yes*
F-test	11.48	11.21
Observations	2,535	2,535

Table K: Robustness-check base model

	Base model Difference-in-Difference			
Gender ratio	*(1)*	*(2)*	*(3)*	*(4)*
Treatment	0.075***	0.095***	0.077**	0.077***
	[0.011]	[0.011]	[0.034]	[0.024]
Post-period	0.047***	0.019***	0.015***	0.015***
	[0.003]	[0.004]	[0.004]	[0.008]
*Treatment * Post-period*	0.073***	0.059***	0.053***	0.053***
	[0.001]	[0.005]	[0.006]	[0.012]
Average age directors		-0.001***	-0.010***	-0.010***
		[0.000]	[0.001]	[0.001]
Nationality Mix		0.029***	0.032***	0.032
		[0.010]	[0.011]	[0.024]
ln average network size		-0.003	-0.016***	-0.016
		[0.004]	[0.005]	[0.010]
Average time in board		0.001	0.001	0.001
		[0.001]	[0.001]	[0.002]
Number of qualifications		-0.003	0.006	0.001
		[0.005]	[0.006]	[0.014]
Board interlock		-0.004	-0.001	-0.007
		[0.005]	[0.006]	[0.013]
Constant	0.070***	0.588***	0.808***	0.808***
	[0.006]	[0.039]	[0.048]	[0.093]
Observations	2,705	2,535	2,535	2,535
R-squared within	0.2936	0.3923	0.3976	0.3976
R-squared between	0.2386	0.1736	1.0000	1.0000
R-squared overall	0.3062	0.3011	0.7671	0.7671
Company fixed effects	*No*	*No*	*Yes*	*Yes*
Clustered standard errors	*No*	*No*	*No*	*Yes*

Standard errors are reported in parentheses.
*** p<0.01; ** p<;0.05; * p<0.1

Appendix D

Figure A: Parallel trend assumption

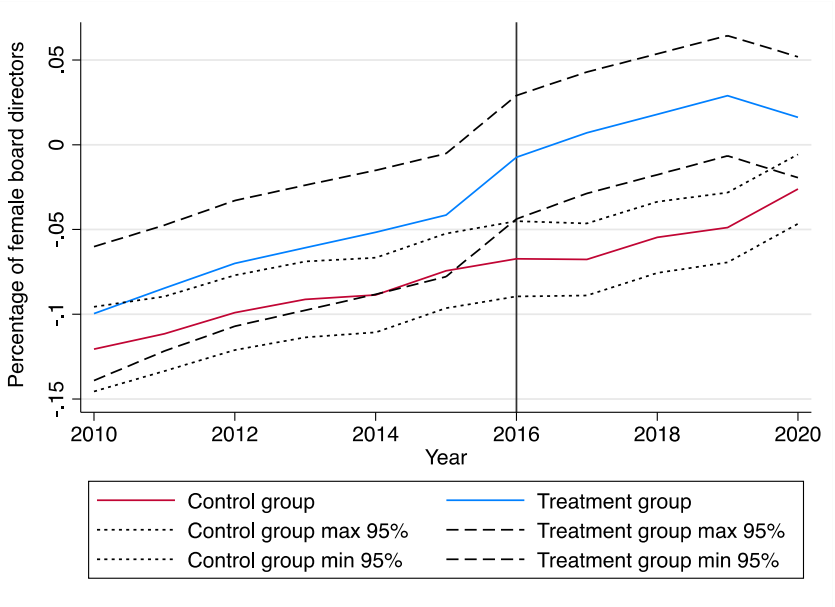


Figure B: Trends of control- and treatment group

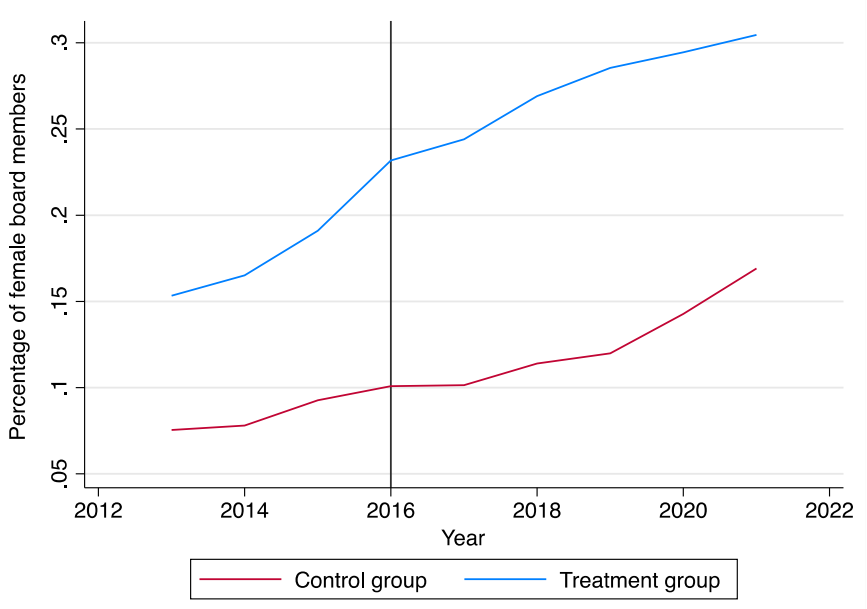


Figure C: Percentage of companies with a female CEOs per year for the treatment and control group

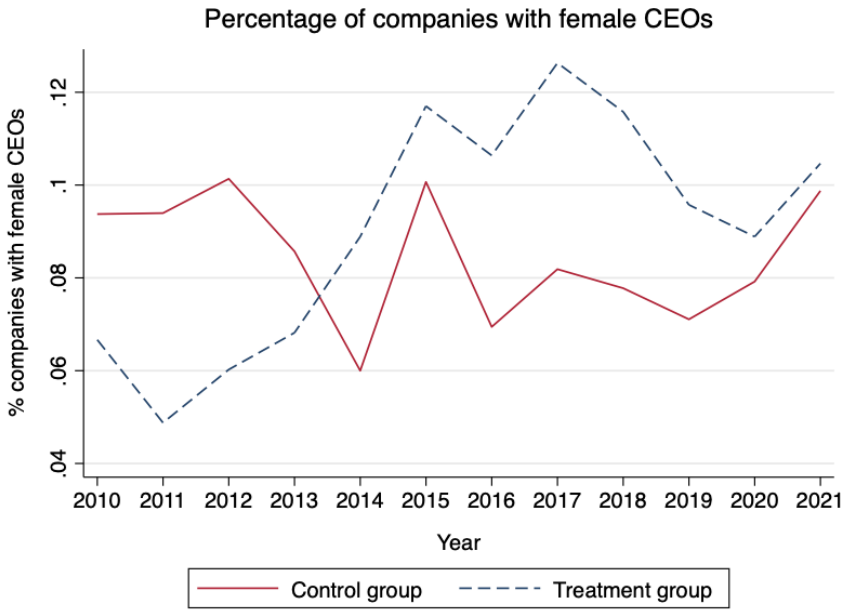


Figure D: Percentage of companies with a female chairs per year for the treatment and control group

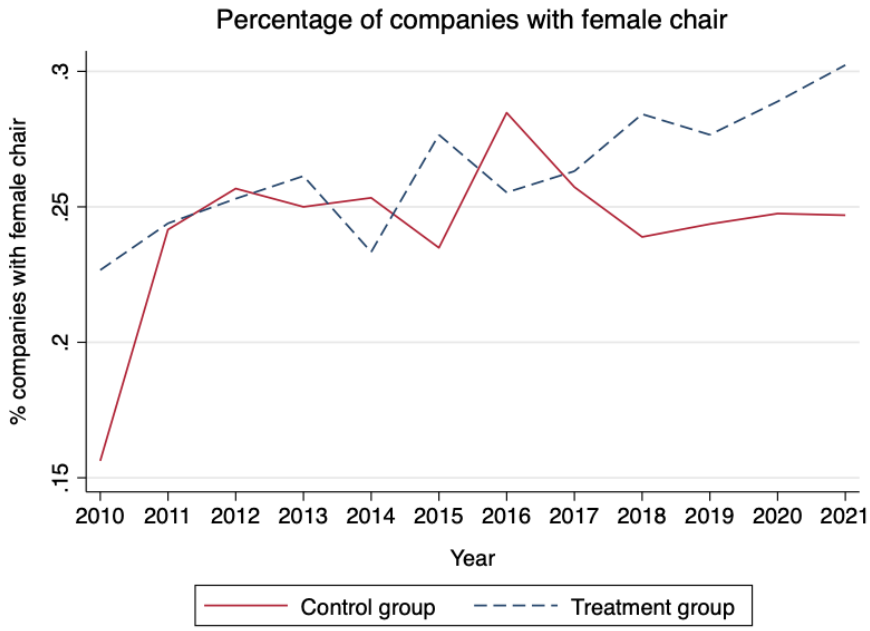
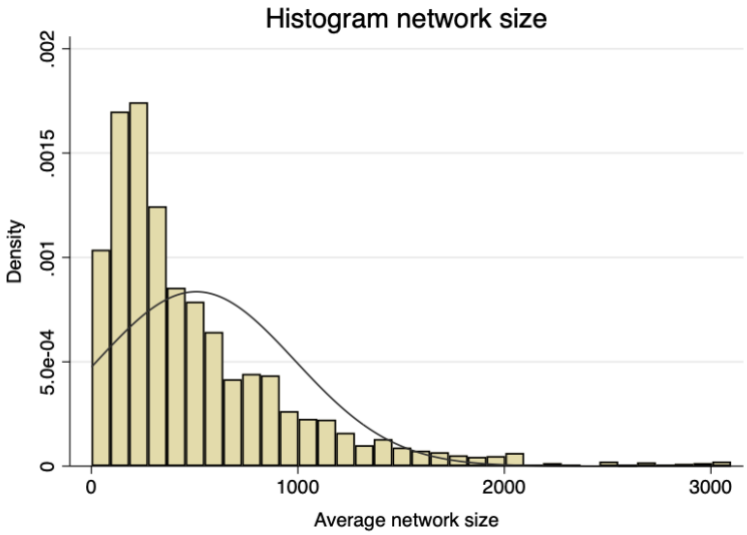


Figure E: histogram average network size



Appendix E

Table L: permutation test

T	T(obs)	c	n	p=c/n	SE(p)	[95% Confidence Interval]	
*Treatment * Post-intervention*	.0526	0	100	0.000	0.000	0	0.036

Table M: number of distinct firms in treatment- and control group per year

	2016-2020	2016	2017	2018	2019	2020
Treatment group	86	94	95	95	94	90
Control group	125	144	171	180	197	202

Table N: number of companies with female CEOs in treatment- and control group per year

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Treatment group	5	4	5	6	8	11	10	12	11	9	8
Control group	9	14	15	12	9	15	10	14	14	14	16

Table O: number of companies with female chairs in treatment- and control group per year

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Treatment group	17	36	21	23	21	26	24	25	27	26	26
Control group	15	20	38	35	38	35	41	44	43	48	50