

Board quotas, women's representation in top management, and firm performance*

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Abstract

This paper examines the effects of a gender quota on supervisory boards implemented in Germany in 2016, which mandated 106 large firms to have at least 30% of women on their supervisory boards. Applying a difference-in-differences approach to panel data on firms, we find that the introduction of the quota increased the share of firms complying with the quota law. We also find, however, that this positive effect originated from earlier attempts to introduce quotas for supervisory boards. We neither find that other characteristics of supervisory board members are affected, nor that the quota created spillover effects on the untargeted executive boards. For firm performance, we find, if any, positive effects of the quota introduction.

Keywords: board quotas, supervisory board, firm performance

JEL Classification Numbers: J16, L25, M51

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1 Introduction

Although progress has been made to achieve better representation of women in leadership positions, women are still largely underrepresented in top management (see, e.g. Adams and Kirchmaier, 2016; Smith, 2018). For the largest publicly listed companies in Europe, an average of 20.0% of executives in 2021 are women with only 7.9% of all chief executive officers being female (EIGE, 2021). Explanations for this imbalance in promotions to higher levels of the organizational hierarchy include gender differences in networks (e.g., Cullen and Perez-Truglia, 2019), gender differences in career interruptions (e.g., Bertrand, Goldin, and Katz, 2010), gender in differences in preferences (see, e.g., Buser, Niederle, and Oosterbeek, 2014), and local or organizational gender norms (Adams and Kirchmaier, 2013; Hospido, Laeven, and Lamo, 2021). Studies have highlighted the importance of equal representation for decision making in political leadership (Chattopadhyay and Duflo, 2004; Clayton and Zetterberg, 2018) and management (see, e.g., Bertrand and Schoar, 2003; Bloom and Van Reenen, 2010; Chen, Leung, Song, and Goergen, 2019), and its importance for economic growth (Hsieh, Hurst, Jones, and Klenow, 2019; Bertay, Dordevic, and Sever, 2020). To achieve gender balance in top management of firms, several countries have introduced explicit policies such as binding gender quotas for boards of directors. Quotas for boards of directors have first been introduced in Norway in 2003, later in several other countries, and were even proposed to be introduced for all European Union countries (European Commission, 2012).¹ While directly targeting female representation among directors, most quota reforms have the explicit aim at generating spillover effects on lower management levels.

Germany, whose largest companies had slightly less women among executive than the EU average (17.0%; EIGE (2021)), introduced a gender quota for supervisory boards effective in January 2016. Following the quota introduction, the largest publicly listed companies were subject to a compulsory board quota that required them to fill board seats with at least 30% women. Given that only about 33% of the firms subject to the quota had already reached the required share at the time of its introduction, most firms were required to increase the share of women on their supervisory board after the introduction of the law. In this paper, we study how the introduction of this quota affected female representation on the targeted supervisory

¹Amongst others, compulsory gender quotas for boards have also been introduced in Norway (effective in 2008), Iceland (2010), Denmark (2012), Italy (2015), Spain (2015), Belgium (2017), France (2017) and in Austria (2018). The United Kingdom (2015) and the Netherlands (2016) passed target quotas without penalties in case of non-compliance. See Smith (2018) and Kuzmina and Melentyeva (2021). Gender quotas have also been studied in other environments in which women are underrepresented, such as politics (see, e.g., De Paola, Scoppa, and Lombardo, 2010; Besley, Folke, Persson, and Rickne, 2017; Bagues and Campa, 2021).

boards and the untargeted executive boards, and also provide evidence on effects of the quota on firm performance. Our empirical strategy is based on a difference-in-differences approach where quota firms are compared to firms that were not subject to the quota. Using detailed firm-level information on board members and firm performance, we show that, over the four years after the reform, an additional 32% of firms reached a female board share of 30% or more. The average supervisory board increased the share of female board members by 7 percentage points. Relating to earlier studies evaluating how gender board quotas affect board composition and firm outcomes, we then analyze to which degree the quota induced changes in the underlying characteristics of board members, and whether the quota increased the probability for women to hold special roles, such as being elected as chairperson or vice-chairperson (cf. Bozhinov, Koch, and Schank, 2019). We then turn to the question whether the increase in female board members had spillover effects on executive boards that were not subject to the quota regulation (Bertrand, Black, Jensen, and Lleras-Muney, 2018; Maida and Weber, 2021). Lastly, we test whether the quota-induced increase of women on supervisory boards affected firm performance and employment-related outcomes of targeted firms (Ahern and Dittmar, 2012; Eckbo, Nygaard, and Thorburn, 2021; Yang, Riepe, Moser, Pull, and Terjesen, 2019; Comi, Grasseni, Origo, and Pagani, 2020; Ferrari, Ferraro, Profeta, and Pronzato, 2021). In a number of robustness tests, we provide evidence that the estimated effects can be interpreted as causal effects.

The effect of quotas on board diversity. With this study, we contribute to the understanding of whether and how (gender) diversity on boards affects firms, and whether board quotas contribute to improving female representation across hierarchies. Besides estimating the direct effect of the board quota on female representation on the targeted supervisory boards, we also study whether supervisory boards' characteristics change with the introduction of the quota. For the introduction of the gender quota for boards of directors in Norway in 2003, Bertrand et al. (2018) show that the women entering boards after the quota introduction are on average better in terms of observable characteristics, such as higher education and higher earnings. In a recent study, Boyallian, Dasgupta, and Homroy (2019) show that women who are appointed to a board the first time, have on average less leadership experience but are faster to get a second appointment suggesting a limited supply of women for boards. Gertsberg, Mollerstrom, and Pagel (2021) show that a board quota in California led to incoming female board members who were not of lower quality than incumbent board members. In our study, we test whether board members become less experienced, have smaller networks, or whether boards become more in-

ternational. Neither of the outcomes is affected by the quota reform, suggesting that there was sufficient supply of qualified women to fill boards seats reserved for the underrepresented gender (cf. Ferrari et al., 2021; Yang et al., 2019; Del Prete, Papini, and Tonello, 2021). Together with the evidence from Norway and Italy showing that boards improved on observable characteristics (Bertrand et al., 2018; Baltrunaite, Cannella, Mocetti, and Roma, 2020; Comi et al., 2020), this adds to the evidence that board quality does *not* decrease, which was often used as an argument against gender quotas for boards. We also test whether the quota affected the probability for women to hold special positions *within* supervisory boards. While Bozhinov et al. (2019), who study elections into leading roles within supervisory boards of large German companies, find that women on supervisory boards are less likely to hold special roles, we find that quota firms have the same probability of having a female chair or vice-chair as non-quota firms.²

Spillover effects of female leadership on wages and employment in firms. This study also relates to earlier analyses on the spillover effects of board quotas on top management in general, and executive boards in particular. For the introduction of the Norwegian gender board quota, Bertrand et al. (2018) find that female representation in top management is not affected by quotas on the boards of directors. Similarly, Maida and Weber (2021) find that the introduction of gender quotas in Italy in 2011 increased female representation in targeted boards, but did not create spillovers for top management levels in firms. In contrast, the study of Dalvit, Patel, and Tan (2021) shows that the 40% quota for French firms led to higher female representation and lower wage gaps for upper layers of the firm. Despite being similar in design, a likely reason for the diverging findings is the temporary nature of the Italian quota: knowing that the quota would be eliminated a few years later, top management might be more reluctant to implement policies for more permanent changes. In a recent working paper written independently from and contemporaneously to ours, Fedorets and Gibert (2020) find that the increase in the share of women on supervisory boards comes at the cost of a *decrease* of women on the executive board in larger firms. Comparing quota firms in Germany before and after the quota introduction, Bozhinov, Joecks, and Scharfenkamp (2021) provide results that suggest that not additional women *per se* improve female representation on executive boards, but that women in *committees* nominating executive board members matter. Similarly, Kirsch and Wrohlich (2020) show positive correlations between past female representation on supervisory boards and

²Our results are not directly comparable to the results shown in Bozhinov et al. (2019) who only analyze quota firms up to 2016 and do not control for the development of non-quota firms as a counterfactual.

current female representation on executive boards, suggesting trickle down effects. Using four years of follow up after the introduction of a 30% quota and an estimation strategy which compares quota and non-quota firms before and after the quota introduction, our results show that there is a relatively precisely estimated zero effect on the share of women, which is line with earlier studies, such as Bertrand et al. (2018) and Maida and Weber (2021). Given that most gender board quotas require around 30% to 40% of board members to be of the minority gender, it is likely that the targeted population, datasets, as well as methods applied to study the effects of board quotas are important for estimated effect sizes.

Effects of female representation on decision making in the firm and firm performance. This study also contributes to the literature analyzing the effect of female leadership in general on decision making within the firm and firm performance. Besides becoming more diverse in terms of gender, quota-induced inflows of new board members can also lead to changes along other dimensions, such as age or educational background (see, e.g., Bertrand et al., 2018; Baltrunaite et al., 2020; Comi et al., 2020; Ferrari et al., 2021; Baltrunaite et al., 2020). Indeed, earlier studies have shown that corporate decisions are affected by board demographics due to differences in risk-taking (see, e.g., Adams and Funk, 2012) and differences in management styles more generally (see, e.g., Bertrand and Schoar, 2003). Studies analyzing the effect of gender diversity of corporate boards on firm performance find mixed results (see, e.g., Adams and Ferreira, 2009; Adams and Mehran, 2012), but also highlight the importance of firm heterogeneity and potential non-linearity in the relation between diversity and firm performance (Owen and Temesvary, 2018; Conyon and He, 2017). These studies also highlight the importance of exogenous variation to identify the effect of female representation and outcome variables.

An arguably credible way for identifying the effects of gender diversity on firm performance is to exploit plausibly exogenous shifts in the gender composition of corporate boards. For the Norwegian board quota, Ahern and Dittmar (2012) show that the gender quota of 40% decreased both stock market valuation and firm value, as measured by Tobin's Q . These results were later challenged by Eckbo et al. (2021) who argue that it is important to take endogenous sorting into account.³ Comparing quota firms in Norway to firms in Sweden, Denmark and Finland, other studies find that the introduction of the board quota led to a decrease in operational profits driven by fewer layoffs, and a decrease in ROA (Matsa and Miller, 2013; Yang et al.,

³Using only a rather short window around the introduction of the Norwegian quota, Dale-Olsen, Schøne, and Verner (2013) find similar results, suggesting that neither return on total assets (ROA) nor changed operating revenues and cost were affected by the introduction.

2019). For the introduction of gender board quotas in France and Italy, Comi et al. (2020) find negative (zero) effects of the French (Italian) board quota on firms' ROA, suggesting that the exact implementation might matter for the results. Exploiting discontinuities created by the introduction of different quota rules across Europe, Kuzmina and Melentyeva (2021) find that a higher share of women on boards improves firm performance and explain this by women scaling down inefficient operations. Importantly, Kuzmina and Melentyeva (2021) also highlight that common trends prior to the quota introductions are crucial and can explain a downward bias in estimates. One explanation for such positive effects is that the replacement of board members induced by the quota is seen as a positive signal by markets. We contribute to these studies by providing corroborative evidence on how the quota introduction in German supervisory boards affected firm performance. While we do find that several outcome measures are affected by the board quota, we also find that quota firms grow differently compared to control group firms, violating the parallel trends assumption. For the outcomes for which the quota led to a structural break, we find that the quota had in fact rather positive effects on firm performance.

More generally, our results contribute to the literature on whether and how diversity in leadership affects organizations, both in business and politics (see, e.g., Byron and Post, 2016; Kirsch, 2018; Profeta, 2020). Using political reservations in India to study the impact of female representation on policy decisions, Chattopadhyay and Duflo (2004) show that leaders invest more in public goods that are directly relevant to the needs of their own genders. Extending this argument to the corporate leadership level, firms may, as a results of higher representation at the top, place more emphasis on issues that are more relevant to women, such as maternity leave or establishing working conditions that reduce women's obstacles to corporate advancement.

The introduction of the gender board quota for larger publicly listed firms in Germany in 2016 is interesting to analyze for several reasons. Firms subject to the quota are parity co-determined, i.e they have both shareholder and employee representatives on the supervisory board. Failing to comply with the quota is costly for firms because either shareholders or the employee side would loose bargaining power on the supervisory board. Despite that female representation in top management are slightly above the European average and progressive policies have been introduced, such as shared parental leave, Germany is still dominated by institutions promoting the male breadwinner model. Estimates for the introduction of the German board quota can then be contrasted against similar estimates for other countries, namely the relatively gender-equal Norway on the one hand, and Italy and Spain on the other hand.

This paper is structured as following. In the following section, we describe the institutional framework, including its two-tier board system (Section 2.1) and details on the gender quota on supervisory boards introduced in 2016 (Section 2.2). Section 3 describes the data used in the study and Section 4 describes our difference-in-differences estimation framework. Descriptive results and regression results on female representation in supervisory boards, executive boards, and firm performance are presented in 5. In Section 6, we show and interpret a range of robustness checks to further support our main findings. Section 7 concludes.

2 Institutional framework

In this section we briefly describe the institutional setting in Germany before discussing the features of the 2016 introduction of the gender quota for supervisory boards of larger and publicly listed firms.

2.1 Background

Despite recent advances in policies towards a more equal participation of men and women in the labour market, such as the introduction of paternity leave in 2007 (Raute, 2019), Germany has a history of institutions promoting the “male breadwinner model”, such as the joint taxation of married couples which creates tax benefits for high degrees of income inequality within households (see, e.g., Meier and Wrede, 2013). Although the share of women in the labor force has increased from 48% in 1991 to 55% in 2020, the share of women in top management and corporate board positions is still rather low. In the year before the introduction of the gender quota for supervisory boards in 2016, the share of women among all supervisory board members was only 20% among the 200 largest firms in Germany. Among members of executive boards, the corresponding number was as low as six percent (Holst and Wrohlich, 2019).

Germany has a two-tier board system, in which supervisory boards are responsible for monitoring the executive board, voting on strategy changes, determining executive pay, and have the right to appoint and fire executives. Together with the executive board, the supervisory board also proposes the annual dividend to the stockholders’ meeting. Executive boards are responsible for day-to-day business and strategy, and propose strategy changes to the supervisory board.

The size and composition of a supervisory board is determined by law and depends on the firm's size, its legal form, and whether the firm is codetermined or not. Limited companies with more than 2,000 employees are *parity codetermined*, i.e., the supervisory board is required to be equally split between shareholder representatives and employee representatives (see, e.g., Jäger, Schoefer, and Heining, 2021).⁴ This is designed to ensure that both shareholders and employees have influence on the supervisory board's decision making. Firms with 500 to 2,000 employees have *third codetermination*, i.e. a third of supervisory board seats are held by employee representatives, or *parity codetermination*, i.e. half of the board seats are held by employee representatives.⁵ Companies with fewer than 500 employees are not subject to codetermination on their supervisory board and hence consist only of shareholder representatives.

The size of supervisory boards also depends on the type of codetermination: parity codetermined firms are required to have 10 supervisory board members when they have 1,000 to 2,000 employees, 12 board members for 2,000 to 10,000 employees, 16 for 10,000 to 20,000 employees, or 20 when firms have more than 20,000 employees, respectively.⁶ Supervisory boards elections are typically held every four to five years. In case supervisory board members step down, individual positions are elected between main elections. There are no restrictions how often board member can be re-elected.

2.2 The gender quota for supervisory boards

Already in 2011 a first attempt was made by Ursula von der Leyen, then Germany's Minister of Labour and Social Affairs, to introduce a mandatory quota of 30% for both supervisory and executive boards. This attempt was subsequently rejected in the cabinet of Chancellor Angela Merkel.⁷ The gender quota re-entered the public debate in late 2013 as part of coalition negotiations between the Social Democrats (SPD) and the Christian Democrats (CDU) following

⁴Regulated in the *Codetermination Act (Mitbestimmungsgesetz)* from 1976.

⁵Firms with 1,000 to 2,000 employees are parity codetermined only if they engage in mining and steel production. In all other cases, firms with 500 to 2,000 employees are third codetermined. This is regulated in laws similar to the codetermination act (*Montan-Mitbestimmungsgesetz*; *Mitbestimmungsergänzungsgesetz*; *Drittelbeteiligungsgesetz*).

⁶For firms that are active in the mining industries, the *Montan-Mitbestimmungsgesetz* and the *Mitbestimmungsergänzungsgesetz* regulate the way these companies are codetermined.

⁷In addition, there were several earlier attempts to introduce or to self-impose gender quotas. In 2008, a number of German women's networks jointly demanded the introduction of a mandatory gender quota for supervisory boards of 40% in what was called the *Nürnberger Resolution*. In March 2010, Deutsche Telekom voluntarily committed to having 30% of all middle and upper management positions held by women by 2015. Several other large German companies in the private sector such as BMW, Daimler, E.ON, Bosch and Airbus followed suit and committed to increasing female representation at the corporate leadership level to between 15 and 22 percent.

the federal elections. A draft of the *Law on Equal Participation of Women and Men in Leadership Positions in the Private and Public Sector* mandating 30% female representation in supervisory boards was passed by the cabinet in December 2014 and was passed by the parliament in March 2015 (Bundesgesetzblatt, 2015). The law came into effect in January 2016. The law had the objective to counter the stalled progress and increase female representation not only on supervisory boards themselves, but also to have positive spillovers onto top management positions (German Federal Government, 2015).

The law required a strict quota of 30% of the underrepresented gender for supervisory boards in firms that are both stock-listed *and* parity codetermined.⁸ The rules for parity codetermination imply that firms falling under the quota have at least 1,000 employees (for firms engaging in mining) or 2,000 employees (for firms in other sectors of industry). In contrast to quota introductions in other countries which required immediate action (see, e.g., Bertrand et al., 2018), the quota introduction in Germany only applies whenever a new supervisory board member is appointed. The 30% quota is applied to all board members, irrespective whether the vacant seat belongs to the employee or the shareholder representatives. If a company fails to comply with the quota, the board seat must remain vacant. Since vacant seats imply weakened power for either side in the supervisory board, this generates relatively strong incentives to fill vacant seats and to comply with the quota rule. As a second, less stringent, part of the law, firms became required to set targets for the proportion of women for the supervisory board, the executive board, and the two management levels below the executive board. In 2019, a total of 106 companies fell under this law (FidAR, 2020).

Firms that are *not* subject to the quota are only required to comply with the second rule, i.e. to set themselves targets. Along with the target figures, companies must furthermore set themselves compliance deadlines. Importantly, however, neither are firms required to report targets and compliance deadlines to a central register, nor do non-complying companies face a penalty. In the current legislation, even zero targets are permitted. Specifically, this was required for all firms that are either third codetermined and which have at least 500 employees, or that are publicly listed. The overall number of firms affected by the target rule is around 3,600, of which 106 are required to comply with the gender quota on the supervisory boards. All remaining firms in Germany are exempt from the law, and are not required to comply with the mandatory quota nor to submit voluntary targets.

⁸This holds for all firms with legal forms of *Aktiengesellschaft* (AG, equivalent to *Incorporated*), *Kommanditgesellschaft auf Aktien* (KGaA), equivalent to *Master Limited Partnership*, or *Société européenne* (SE).

3 Data

To study the effects of the 2016 introduction of the gender quota for supervisory boards in Germany, we use and combine data from two different sources: Bureau van Dijk (2020) and BoardEx (2020).⁹ While the *Amadeus* database of Bureau van Dijk (2020) gathers information on firms including annual information on firm performance, BoardEx (2020) provides detailed information on supervisory and executive board members including –central to this study– gender of the individual board members.¹⁰

In our empirical analyses, we compare outcomes for the group that was subject to the quota with firms that were only subject to the target rule.¹¹ The definition of both treatment and control groups follows clear definitions in the law, which are mainly depending on the legal form of the firm and its firm size. Firms that are parity codetermined follow the quota rule as well as the target rule, whereas firms that are either third codetermined or that have at least 500 employees belong to the control group are only required to follow the target rules.¹² We therefore first limit the data to firms that belong to treatment or control group from Bureau van Dijk (2020). These data include firm characteristics (firm name, firm identifier, the firm’s legal status, whether they are publicly listed or private, the firm’s main sector of industry), number of employees and (annual) firm performance. This results in a panel data set with annual firm-level data from 2011 to 2019.

To these data, we then merge available information on supervisory boards and executive boards from BoardEx (2020) from 2008 to 2019. These data contain information on the gender distribution of the boards as well as background information on their members, including age and board members’ network size, which is defined as the number of individuals to which the average board member is connected to, through other boards, employment or other activities.¹³

⁹Compared to, for example, Scandinavian countries (Bertrand et al., 2018), there is no register data with information on firms and their board members available.

¹⁰Both Bureau van Dijk and BoardEx are private data providers, whose data has been used in earlier studies analyzing gender quotas for boards and composition of boards (see., e.g., Matsa and Miller, 2013; Adams and Kirchmaier, 2016; Comi et al., 2020; Dalvit et al., 2021). Bureau van Dijk (2020) contains financial and business information on Europe’s largest 520,000 public and private companies by total assets. BoardEx (2020) contains more than 1.8 million profiles of public, private and not-for-profit organizations and more than 1.2 million board members worldwide. The majority of firms covered by BoardEx are publicly listed companies.

¹¹While it would be preferable to estimate the effects based on a group not subject to *any* change in applicable rules, only very small firms with less than 500 employees are neither subject to the quota nor to the target rule. These firms, however, are very different both in baseline characteristics but also in terms of their board structure.

¹²See Section 2 for details. Specifically, we selected all firms following this criteria with at least 500 employees in at least one of the years 2015 to 2017. We address entry and exit into our sample in Section 6.5.

¹³Other information included in BoardEx (2020), such as individual remuneration and board member’s educational attainment, contains a large number of missing information and can therefore not be included in the study.

Because the BoardEx (2020) database is based on survey information, it does not include board information on all firms but undersamples small and unlisted firms. For the 106 firms subject to the quota law, our data covers 98 firms with information on board composition, and 105 firms with information on firm performance. While we have information on firm performance for the almost 3,500 firms that are only subject to the target rule, our data contain information on only 236 firms with information on board composition. We are testing the implications of this selection in detail in Section 6.2. Our estimation sample contains 334 firms with a total of 2,865 firm-year observations for analyses on board composition, and between 2,418 and 3,437 firms for analyses of firm performance, depending on the outcomes.

Table 1 shows descriptive statistics for firms subject to the gender quota for supervisory boards and those that were not.¹⁴ The table is based on information in the last year before the introduction of the quota, i.e. 2015. Firms subject to the gender quota, shown in Column (1) of Table 1 have more women represented in their supervisory board compared to firms that are not subject to the quota (Column (2)). Nonetheless, the share of firms complying with the 30% rule even *before* the introduction is as low as 33% for firms in the treatment group. Given differences in firm size that are implemented in the legal definition of treatment and control firms, firms subject to the quota are much larger compared to non-quota firms. While this translates to much larger supervisory boards on average for quota firms, boards are similar in terms of characteristics of board members other than gender. Board members of treatment and control firms have similar average age, similar network size, whereas non-quota firms are more likely to have non-German board members in their supervisory board. Differences in definitions of quota and non-quota firms can also be seen in stock market listing and sector of industries: all quota firms are stock market listed, and are more likely to be in manufacturing.

4 Estimation framework

In this study, we are estimating the effect of the gender quota for supervisory boards on the gender share in supervisory boards, the gender share in executive boards, and firm performance. With the 2016 introduction of the gender quota, publicly listed and parity codetermined firms were required to achieve 30% female representation whenever board members are being elected. Effectively, this means that for most firms all seats up for re-election would be required to be

¹⁴Table C.2 in the Online Appendix contains a full list of all variable descriptions. Table C.3 presents descriptive statistics for quota and non-quota firms on firm performance.

Table 1: Pre-treatment characteristics of quota and non-quota firms

	(1) Quota	(2) No quota	(3) Diff. (2)-(1)
Female Supervisory Board Share	0.2360 (0.1022)	0.1236 (0.1388)	-0.1125*** (0.0155)
Comply with quota	0.3265 (0.4714)	0.1653 (0.3722)	-0.1613*** (0.0485)
Number of Board Members	14.2857 (3.5143)	6.3432 (4.2662)	-7.9425*** (0.4880)
Supervisory board turnover	0.1292 (0.1431)	0.1099 (0.1953)	-0.0194 (0.0231)
Supervisory board member age	56.8961 (3.3731)	57.4149 (6.4126)	0.5188 (0.6844)
Supervisory board member network size	445.4884 (350.5396)	413.9642 (493.2561)	-31.5242 (54.8225)
Supervisory board member non-German	0.4467 (0.2504)	0.6603 (0.2707)	0.2137*** (0.0318)
Female chair supervisory board	0.0408 (0.1989)	0.0297 (0.1700)	-0.0112 (0.0215)
Female vicechair supervisory board	0.1531 (0.3619)	0.0805 (0.2727)	-0.0726** (0.0362)
Supervisory board turnover	0.1292 (0.1431)	0.1099 (0.1953)	-0.0194 (0.0231)
Female Executive Board Share	0.0441 (0.0960)	0.0289 (0.0978)	-0.0151 (0.0117)
Num. of Employees	53,622 (97,783)	11,104 (45,005)	-42,518*** (8,200)
Small firms (<5,000 empl.)	0.1429 (0.3517)	0.6186 (0.4868)	0.4758*** (0.0543)
Publicly quoted	1.0000 (0.0000)	0.7203 (0.4498)	-0.2797*** (0.0477)
Not in DAX	0.7245 (0.4491)	0.9915 (0.0919)	0.2670*** (0.0306)
Manufacturing	0.3980 (0.4920)	0.2754 (0.4477)	-0.1225** (0.0554)
Natural resources	0.0408 (0.1989)	0.0127 (0.1123)	-0.0281 (0.0172)
Services	0.5612 (0.4988)	0.7119 (0.4539)	0.1506*** (0.0562)
Financial sector	0.0816 (0.2752)	0.1144 (0.3190)	0.0328 (0.0369)
Number of firms	98	236	

Notes: *** p<0.01, ** p<0.05, * p<0.1. Descriptive statistics are based on the last year before the quota introduction, 2015.

filled with a female candidate. To analyze the effects of the introduction, we employ a difference-in-differences estimation framework, in which we compare firms subject to the quota with firms that were not subject to the gender quota, and compare these firms before and after the 2016 introduction of the quota.

The effect of the introduction of the board quota can be analyzed with the following difference-in-differences specification:

$$y_{it} = \alpha + \beta Q_i * POST_t + \gamma * POST_t + \delta Q_i + \epsilon_{it}, \quad (1)$$

where y_{it} is the outcome of interest for firm i in year t , Q_i is an indicator whether the firm is subject to the quota after its introduction, and $POST_t$ denotes the post-treatment period, i.e. the years 2016 to 2019. The estimate of interest, i.e. the treatment effect of the quota, is denoted by β .

Counterfactuals The law that required quota firms to achieve 30% of the minority gender came with a second rule, which required quota firms as well as firms that are either codetermined and have at least 500 employees, or which are publicly listed firms to set targets for the share of women on their supervisory board and in top management levels. While failing to reach targets does not come with penalties, it is important to note that the counterfactual to the quota is not having no regulation, but rather having a voluntary target measure. Henceforth, we use the term *control group* to refer to these firms. Our parameter of interest, $\hat{\beta}$, therefore captures the effect of the introduction of the quota, relative to being subject to the target rule. Because the target rule affected treatment and control firms equally, we do not expect this to bias our estimates of main interest, $\hat{\beta}$.

Key identifying assumptions Our key identifying assumption is $\mathbb{E}[\epsilon_{it}|Q_i * POST_t] = 0$: in absence of the introduction of the gender quota, quota firms' and control firms' gender shares in boards as well as firm performance would have followed a parallel trend. While it is not possible to test this assumption for the years after the introduction, we can assess whether the

assumption holds for the years before the introduction by estimating event-study versions of Equation (1):

$$y_{it} = \alpha + \sum_t (\beta_t Q_i * \gamma_t) + \gamma_t + \delta Q_i + \varepsilon_{it}, \quad (2)$$

where the DiD coefficient β_t is year-specific, and the year before the law was proposed initially (2013) serves as the reference year. To allow for dynamic effects before and after the introduction of the quota, year dummies γ_t are included in Equation (2). If the β_t s are indistinguishable from zero for the years prior to the introduction of the quota (2008 to 2015), the results lend support to validity of the parallel trend assumption. The results from estimating Equation (2) for different outcome variables also allow us to address possible anticipation effects. The fact that the law was first discussed two years before the actual introduction makes it likely that firms adjusted their nomination behavior even before the legal requirement.¹⁵

Second, it is also important that there are no other policy reforms occurring around the same time and which have similar treatment definitions that might confound our estimate of interest. Prominent reforms that aimed at addressing gender equality were the introduction of paid parental leave in 2007, or the introduction of the legal right to childcare for all children below the age of four in 2013. There were no other reforms at the firm level that were introduced at the same time as the gender quota for supervisory boards, and with the same or similar definition of treatment and control groups.

Third, the Stable Unit Treatment Value Assumption (SUTVA) would be violated if, for example, the introduction of the gender quota could create excess demand for female candidates for supervisory board seats. Firms in our control group which are not directly affected by the quota might be indirectly affected and aim for a higher share of female board members. If control group firms would indirectly react to the gender quota by *also* increasing the share of women on their supervisory boards, this would imply that our estimates of interest are likely to be downward biased, i.e. that the causal effect of the quota is actually larger. Given the relatively small treatment group of only 106 firms, it does not seem very likely that the quota introduction would lead to a crowding-out of women suitable for supervisory board positions.

¹⁵One possible threat to identification is reverse causality, i.e. that the definition of treatment and control group is affected by trends in board composition *prior* to the parliament passing the law in early 2015 which should result in non-parallel pretrends.

Due to the relatively recent introduction of the reform the parameters of interest, β and β_t , respectively, are based on four years under the quota regime. Given that supervisory board members are frequently (re-)elected it is likely that firms comply with the quota rule already in a short period of time (cf. Section 2.2).

5 Results

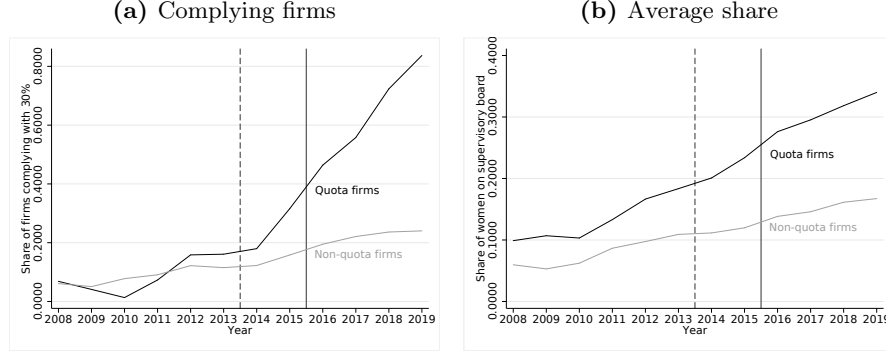
In this section, we present the main results of this study. We first present evidence to which degree the introduction of the gender quota affected the targeted supervisory board, and to which degree the characteristics of board members changed with the introduction of the quota (Section 5.1). In Section 5.2, we show results on the spillover effect of the gender quota for supervisory boards on the untargeted executive board. Section 5.3 provides further evidence whether increasing the share of women in supervisory boards also affects firm outcomes, such as financial performance and firms' employment.

5.1 Effects of the quota on supervisory boards

Gender composition on supervisory boards. To show how female representation on supervisory boards changed before and after the introduction of the gender quota for treatment and control firms, Figure 1 provides first descriptive evidence. Panel (a) shows that the share of firms that have at least 30% women on supervisory boards increased with the quota introduction in 2016, which suggests that firms reacted to the law and aimed at increasing female representation of women on supervisory boards such they could comply with the law. Indeed, Panel (b) shows that the average *share* of women on supervisory boards increased for both treatment and control firms. Albeit being stronger for treatment group firms, the figure shows the increase in the share of women on boards started to increase several years before the introduction of the quota.

As suggested by the descriptive statistics shown in Table 1 and Figure 1, purely descriptive evidence on gender shares in supervisory boards or other firm outcomes might be misleading. To account for underlying differences between quota and non-quota firms, Table 2 shows results applying the difference-in-differences estimation framework presented in Section 4. Columns (1) to (5) show the results of estimating Equation (1) with a dummy for whether a firm has at least 30% women on its supervisory board as demanded by the quota, as the dependent

Figure 1: Female representation in supervisory boards



Notes: Figure (a) shows the share of firms having at least 30% women on their supervisory board for quota firms (black line) and firms only subject to targets (gray line). Figure (b) shows the average share of women on supervisory boards for firms that are subject to the gender quota from 2016 onwards (black line), and for firms that are only subject to the voluntary target measure (gray line). The solid vertical line indicates the introduction of the gender quota. The dashed vertical line indicates the time when the cabinet started their discussions on the law.

variable. Column (1) shows the most basic difference-in-differences specification with a dummy for whether or not a firm falls under the quota rules, a dummy for 2016 and later, and the interaction effect between the two. The parameter of interest $\hat{\beta}$, i.e. the interaction term between the quota dummy and the dummy indicating the period after the introduction, shows that the quota increased the share of firms surpassing the quota-threshold of 30% by 39.7 percentage points.

To account for possible unobserved time-invariant differences between treated and control firms, we then include firm fixed-effects in Column (2). In Column (3) and following, year fixed-effects replace the *POST* coefficient in Equation (1) to more flexibly control for time-specific effects. In Column (4) and following, we augment the regression by also controlling for supervisory board size. Adding these fixed-effects and controls lowers the estimated effect of the reform to 32.3 percentage points. This specification is the most conservative and our preferred estimation as potential bias due to unobserved differences between treatment and control firms are taken into account as well as time trends are controlled for in a very flexible manner. To estimate whether firms already anticipated the introduction of the quota introduction, Column (5) includes an additional interaction effect between being subject to the quota and a dummy for the two years in which the law already underwent the legislative procedure (in 2014) and already passed parliament (in March 2015). The results show that we can quantify this anticipation effect to be 6.2 percentage points.¹⁶

¹⁶An alternative approach would be to exclude the years 2014 and 2015 so that the parameter of interest is not confounded by the anticipation. Panel (A) of Table C.4 in the Online Appendix shows corresponding results

Table 2: Effects of the gender quota on share of women on supervisory boards

Dep. variable	At least 30% of supervisory board female					Share of women (6)
	(1)	(2)	(3)	(4)	(5)	
Treated x Post introduction	0.3971*** (0.0441)	0.3561*** (0.0457)	0.3289*** (0.0466)	0.3229*** (0.0470)	0.3445*** (0.0535)	0.0691*** (0.0131)
Treated	0.0241 (0.0289)					
Post introduction	0.1116*** (0.0250)	0.1237*** (0.0251)				
Treated x anticipation period					0.0618 (0.0446)	
R-squared (adj.)	0.1775	0.2062	0.2390	0.2407	0.2416	0.3183
Number of firms	334	334	334	334	334	334
Number of observations	2,865	2,865	2,865	2,865	2,865	2,865
Mean dependent var.	0.2095	0.2095	0.2095	0.2095	0.2095	0.1549
Control variables	No	No	No	Yes	Yes	Yes
Firm FE	No	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Dependent variable: At least 30% of supervisory board female (Columns (1) to (5)); share of women in supervisory board (Column (6)). Standard errors are clustered at the firm level. Control variables include supervisory board size. All regressions include a constant. Variable *Post introduction* is defined as observations after the introduction of the quota, i.e. 2016 and later. Alternative treatment and sample specifications are shown in Table C.4 in the Online Appendix.

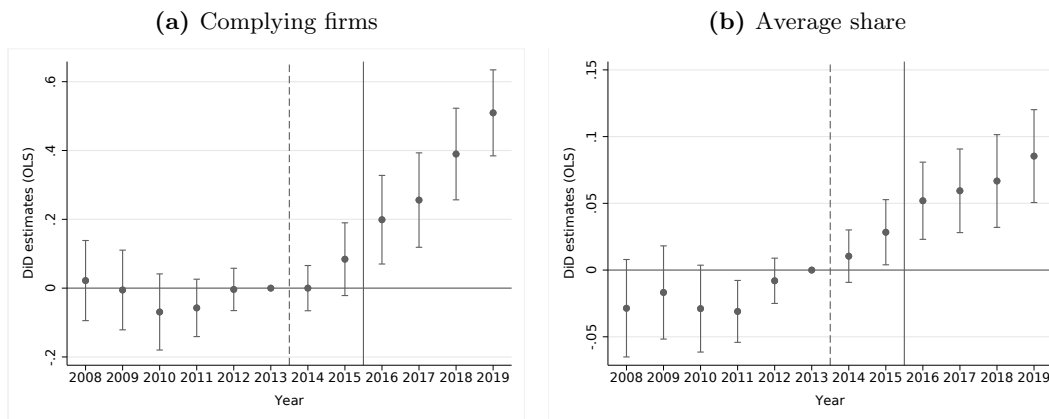
A key assumption with this approach is the assumption of parallel trends, i.e. that in the absence of the quota introduction treated and untreated firms would have evolved similarly. Panel (a) of Figure 2 shows the estimated treatment effect interacted with year fixed effects. The figure shows that all interactions are fairly close to zero up until 2014, the year when the law entered legislation. In 2015, when the law passed parliament, the estimates already show relatively clear anticipation effects, followed by a strong and significant upward trend.

These results show that the introduction of the quota causally increased the share of firms surpassing the 30% minimum share of women on supervisory boards by 32.3 percentage points, relative to the firms that were only subject to the target rule. Even though this is a relatively strong and significant increase in the share of female board members, by far not all quota firms are complying with the quota of 30 percent. In part, this is also due to the specifics of the law: firms are not required to immediately comply with the quota, but rather each board seat that will be elected after the quota introduction needs to comply with it.

While showing that the quota had its main effect, i.e. increasing the share of firms with at least 30% women on their supervisory boards, a natural question is how the reform affected the underlying *share of female supervisory board members*. Column (6) of Table 2 shows the effect of the quota on the share of women on supervisory boards. The estimate shows that the reform increased the share of women on supervisory boards by about 6.9 percentage points.

with the years 2014 and 2015 excluded, i.e. the year in which the quota law passed the parliament (March 2015). Expectedly, the point estimates shown in Table C.4 are quite similar to the ones shown in Column (5) of Table 2.

Figure 2: Dynamic effects of the gender quota on representation of women on supervisory boards



Note: This figure shows yearly DiD estimates for the effect of the gender quota for supervisory boards on a dummy whether a firm has at least 30% of women among their supervisory board members (Panel (a)), and on the share of women on supervisory boards (Panel (b)). The underlying regressions include a control variable for board size, firm fixed-effects, and a constant. The solid vertical line indicates the introduction of the gender quota. The dashed vertical line indicates the time when the cabinet started their discussions on the law. Standard errors are clustered at the firm level.

Closer inspection of Panel (b) of Figure 2 shows, however, that the upward trend leading to the positive estimate shown in Table 2 already started *before* the legislative process, in around 2011. Albeit almost all of the estimated parameters prior to the anticipation period (2014-2015) are insignificantly different from zero, the figure also shows that the quota introduction in 2016 did not lead to a break in the trend.¹⁷ Taken at face value, the figure suggests that not the quota itself led to a change in the share of women on supervisory boards, but rather earlier attempts such as the legislative proposal in 2011 (cf. Section 2.2). One possible explanation is that firms increased female representation on supervisory boards preemptively, either to anticipate later regulation or to avoid ‘hard’ regulations at all (cf. Tyrefors and Jansson, 2017).

Who is elected onto supervisory boards? One hypothesis why higher female representation in supervisory boards could generate spillover effects on top management levels and other firm performance indicators is that quotas induce changes in the selection of new candidates for supervisory boards. Quotas may force firms to change or broaden their search criteria, possibly leading not only to more female members (as required by law), but also changes in the age structure for example.

To analyze whether the quota led to a change not only in the gender composition in supervisory boards, but also in other dimensions, we use detailed information on board members’

¹⁷Panel C of Table C.4 shows the results of a regression of board outcomes on a linear time trend for the years leading up to 2015. The results show that pre-trends for the share of women on supervisory boards are significantly different from zero.

characteristics, including age, network size, and nationality.¹⁸ Age of supervisory board members and network size, which is defined as the sum of all professional contacts and which is correlated with the number of positions previously held, can be interpreted as proxies for experience. In addition, we also test whether the quota increased the share of international board members. More international boards could either be interpreted as suggestive evidence that there is no sufficient supply for supervisory board candidates, and/or as an indicator of whether boards become less connected to each other (Comi et al., 2020). We then estimate regressions with age, network size and the nationality dummy as outcome variables in our difference-in-differences framework. To the degree that incoming board members differ in their observable characteristics, this should be reflected in the parameter of interest, $\hat{\beta}$.

The point estimates of β in Table 3 have the sign in line with previous findings, i.e. that the increase in the share of female members of the board come with a slight reduction in average age (Column (1)), a decrease in network size (Column (2)), and an increase in internalization of the board (Column (3)). The estimates, however, are not significantly different from zero. This lends support to the interpretation that women are, in fact, not less professionally experienced than their male counterparts, and that there is sufficient supply of female candidates.¹⁹

While we are not able to estimate effects on board members' level of education (cf. Yang et al., 2019; Comi et al., 2020), our results are in line with earlier research showing limited effects of changes in the board structure induced by gender quotas (Yang et al., 2019). The results for board members' age differ from studies for Italy where studies have shown that a board quota led to a decrease of the average age (cf. Baltrunaite et al., 2020; Ferrari et al., 2021). Given that supervisory board characteristics changed along one dimension, i.e. board members' gender, it is most likely that women entering supervisory boards due to the reform are drawn from an observably similar pool as incumbents.

We also analyze the question whether a larger representation of women on supervisory boards helps women to be elected for special positions *within* the supervisory board. To this end, we use detailed information on the roles within boards provided by BoardEx (2020), and use a dummy equal to one when a supervisory board chair and vice-chair, respectively, is held by a woman. Columns (4) and (5) show that neither the probability that a woman holds a position

¹⁸In contrast to other studies (e.g. Ferrari et al., 2021), we do not analyze the effect of the supervisory board quota on board members' education as this variable contains substantial missing information in our data.

¹⁹Panel C of Table C.4 in the Online Appendix shows that all pre-trends are insignificantly different from zero, except for the outcome variable network size.

as a chairperson, nor that a woman holds a position as a vice chairperson is affected by the quota.

While one could argue that individuals are only elected into leading roles after having served a number of years on the board, the increased share of women on boards also creates a relative increase in the voting power of female board members. Given that the average tenure when board members are appointed as chairs (vice-chairs) is 4.1 years (4.6 years), it is more likely that women do not yet have sufficient voting power.

Table 3: The effect of the quota on board characteristics

Dependent variable	Supervisory board composition			Chair-woman (4)	Vice-chairwoman (5)	Executive board (6)
	age (1)	network size (2)	non-German (3)			
Treated x Post introduction	-0.2686 (0.4502)	-39.0231 (30.0938)	0.0333 (0.0223)	0.0130 (0.0138)	-0.0319 (0.0386)	0.0063 (0.0097)
R-squared (adj.)	0.0034	0.0433	0.0155	0.0001	0.0155	0.0361
Number of firms	334	334	334	334	334	334
Number of observations	2,850	2,863	2,864	2,864	2,864	2,856
Mean dependent var.	57.4447	413.1723	0.5901	0.0286	0.1048	0.0327

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at the firm level. All regressions include a control variable for board size, firm fixed-effects, year fixed-effects and a constant.

5.2 Spillover effects on executive boards

Female representation in executive boards has been notoriously low. In 2008, only about 1.5% of executive board members were female, translating into only five percent of firms that had *at least* one woman as part of their executive boards.²⁰ One of the arguments put forward to introduce the quota on supervisory boards was to generate positive spillover effects on female representation in executive boards, which might then further trickle down to management levels below. From a theoretical perspective, this link may exist for at least two reasons: first, increased female representation on supervisory boards could affect the selection of (female) candidates into the executive board. While higher shares of women might positively affect the selection of female candidates into board rooms, recent evidence has shown that female evaluators are *not* more favorable towards female candidates (Bagues, Sylos-Labini, and Zinovyeva, 2017). Second, if highly qualified women receive more attention in the wake of the public debate around the gender quota, then that may have directly increased their likelihood to be appointed to the

²⁰See Figure B.1 in the Online Appendix for the share of women, and the share of firms with at least one woman on their executive board by treatment status over the years.

executive board. The quota may thus indirectly increase the share of women on executive board if the increased diversity of supervisory boards is reflected in their decisions regarding executive directors.

While the share of women on executive boards rose to an average of 4.8% in the years after the introduction of the board quota, Column (6) of Table 3 shows that the estimated effect of the quota on the share of women on executive boards is positive and statistically insignificant ($\hat{\beta}=0.006$). Despite the quota introduction and the subsequent increase in the share of women on supervisory boards, quota firms did not increase their share of women on executive boards. This is also confirmed by the event-study plot shown in Figure 3, which shows parallel trends before the introduction of the quota, but also zero effects after the introduction.²¹ Neither the quota introduction itself, nor the early increase in the share of women on supervisory boards are reflected in the estimates (cf. Section 5.1). We confirm this result with an alternative instrumental variables approach (cf. Bertrand et al., 2018; Dalvit et al., 2021), in which we use the pre-reform supervisory board gender share as an instrument for the current supervisory board gender share. The results in Online Appendix A provide qualitatively the same results, i.e. that the quota did not affect the executive board gender share.

While being consistent with international evidence on spillover effects of gender board quotas on top management (e.g. Bertrand et al., 2018), our results can be contrasted with two studies for Germany (Bozhinov et al., 2021; Fedorets and Gibert, 2020). In a study using data on 95 firms up to 2016 (i.e., the first post-quota year), Bozhinov et al. (2021) estimate a random-effects model and find a positive effect of the share of women on supervisory boards on the share of women on executive boards. Fedorets and Gibert (2020) compare 69 out of the 106 quota firms with a sample of untreated firms up to 2017, and find that the supervisory board quota led to an more women on supervisory boards but to a *negative* effect on the share of women on executive boards. Difference between our results and the results of Bozhinov et al. (2021) and Fedorets and Gibert (2020) are to be likely driven by a different methodology and different data used, respectively.²²

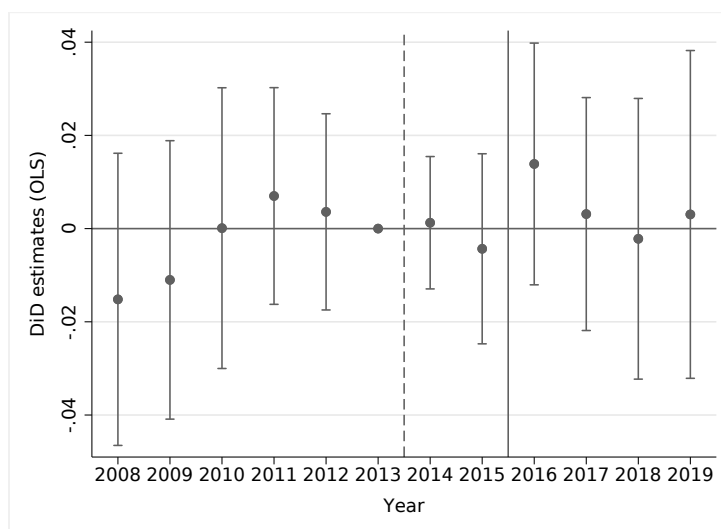
There are two potential explanations for this result. First, it might simply be that the period *after* the quota introduction was too short to increase female representation in executive boards.

²¹Similarly, the estimate in Column (1) of Panel C of Table C.4 in the Online Appendix shows that pre-trends are insignificantly different from zero.

²²In contrast to our study, Fedorets and Gibert (2020) use a different dataset with a smaller treatment group (69 in their study compared to 98 in this study) and a shorter post-quota period (1 to 2 years compared to four years in our study). It is unclear to which degree their treatment group definition is selective relative to the overall population of treatment firms.

Firms were not required to *immediately* increase the share of women on supervisory boards to 30 percent. Additionally, replacing executive board members might come with another delay. Yet, even for the four years after the introduction there is no sign for a trend as shown for the supervisory board share of women.²³ Second, and in line with previous research for academic evaluations (Bagues et al., 2017) and for quota reforms with longer follow-up (Bertrand et al., 2018), women in supervisory boards might not contribute much to female representation on executive boards.

Figure 3: Dynamic effects of the supervisory board gender quota on share of women on executive boards



Note: This figure shows yearly DiD estimates for the effect of the gender quota on the share of women on executive boards. The underlying regression includes a control variable for executive board size, firm fixed-effects, and a constant (cf. Column (4) of Table ??). The solid vertical line indicates the introduction of the gender quota. The dashed vertical line indicates the time when the cabinet started their discussions on the law. Standard errors are clustered at the firm level.

5.3 Gender quotas and firm performance

Previous studies have shown relatively mixed evidence on the effects of gender quotas on boards, suggesting that differences between studies either originate from differences in methodology, or from institutional differences. In this section, we are estimating the effects of the 2016 introduction of the gender quota for supervisory boards in Germany on firm performance. Because this analysis does not require information on board members' characteristics, we are able to

²³Besides time playing an important role in materializing effects, another argument could be moral licensing (see, e.g., Lasarov and Hoffmann, 2020): after complying with the quota and increasing the share of female board members, supervisory boards might not be interested in further improving female representation in top management. We would like to thank an anonymous referee for highlighting this potential mechanism.

use data of *all* firms that were subject to either the quota or only the targets. To study firm performance, we use a range of potential outcomes that have partly been studied by earlier research on the effects of board quotas allowing us to reconcile our findings with those of other studies (Matsa and Miller, 2013; Eckbo et al., 2021; Comi et al., 2020). In particular, we use measures of firm performance (assets, revenues, ROA, ROE, profit margin, liquidity ratio) and employment-related outcomes (number of employees, cost of labor per employee). Due to data availability reasons, these outcomes are available only for the years 2011 to 2019.²⁴

Descriptive statistics show that quota firms have significantly larger assets, larger operational revenues, lower liquidity ratio, larger number of employees as well as higher (total) costs of labor (see Table C.3 in the Online Appendix). This is in line with the earlier results that quota firms are more likely to be in the prime stock market index (DAX) covering Germany’s largest firms listed on the stock market.

To account for these underlying differences in firms’ outcomes, we then estimate the effect of the quota on these outcomes. Among firm performance outcomes, Table 4 shows that the quota introduction appears to have significantly lowered revenues as well as liquidity ratios. Regarding labor outcomes, the results suggest that the quota led to smaller firms (in terms of number of employees). Other outcomes tested are not affected by the quota. Even though we do not find evidence of spillover effects of the supervisory board quota on female representation in top management, these results could be explained by women on supervisory boards having influence over larger strategy decisions, such as larger mergers and acquisitions.

Within our estimation framework in which we compare outcomes before and after the introduction of the quota for firms with and without the quota rule, a crucial assumption is the assumption of parallel trends. Parallel trends should be reflected in pre-reform interactions effects between the quota dummy and year dummies that are not significantly different from zero. For the same outcomes as shown in Table 4, Panel C of Table C.4 shows the results of a regression of firm performance outcomes on a linear time trend for the years up to 2015, i.e., the year before the actual implementation of the quota (Muralidharan and Prakash, 2017; Dustmann, Lindner, Schönberg, Umkehrer, and Vom Berge, 2021). The results show that there are significant pre-trends prior to the quota. This can also be seen in Figure B.2 in the Online Appendix, which shows the estimated pre-trends extrapolated to the full sample period, together with the event study results. For several outcomes, including showing a significantly negative effect in

²⁴To reduce the impact of outliers, we remove outcomes below the first percentile and above the 99th percentile in each year (cf. Yang et al., 2019). When including those observations, the interpretation of the results is unchanged. All monetary values are discounted to 2010 prices using the official consumer price index.

Table 4, the figures suggest that there was a *positive* structural break at the time the quota was introduced. This suggests that, if there was any effect of the quota on firm performance outcomes, these were positive, not negative. This result is similar to the results of Comi et al. (2020) who show that estimated pre-trends partly violate the assumption of parallel pre-trends.

Table 4: Effects of the gender quota for supervisory boards for firm performance

Dependent variable	Assets (log) (1)	Revenues (log) (2)	ROA (3)	ROE (4)	Profit margin (5)	Liq. ratio (log) (6)	Empl. (log) (7)	Labor costs (log) (8)
Treated x Post introduction	-0.0458 (0.0307)	-0.0715*** (0.0263)	-0.0891 (0.3603)	0.2020 (1.2130)	0.2207 (0.3350)	-0.0840*** (0.0275)	-0.0860*** (0.0278)	0.0016 (0.0093)
R-squared (adj.)	0.2168	0.1952	0.0104	0.0090	0.0072	0.0024	0.0915	0.3170
Number of firms	2,828	3,024	2,718	2,418	2,575	2,828	3,437	2,685
Number of observations	20,942	20,122	19,348	16,297	17,813	20,049	23,471	18,894
Mean dependent var.	11.0091	16.7707	5.9739	9.4196	3.7893	0.4667	7.0269	8.3758

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions include firm fixed-effects, year fixed-effects, and a constant. Financial outcomes are adjusted to 2010 values. To reduce the impact of outliers, the lowest and highest percentile has been removed. Standard errors are clustered at the firm level.

6 Robustness

In this section, we present additional evidence on the stability of our estimates of interest. We first explore to which degree the effects on the gender share in supervisory and executive boards, respectively, hold across subsamples (Section 6.1). We then provide evidence on whether the survey data on board members' characteristics is driven by self selection (Section 6.2). In Section 6.3, we discuss results on whether quota firms decreased the number of elections to slow down the effective introduction of the gender quota. We then show placebo estimation results with randomly assigned treatment status (Section 6.4), and finally show to which degree the unbalancedness of the panel causes estimation bias (Section 6.5).

6.1 Subsample analysis

As shown in Table 1, firms subject to the quota are inherently different than firms in the control group. Quota firms include some of the largest firms in Germany, creating variation in type and size of firms in the treatment group. To minimize the risk of violating assumptions underlying our estimation framework (see Section 4), we ideally would like to have firms in the control group which are relatively similar to those subject to the quota. To study whether results are sensitive

to sample restrictions, this study replicates the main results for subsamples. The results can be directly compared to the full specification shown in Column (4) of Table 2 (for supervisory boards), and to the full specification shown in Column (6) of Table 3 (for executive boards).

Columns (1) and (2) of Table 5 show the results for small firms and large firms. The results for the effect on supervisory board shares (Panel A) show that the effects appear to be mainly driven by smaller firms. The equivalent point estimates for the effect on executive boards (Panel B) are positive for larger firms, and significantly negative for smaller firms. A possible yet untestable explanation for this finding is that women move from executive boards to supervisory boards in smaller firms, whereas larger firms manage to increase the share of women on their supervisory boards while leaving executive boards unchanged.

The results in Columns (3) and (4) show the estimation results for firms active in the manufacturing sector and the service sector, respectively. Women in boards of manufacturing sector firms have been shown to be even more underrepresented than women in boards in general (Adams and Kirchmaier, 2016). This could both lead to a larger ‘catching-up’ effect creating a larger impact of the quota, or even lower estimates if prevailing gender stereotypes in these firms are deeply rooted. The results show that, for firms in the manufacturing sector, effects are slightly smaller than for firms in the service sector. The effects, however, are not significantly different from each other. Panel B shows that the quota led to an increase in female representation on executive boards for firms in the manufacturing sector. One explanation for this finding is that this is driven by a smaller pre-quota share of women on executive boards, compared to firms in the service sector.

In Columns (5) and (6), we turn to whether or not firms are listed. Column (5) shows results for firms (publicly) listed on the stock market. Compared to privately listed firms, one might expect that these firms are more likely to follow the quota as these firms might be more in the spotlight. Similarly, Column (6) exclude all blue chip stocks that are listed in the leading German stock index, *DAX*. While the estimates in Column (5) are equal to the main results, firms *not* listed in the stock index appear to having increased the share of women on supervisory boards slightly more. While the point estimate is not significantly different from the point estimate in our main results, this could be in line with stronger gender stereotypes in some of Germany’s largest companies.

Table 5: Effects of the gender quota on supervisory board by firm type

Subsample	Small firms (1)	Large firms (2)	Manufacturing (3)	Services (4)	Stock-listed (5)	Not in DAX (6)
<i>Panel A (dependent variable: dummy whether firm complies with the quota)</i>						
Treated x Post introduction	0.2663*** (0.0949)	0.2317*** (0.0629)	0.2211*** (0.0790)	0.2550*** (0.0736)	0.2279*** (0.0566)	0.3523*** (0.0537)
R-squared (adj.)	0.0803	0.3369	0.1724	0.1673	0.1565	0.2137
Number of firms	160	174	107	223	259	329
Number of observations	1,381	1,484	765	1,602	1,948	2,579
Mean dependent var.	0.1750	0.2452	0.2178	0.2067	0.2114	0.1853
<i>Panel B (dependent variable: executive board gender share)</i>						
Treated x Post introduction	-0.0362** (0.0158)	0.0045 (0.0142)	0.0347*** (0.0101)	0.0044 (0.0140)	0.0091 (0.0102)	-0.0055 (0.0113)
R-squared (adj.)	0.0224	0.0639	0.1526	0.0245	0.0215	0.0206
Number of firms	160	174	107	223	259	329
Number of observations	1,377	1,479	763	1,597	1,942	2,570
Mean dependent var.	0.0339	0.0316	0.0282	0.0337	0.0314	0.0282

Notes: *** p<0.01, ** p<0.05, * p<0.1. All regression control for year and firm fixed-effects as well as for the respective board size (cf. Column (4) of Table 2 for supervisory boards and Column (4) of Table ?? for executive boards). Small firms are defined as firms with less than 5,000 employees (Column (1)); large firms with 5,000 or more employees (Column (2)). Columns (3) and (4) include only firms in the manufacturing and services sector, respectively. Column (5) includes only stock market listed firms; Column (6) only non-DAX firms (DAX is the leading stock market index). Standard errors are clustered at the firm level.

6.2 Sample selection

Overall, the 2016 introduction targeted 106 firms with the (explicit) quota rule which comprise our treatment group. As discussed in Section 3, we define our control group as firms that were only subject to target rule. This group, which is comprised of 3,642 firms, is defined by (1) whether the firms are sufficiently large (500 employees or more), (2) whether they are third or parity codetermined, and (3) whether they are stock market listed. Because detailed public register data with information on *both* firm data and treatment status *and* board members' characteristics is not available, survey data typically does not cover the entire sample of firms existing but is only available for smaller sets of firms. If the surveyed sample is not representative for the *actual* sample of firms that were only affected by the target, our results might be driven by sample selection inducing bias into our estimates.

In this section, we therefore test to which degree non-quota firms are representative for the sample of firms that was only subject to targets. For this purpose, we make use of the 2016 wave of Bureau van Dijk (2020), which –similarly to the data by BoardEx (2020) used in the main analyses– contains information on supervisory board members' gender and age.²⁵

Table 6 shows descriptive statistics for the unmatched sample, i.e. firms that were not subject to the quota and for which there are no annual board members' characteristics available for the analysis. In other words, these firms cannot be used for the main analyses. Firms part of the

²⁵In contrast to Matsa and Miller (2013), who use archival data with board characteristics from Bureau van Dijk (2020), we do not have access to equivalent annual data for German firms.

matched sample, shown in Column (2), can be merged to annual board members' characteristics and used for our analyses. Importantly, Table 6 shows that firms in the matched and the unmatched sample are fairly similar with the exception of the firm size, which shows that matched firms are on average substantially larger, and board members' age who are slightly older in matched firms. While this does imply some selection on observables into our sample of firms based on firm size, it is reassuring that there is only little evidence for selection on the outcome variables, i.e. on board characteristics. This result is also in line with Figure 2, which provided evidence for the validity of the parallel trends assumption.

Table 6: Matched and unmatched non-quota firms

	Unmatched (1)	Matched (2)	Difference (3)
Female Supervisory Board Share	0.1704 (0.1721)	0.1513 (0.1431)	-0.0191 (0.0130)
Supervisory board member age	58.0909 (6.6328)	58.7171 (5.3866)	0.6262 (0.4992)
Number of Employees	2,287 (9,367)	7,641 (30,252)	5,354*** (847)
Manufacturing	0.2843 (0.4512)	0.2718 (0.4460)	-0.0125 (0.0323)
NaturalResources	0.0291 (0.1681)	0.0146 (0.1201)	-0.0145 (0.0119)
Services	0.6866 (0.4640)	0.7136 (0.4532)	0.0270 (0.0332)
Number of firms	3,436	206	3,642

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. This table is based on data from Bureau van Dijk (2020) for 2017, for which these data also contain board information, including board members' gender and board members' age. The unmatched sample in Column (1) is defined as firms for which there is no annual board member characteristics available and which therefore cannot be used for our main analyses. The matched sample in Column (2) is defined as those for which there is detailed information on board members in BoardEx (2020), and which are used as non-quota firms in our main analyses. Columns (1) and (2) show standard deviations in parentheses; Column (3) shows the standard errors of the difference.

6.3 Frequency of elections and board turnover

Typically, board members are elected for a term of four to five years. While our data does not contain direct information on an individual board member's years reelection, the distribution of board members' overall length on supervisory boards shows clear spikes at five and ten years.²⁶ It also shows, however, that board members can practically leave after 'irregular' intervals. Although elections of supervisory board members follow strict legal guidelines, our estimates

²⁶See Figure B.3 in the Online Appendix.

might be biased if quota firms would be able to increase term length and thereby decreasing the necessity of electing new (female) board members.²⁷

Using our preferred specification with firm and year fixed-effects, we can estimate the effect of the quota introduction on the turnover on supervisory boards, which is defined as the annual replacement. The results show that supervisory board turnover is not affected by the introduction of the quota, suggesting that election frequency on supervisory boards did not change with the introduction of the quota.²⁸

6.4 Placebo estimation

The estimation framework used in this study takes underlying differences both in levels and in trends into account. A crucial assumption is that, in the absence of the quota introduction, trends remain parallel. While there are no direct tests for this assumption, we provide evidence by randomly varying the treatment definition. We allocate the treatment status to randomly chosen firms. If the underlying assumptions are not violated, we should expect the distribution of estimates based on randomly generated treatments should not overlap strongly with our estimate of β .

In Figure 4, we present the distribution of estimated β from Equation (1), where each estimate is based on our main estimation sample with the treatment status being randomly assigned. In this exercise, the number of quota and non-quota firms are kept constant. The figure is based on a total of 1,000 random samples each of which randomly assigned the treatment status to firms, and each of which generates one $\hat{\beta}$. The figure shows that the distribution of estimates is relatively precisely centered around zero. The placebo estimate is always smaller than the lower bound of the 95% confidence interval. This suggests that it is unlikely that our main estimate is driven by a violation of the underlying assumptions.

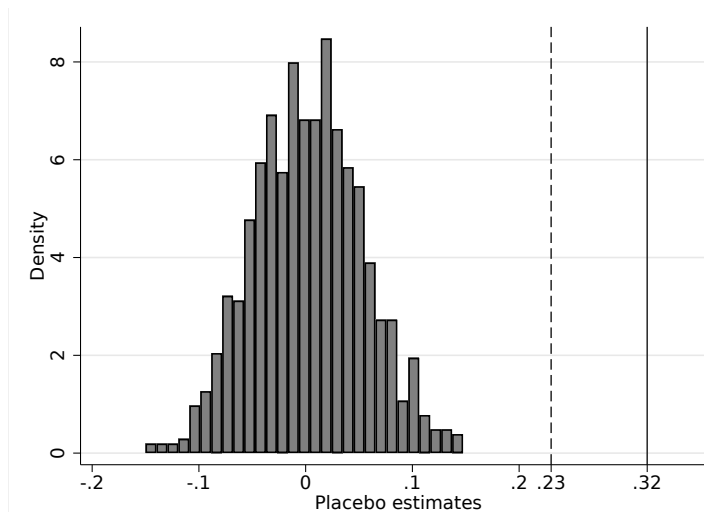
6.5 Balancing of panel

The dataset used in this study is unbalanced by nature: firms are founded, merged, or split into different entities. Also, changing firm's legal form or de-listing firms from the public stock market affects whether or not firms are subject to the quota rule (the treatment group), are only subject to targets (the control group), or neither of them.

²⁷The legislative basis for supervisory boards can be found in §95 to §116 of the company law (*Aktiengesetz (AktG)*).

²⁸The estimation results can be found in Table C.6 in the Online Appendix.

Figure 4: Placebo estimates on supervisory board shares



Note: This figure shows DiD estimates for 1,000 samples with randomized quota status. Each sample has the same number of quota firms as the actual estimation sample. The DiD estimate is based on the preferred specification shown in Column (4) of Table 2, i.e. including year and firm fixed-effects and a control variable for supervisory board size. Standard errors are clustered at the firm level.

To assess whether estimates hold when restricting our sample to be balanced, we re-estimate our preferred specification for a balanced sample only, i.e. with firms only included when they are observed in at least ten of the twelve years of our observation period from 2008 to 2019. The resulting sample oversamples larger and more stable firms, and includes a total of 144 firms. The estimate for the effect of the quota on the supervisory board share is slightly larger with 0.076, yet not significantly different from our baseline estimate of 0.06, shown in Table 2. For the effects on the executive boards gender share, the effects are relatively precisely estimated zero. These results suggest that unbalancedness of the sample does not result in biased estimates. Table C.7 shows results based on a sample

7 Conclusion

This paper studies the effects of the 2016 introduction of a gender quota for supervisory boards in Germany. Although representation in top management is higher compared to other European countries, Germany is still dominated by institutions promoting the male breadwinner model, such as joint taxation. We analyze how the introduction affected the targeted board composition itself, but also whether it affected female representation in executive boards and firm performance. While we find that firms reacted to the quota by complying with the quota, i.e. having at least 30% of women on their supervisory boards, we also find that the share of women on

supervisory boards already started to increase earlier, around 2011. This result suggests that firms preemptively started to increase the share of women on their supervisory boards. We find that neither other observable characteristics of supervisory board members were affected by the quota, nor was female representation on executive boards. We also find that firm performance is, if at all, positively affected by the quota introduction.

One way to explain these null findings for executive boards and firm performance lie in the details of the law. First, the quota legislation implied a lagged introduction. Supervisory boards were not required to comply with the quota in 2016 immediately but only when seats are up for election, suggesting a lagged impact of the law which might, in turn, materialize in effects on firm outcomes later on. Second, the law targeted supervisory boards which do not have as much power in day-to-day decisions as the executive boards. Our findings, however, are fairly consistent with other studies exploiting longer observation periods after the introduction of gender quotas for boards of directors. For Norway, for example, Bertrand et al. (2018) find that even after six to ten years the Norwegian gender quota did not change the careers of women in quota firms. Similarly, Maida and Weber (2021) find no spillover effects on top management with a follow-up of four years after the quota introduction. In contrast, there is less consistent evidence for estimates of gender quotas on firm performance. Comi et al. (2020) conclude that effects are likely to be determined by differences in methodology and differences in institutional settings between countries.

What can we conclude from our findings? First, board quotas neither led to changes in observable board characteristics, nor to worse firm outcomes. Second, the introduction of gender quotas on supervisory boards might lead to outcomes that are not yet captured. For example, larger female representation on supervisory boards might create role-model effects changing decisions of young women to enroll in business studies (cf. Porter and Serra, 2020; Riise, Willage, and Willén, 2021). Further research is needed to analyze such possible pathways.

In June 2021, a reform of the quota law was passed by the German parliament requiring executive boards of treatment firms with at least four board members to fill a seat with a female executive (Bundesregierung, 2021). This was motivated with the lacking development in women's executive board share compared to the successful increase in supervisory board representation. Furthermore, the existing 30% quota for supervisory boards will be extended to firms under partial government ownership. Those firms only subject to setting voluntary targets - a subset of which forms our control group - are now required to formally report and motivate their reason for setting no or zero-targets. If passed by the Federal Council, it will require further research to

analyze whether higher female representation in *executive* boards changes the relative position for women in firms and ultimately firm outcomes.

References

- ADAMS, R. AND D. FERREIRA (2009): “Women in the boardroom and their impact on governance and performance,” *Journal of Financial Economics*, 94, 291–309.
- ADAMS, R. B. AND P. FUNK (2012): “Beyond the Glass Ceiling: Does Gender Matter?” *Management Science*, 58, 219–235.
- ADAMS, R. B. AND T. KIRCHMAIER (2013): “Barriers to Boardrooms,” ECGI - Finance Working Paper 347, ECGI.
- (2016): “Women on Boards in Finance and STEM Industries,” *American Economic Review*, 106, 277–81.
- ADAMS, R. B. AND H. MEHRAN (2012): “Bank board structure and performance: Evidence for large bank holding companies,” *Journal of Financial Intermediation*, 21, 243–267.
- AHERN, K. R. AND A. K. DITTMAR (2012): “The Changing of the Boards: The Impact on Firm Valuation of Mandated Female Board Representation,” *Quarterly Journal of Economics*, 127, 137–197.
- BAGUES, M. AND P. CAMPA (2021): “Can Gender Quotas in Candidate Lists Empower Women? Evidence from a Regression Discontinuity Design,” *Journal of Public Economics*, forthcoming.
- BAGUES, M., M. SYLOS-LABINI, AND N. ZINOVYEVA (2017): “Does the Gender Composition of Scientific Committees Matter?” *American Economic Review*, 107, 1207–38.
- BALTRUNAITE, A., M. CANNELLA, S. MOCETTI, AND G. ROMA (2020): “Board composition and performance of state-owned enterprises: Quasi-experimental evidence,” Temi di discussione (Economic working papers) 1328, Bank of Italy, Economic Research and International Relations Area.
- BERTAY, A., L. DORDEVIC, AND C. SEVER (2020): “Gender Inequality and Economic Growth: Evidence from Industry-Level Data,” IMF Working Papers 2020/119, International Monetary Fund.
- BERTRAND, M., S. E. BLACK, S. JENSEN, AND A. LLERAS-MUNEY (2018): “Breaking the Glass Ceiling? The Effect of Board Quotas on Female Labour Market Outcomes in Norway,” *Review of Economic Studies*, 86, 191–239.

- BERTRAND, M., C. GOLDIN, AND L. F. KATZ (2010): “Dynamics of the Gender Gap for Young Professionals in the Financial and Corporate Sectors,” *American Economic Journal: Applied Economics*, 2, 228–55.
- BERTRAND, M. AND A. SCHOAR (2003): “Managing with Style: The Effect of Managers on Firm Policies,” *Quarterly Journal of Economics*, 118, 1169–1208.
- BESLEY, T., O. FOLKE, T. PERSSON, AND J. RICKNE (2017): “Gender Quotas and the Crisis of the Mediocre Man: Theory and Evidence from Sweden,” *American Economic Review*, 107, 2204–42.
- BLOOM, N. AND J. VAN REENEN (2010): “Why Do Management Practices Differ across Firms and Countries?” *Journal of Economic Perspectives*, 24, 203–24.
- BOARDEX (2020): “Board data,” data, London.
- BOYALLIAN, P., S. DASGUPTA, AND S. HOMROY (2019): “Supply and Demand Side Determinants of Board Gender Imbalance: The U.S. Evidence,” Tech. rep.
- BOZHINOV, V., J. JOECKS, AND K. SCHARFENKAMP (2021): “Gender spillovers from supervisory boards to management boards,” *Managerial and Decision Economics*, 42, 1317–1331.
- BOZHINOV, V., C. KOCH, AND T. SCHANK (2019): “The Second Glass Ceiling: Women’s Role in Supervisory Boards of German Firms,” *Schmalenbach Business Review*, 71, 385–411.
- BUNDESGESETZBLATT (2015): “Gesetz für die gleichberechtigte Teilhabe von Frauen und Männern an Führungspositionen in der Privatwirtschaft und im öffentlichen Dienst,” Tech. Rep. 17, Deutscher Bundestag, Bonn.
- BUNDESREGIERUNG (2021): “Mehr Frauen in Vorstände,” Press release June 11, 2021, Bundesregierung, <https://www.bundesregierung.de/breg-de/suche/mehr-frauen-in-vorstaende-1834446>.
- BUREAU VAN DIJK (2020): “Amadeus: Information on companies across Europe,” data, Brussels.
- BUSER, T., M. NIEDERLE, AND H. OOSTERBEEK (2014): “Gender, Competitiveness, and Career Choices *,” *Quarterly Journal of Economics*, 129, 1409–1447.

- BYRON, K. AND C. POST (2016): “Women on Boards of Directors and Corporate Social Performance: A Meta-Analysis,” *Corporate Governance: An International Review*, 24, 428–442.
- CHATTOPADHYAY, R. AND E. DUFLO (2004): “Women as Policy Makers: Evidence from A Randomized Policy Experiment in India,” *Econometrica*, 72, 1409–1443.
- CHEN, J., W. S. LEUNG, W. SONG, AND M. GOERGEN (2019): “Why female board representation matters: The role of female directors in reducing male CEO overconfidence,” *Journal of Empirical Finance*, 53, 70–90.
- CLAYTON, A. AND P. ZETTERBERG (2018): “Quota shocks: Electoral gender quotas and government spending priorities worldwide,” *The Journal of Politics*, 80, 916–932.
- COMI, S., M. GRASSEN, F. ORIGO, AND L. PAGANI (2020): “Where women make a difference: gender quotas and firms’ performance in three European countries,” *ILR Review*, 73, 768–793.
- CONYON, M. J. AND L. HE (2017): “Firm performance and boardroom gender diversity: A quantile regression approach,” *Journal of Business Research*, 79, 198–211.
- CULLEN, Z. B. AND R. PEREZ-TRUGLIA (2019): “The Old Boys’ Club: Schmoozing and the Gender Gap,” Working Paper 26530, National Bureau of Economic Research.
- DALE-OLSEN, H., P. SCHØNE, AND M. VERNER (2013): “Diversity Among Norwegian Boards of Directors: Does a Quota for Women Improve Firm Performance?” *Feminist Economics*, 19, 110–135.
- DALVIT, N., A. PATEL, AND J. TAN (2021): “Intra-firm hierarchies and gender gaps,” *Labour Economics*, forthcoming.
- DE PAOLA, M., V. SCOPPA, AND R. LOMBARDO (2010): “Can gender quotas break down negative stereotypes? Evidence from changes in electoral rules,” *Journal of Public Economics*, 94, 344 – 353.
- DEL PRETE, S., G. PAPINI, AND M. TONELLO (2021): “Gender quotas, board diversity and spillover effects. Evidence from Italian banks,” unpublished manuscript, Bank of Italy, Florence.
- DUSTMANN, C., A. LINDNER, U. SCHÖNBERG, M. UMKEHRER, AND P. VOM BERGE (2021): “Reallocation Effects of the Minimum Wage,” *Quarterly Journal of Economics*, forthcoming.

- ECKBO, B. E., K. NYGAARD, AND K. S. THORBURN (2021): “Does Gender-Balancing the Board Reduce Firm Value?” *Management Science*, forthcoming.
- EIGE (2021): “Gender Statistics Database,” Tech. rep., European Institute for Gender Equality.
- EUROPEAN COMMISSION (2012): “Proposal for a directive of the European Parliament and of the Council on improving the gender balance among non-executive directors of companies listed on stock exchanges and related measures,” Tech. rep., European Commission, Brussels, Belgium.
- (2016): “Gender Balance on Corporate Boards. Europe is Cracking the Glass Ceiling,” Tech. rep., Directorate-General for Justice and Consumers.
- FEDORETS, A. AND A. GIBERT (2020): “Unintended Consequences of Gender Quotas in a Dual Board System,” unpublished manuscript, DIW Berlin.
- FERRARI, G., V. FERRARO, P. PROFETA, AND C. D. PRONZATO (2021): “Do Board Gender Quotas Matter? Selection, Performance and Stock Market Effects,” *Management Science*, forthcoming.
- FIDAR (2020): *Frauenanteil in Führungspositionen*, FidAR – Frauen in die Aufsichtsräte e. V.
- GERMAN FEDERAL GOVERNMENT (2015): “Im Wortlaut: Schwesig ”Das ist moderne Gleichstellungspolitik”,” online.
- GERTSBERG, M., J. MOLLERSTROM, AND M. PAGEL (2021): “Gender Quotas and Support for Women in Board Elections,” Working Paper 28463, National Bureau of Economic Research.
- HOLST, E. AND K. WROHLICH (2019): “Increasing Number of Women on Supervisory Boards of Major Companies in Germany: Executive Boards Still Dominated by Men,” *DIW Weekly Report*, 9, 17–32.
- HOSPIDO, L., L. LAEVEN, AND A. LAMO (2021): “The Gender Promotion Gap: Evidence from Central Banking,” *Review of Economics and Statistics*, forthcoming.
- HSIEH, C.-T., E. HURST, C. I. JONES, AND P. J. KLENOW (2019): “The Allocation of Talent and U.S. Economic Growth,” *Econometrica*, 87, 1439–1474.
- JÄGER, S., B. SCHOEFER, AND J. HEINING (2021): “Labor in the Boardroom,” *Quarterly Journal of Economics*, 136, 669–725.

- JANN, B. (2007): “Making regression tables simplified,” *Stata Journal*, 7, 227–244(18).
- (2014): “Plotting regression coefficients and other estimates,” *Stata Journal*, 14, 708–737(30).
- KIRSCH, A. (2018): “The gender composition of corporate boards: A review and research agenda,” *The Leadership Quarterly*, 29, 346 – 364.
- KIRSCH, A. AND K. WROHLICH (2020): “More Women on Supervisory Boards: Increasing Indications that the Effect of the Gender Quota Extends to Executive Boards,” *DIW Weekly Report*, 4/5, 44–49.
- KUZMINA, O. AND V. MELENTYEVA (2021): “Gender diversity in corporate boards: Evidence from quota-implied discontinuities,” ZEW Discussion Papers 21-023, Mannheim.
- LASAROV, W. AND S. HOFFMANN (2020): “Social Moral Licensing,” *Journal of Business Ethics*, 165, 45–66.
- MAIDA, A. AND A. WEBER (2021): “Female Leadership and Gender Gap within Firms: Evidence from an Italian Board Reform,” *Industrial and Labor Relations Review*, forthcoming.
- MATEOS DE CABO, R., S. TERJESEN, L. ESCOT, AND R. GIMENO (2019): “Do ‘soft law’ board gender quotas work? Evidence from a natural experiment,” *European Management Journal*, 37, 611–624.
- MATSA, D. A. AND A. R. MILLER (2013): “A Female Style in Corporate Leadership? Evidence from Quotas,” *American Economic Journal: Applied Economics*, 5, 136–69.
- MEIER, V. AND M. WREDE (2013): “Reducing the excess burden of subsidizing the stork: joint taxation, individual taxation, and family tax splitting,” *Journal of Population Economics*, 26, 1195–1207.
- MURALIDHARAN, K. AND N. PRAKASH (2017): “Cycling to School: Increasing Secondary School Enrollment for Girls in India,” *American Economic Journal: Applied Economics*, 9, 321–50.
- OWEN, A. L. AND J. TEMESVARY (2018): “The performance effects of gender diversity on bank boards,” *Journal of Banking & Finance*, 90, 50–63.

- PORTER, C. AND D. SERRA (2020): “Gender Differences in the Choice of Major: The Importance of Female Role Models,” *American Economic Journal: Applied Economics*, 12, 226–54.
- PROFETA, P. (2020): *Gender Equality and Public Policy*, no. 9781108437462 in Cambridge Books, Cambridge University Press.
- RAUTE, A. (2019): “Can financial incentives reduce the baby gap? Evidence from a reform in maternity leave benefits,” *Journal of Public Economics*, 169, 203 – 222.
- RIISE, J., B. WILLAGE, AND A. WILLÉN (2021): “Can Female Doctors Cure the Gender STEMM Gap? Evidence from Exogenously-Assigned General Practitioners,” *Review of Economics and Statistics*, forthcoming.
- SMITH, N. (2018): “Gender quotas on boards of directors,” *IZA World of Labor*, 7.
- TERJESEN, S., R. V. AGUILERA, AND R. LORENZ (2015): “Legislating a Woman’s Seat on the Board: Institutional Factors Driving Gender Quotas for Boards of Directors,” *Journal of Business Ethics*, 128, 233–251.
- TYREFORS, B. AND J. JANSSON (2017): “Gender Quotas in the Board Room and Firm Performance: Evidence from a Credible Threat in Sweden,” Working Paper Series 1165, Research Institute of Industrial Economics.
- YANG, P., J. RIEPE, K. MOSER, K. PULL, AND S. TERJESEN (2019): “Women directors, firm performance, and firm risk: A causal perspective,” *The Leadership Quarterly*, 30, 101297.

Online Appendix

Annadanam, Harini, Jan Sauermann, and Aylin Shawkat: *Board quotas, women's representation in top management, and firm performance* (November 2021)

A Instrumental variables results

All main analyses employ a difference-in-differences approach, in which outcomes of treated firms are compared to control group firms. In the absence of a suitable control group, an alternative approach is to use pre-quota values of the female supervisory board share as an instrument for current female supervisory board share (cf. Bertrand et al., 2018; Dalvit et al., 2021). The first stage regression can therefore be written as

$$y_{it}^{sb} = \alpha + \beta \bar{y}_i^{sb} + \sum_t (\delta_t \bar{y}_i^{sb} * \gamma_t) + \epsilon_{it}, \quad (\text{A.1})$$

where y_{it}^{sb} is the female board share for firm i in year t , \bar{y}_i^{sb} its value in 2013, i.e. before the implemented quota entered the legislative process, and γ_t are year fixed effects. Equation (A.1) is estimated for treatment groups only for year 2014 to 2019. The predicted female supervisory board share from Equation (A.1), \hat{y}_i^{sb} is then used as an instrument for the second stage regression, shown in Equation (A.2):

$$y_{it}^{ex} = \alpha + \beta \hat{y}_i^{sb} + \epsilon_{it}, \quad (\text{A.2})$$

Columns (1) and (2) of Table A.1 show estimation results for the first stage of this instrumental variables regression, estimated for quota firms only for the years 2014 to 2019. This estimation is estimated for a balanced sample that can be observed over the full period. The results show that the supervisory board gender share in 2013 is significantly related to current supervisory board gender share, and that the interaction terms are negative. This is because those firms with higher pre-reform women on their supervisory boards have lower gains in the share of women on their supervisory boards on average. Column (3) shows the second stage *without* the instrumented share of women on the supervisory board: here, supervisory board gender share in 2013 is significantly negatively related to current gender share on *executive* boards. When

instrumenting the supervisory board share, however, the estimate is not significant (Column (4)).

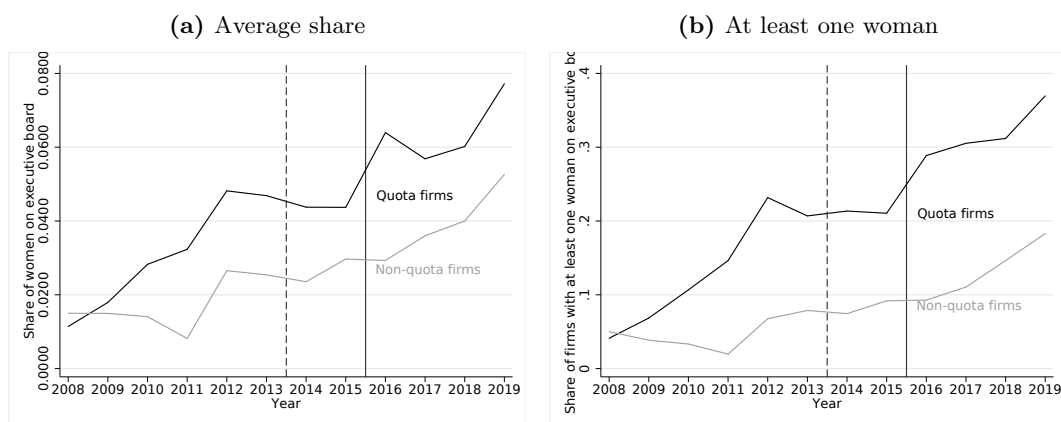
Table A.1: First and second stage results of instrumental variables regression

	<i>First stage</i>		<i>Second stage</i>	
	(1)	(2)	(3)	(4)
	Supervisory board		FE-OLS	IV
Female board share in...			Executive board	
Female supervisory board share 2013	0.8389*** (0.0878)			
Year=2015 \times Female supervisory board share 2013	-0.0901 (0.1040)	-0.0901 (0.1003)		
Year=2016 \times Female supervisory board share 2013	-0.4618*** (0.1090)	-0.4618*** (0.1052)		
Year=2017 \times Female supervisory board share 2013	-0.5721*** (0.1145)	-0.5730*** (0.1105)		
Year=2018 \times Female supervisory board share 2013	-0.6670*** (0.1095)	-0.6086*** (0.1126)		
Year=2019 \times Female supervisory board share 2013	-0.7103*** (0.1141)	-0.6538*** (0.1199)		
Female Supervisory Board Share			-0.0647 (0.0680)	0.0041 (0.1139)
R-squared (adj.)	0.5679	0.6232	0.0379	0.0356
Number of firms	87	87	98	87
Number of observations	511	511	561	511
Mean dependent var.	0.2304	0.2304	0.2338	0.2304
Firm FE	No	Yes	Yes	Yes

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Columns (1) and (2) present results of the first stage regression, in which the supervisory board share in t is regressed on the supervisory board share in 2013, and its interactions with year dummies. The regression in Columns (1) and (2) also control for year fixed effects, sector fixed effects, and sector \times year interactions. Column (2) also controls for firm fixed effects.

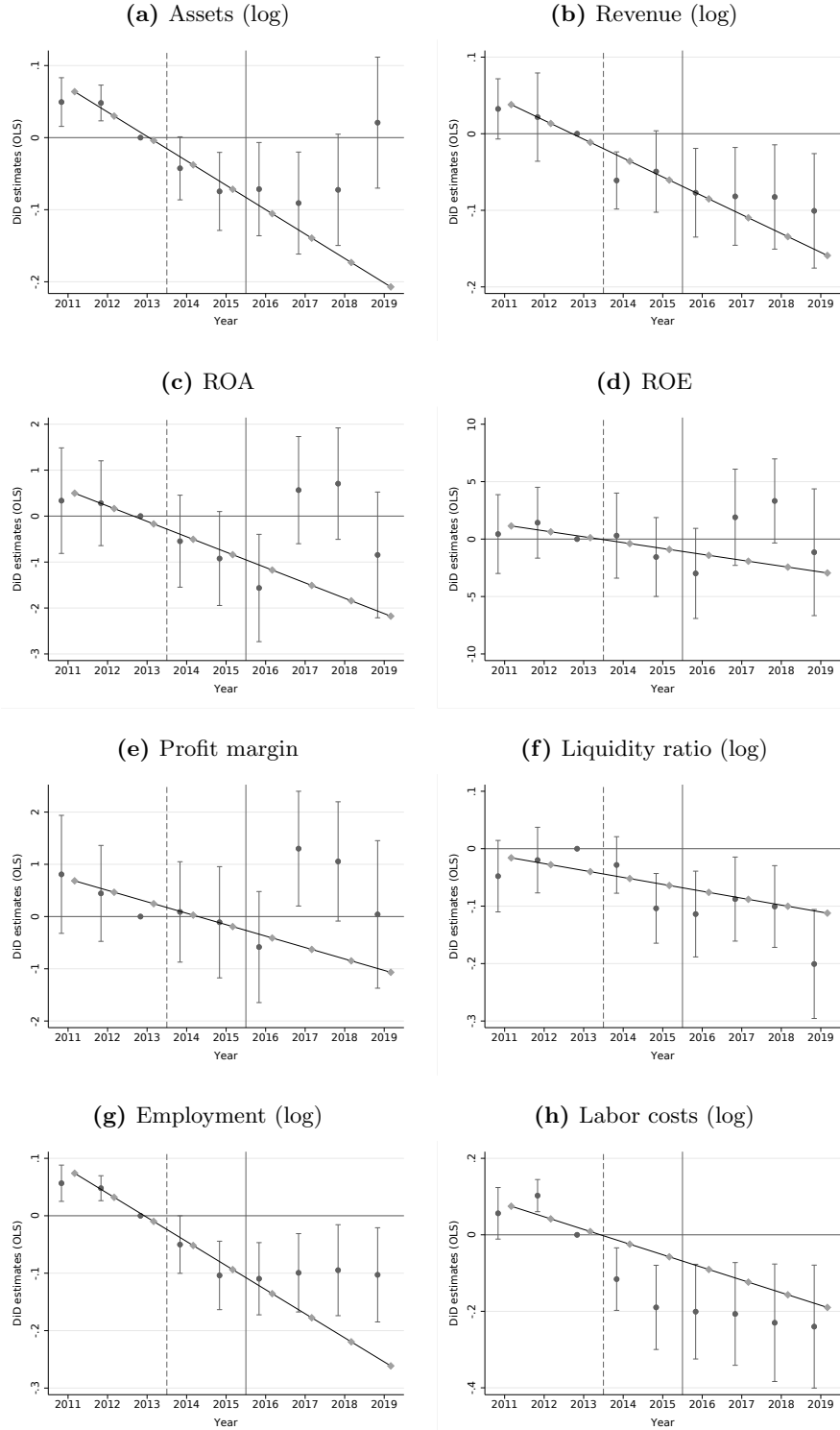
B Figures

Figure B.1: Female representation in executive boards



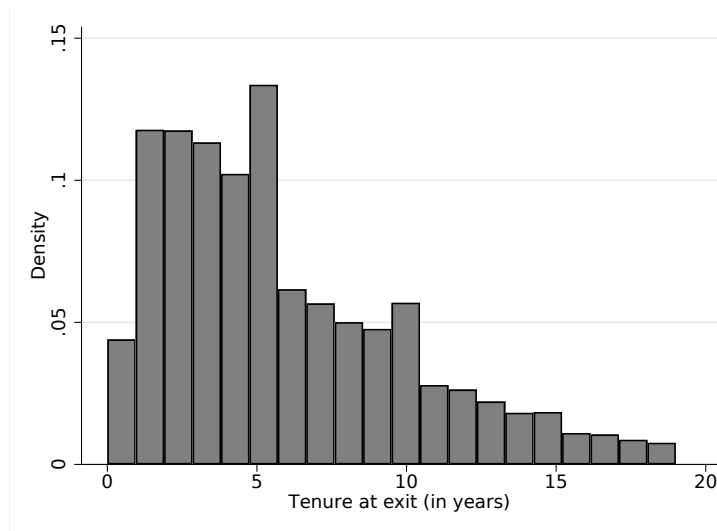
Notes: Figure (a) shows the average share of women on executive boards for firms that are subject to the gender quota from 2016 onwards (black line), and for firms that are only subject to the voluntary target measure (gray line). Figure (b) shows the share of firms that have at least one women on their executive board for quota firms (black line) and firms only subject to targets (gray line). The solid vertical line indicates the introduction of the gender quota. The dashed vertical line indicates the time when the cabinet started their discussions on the law.

Figure B.2: Board quota and firm outcomes



Notes: The figure shows event study estimates $\hat{\beta}_t$ for the seven outcome variables. The underlying regression includes a control variable for executive board size, firm fixed-effects, and a constant (cf. Column (4) of Table 2). The solid vertical line indicates the introduction of the gender quota. The dashed vertical line indicates the time when the cabinet started their discussions on the law. Standard errors are clustered at the firm level.

Figure B.3: Leaving supervisory board members and time on board



Notes: The figure shows the distribution of tenure when leaving the supervisory board, as measured in years. The highest percentile has been removed to ease interpretation.

C Tables

Table C.2: List of Variables and Sources

Variable	Description
Board characteristics (<i>source:</i> BoardEx (2020))	
Female supervisory board share	Share of female supervisory board directors
Comply with quota	Dummy if at least 30% women on supervisory board
Number of board members	Total number of directors on supervisory board
Supervisory board turnover	Share of newly elected individuals on supervisory board
Supervisory board member age	Average age of supervisory board members (in years)
Supervisory board member network Size	The number of individuals to which the average supervisory board director is connected through overlaps in start and end dates of all roles, including employment, education, or other activities
Supervisory board member non-German	Dummy if board member born abroad
Chairwoman	Dummy if supervisory board chair is female
Vice-chairwoman	Dummy if at least one supervisory board vicechair is female
Female Executive Board Share	Share of female executive board directors
Number of Executive Board Directors	Total number of directors on executive board
Firm performance (<i>source:</i> Bureau van Dijk (2020))	
Assets	A firm's assets
Revenues	Revenue generated from the company's primary business activities
ROA	Return on assets: net income before taxes divided by total assets
ROE	Return on equity: net income divided by equity
Profit Margin	Cents of profit generated by the company per Euro of revenue
Liquidity Ratio	Current assets that can be quickly liquidated divided by current liabilities
Labor costs	Costs of labor per employee
Other Variables (<i>source:</i> Bureau van Dijk (2020))	
Number of Employees	Number of employees employed by the company globally
Publicly Quoted	Dummy variable taking the value of one if the company is listed on a stock exchange
Not in DAX	Firm not listed in DAX
Natural Resources	Dummy variable taking the value of one if the company is in the natural resources sector
Manufacturing	Dummy variable taking the value of one if the company is in the manufacturing sector
Services	Dummy variable taking the value of one if the company is in the services sector

Table C.3: Firm performance of quota and non-quota firms

	(1) Quota	(2) No quota	(3) Diff. (2)-(1)
Assets (log)	15.6797 (2.0642)	11.3152 (2.0026)	-4.3645*** (0.2107)
Revenues (log)	20.0586 (1.7587)	16.8013 (1.4161)	-3.2573*** (0.1486)
ROA	4.6231 (7.4691)	6.3508 (11.9235)	1.7277 (1.2397)
ROE	7.4933 (16.0546)	10.0679 (60.4204)	2.5746 (6.3457)
Profit margin	4.7021 (9.7834)	3.5932 (8.9963)	-1.1089 (0.9517)
Liquity ratio (log)	0.0197 (0.3844)	0.4869 (0.9628)	0.4672*** (0.1024)
Employment (log)	9.7471 (1.4148)	7.0037 (0.9718)	-2.7434*** (0.1020)
Labor costs (log)	8.7341 (0.4251)	8.4848 (0.6099)	-0.2493*** (0.0653)
Number of firms	105	3,636	

Notes: *** p<0.01, ** p<0.05, * p<0.1. Descriptive statistics are based on the last year before the quota introduction, 2015. Financial outcomes are adjusted to 2010 values.

Table C.4: Alternative treatment and post-period specifications

Dependent variable	Supervisory board Complying firms (1)	Supervisory board Share of women (2)	Executive board Share of women (3)	Board member age (4)	Supervisory board characteristics Network size (5)	Non-German (6)	Chairwoman (7)	Vice-chairwoman (8)
<i>Panel A: Post-period defined as 2016 and later (2014, 2015 excluded)</i>								
Treated x Post introduction	0.3415*** (0.0542)	0.0820*** (0.0156)	0.0052 (0.0116)	-0.2208 (0.5564)	-51.1736 (40.3877)	0.0468* (0.0280)	0.0171 (0.0178)	-0.0257 (0.0445)
R-squared (adj.)	0.2736	0.3704	0.0406	0.0045	0.0535	0.0205	0.0006	0.0156
Number of firms	330	330	330	330	330	330	330	330
Number of observations	2,297	2,297	2,288	2,283	2,295	2,296	2,296	2,296
Mean dependent var.	0.1667	0.0930	0.0111	0.1007	0.1007	0.1007	0.0556	0.1111
<i>Panel B: Post-period defined as 2014 and later</i>								
Treated x Post announcement	0.2427*** (0.0451)	0.0656*** (0.0132)	0.0036 (0.0100)	-0.2207 (0.4771)	-50.9484 (37.6935)	0.0460* (0.0243)	0.0227 (0.0159)	-0.0152 (0.0371)
R-squared (adj.)	0.2188	0.3161	0.0358	0.0033	0.0445	0.0185	0.0020	0.0145
Number of firms	334	334	334	334	334	334	334	334
Number of observations	2,865	2,865	2,856	2,850	2,863	2,864	2,864	2,864
Mean dependent var.	0.2095	0.1549	0.0327	57.4447	413.1723	0.5901	0.0286	0.1048
<i>Panel C: Pre-trend estimation (≤ 2015)</i>								
Treated x Year	0.0132 (0.0101)	0.0086*** (0.0029)	0.0021 (0.0025)	-0.0846 (0.1129)	-13.8959 (9.3895)	0.0078 (0.0053)	0.0057 (0.0035)	0.0038 (0.0074)
R-squared (adj.)	0.0589	0.1907	0.0209	0.0081	0.0236	0.0230	0.0064	0.0356
Number of firms	315	315	315	315	315	315	315	315
Number of observations	1,774	1,774	1,769	1,759	1,773	1,773	1,773	1,773
Mean dependent var.	0.2095	0.1549	0.0327	0.1158	0.1158	0.1158	0.0286	0.1048

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at the firm level. All regressions include a control variable for board size, firm fixed-effects and a constant. Standard errors are clustered at the firm level.

Table C.5: Effects of the gender quota for supervisory boards for firm performance

Dependent variable	Assets (log) (1)	Revenues (log) (2)	ROA (3)	ROE (4)	Profit margin (5)	Liq. ratio (log) (6)	Empl. (log) (7)	Labor costs (log) (8)
<i>Panel A: Post-period defined as 2016 and later (2014, 2015 excluded)</i>								
Treated x Post introduction	-0.0918** (0.0401)	-0.1045*** (0.0376)	-0.6023 (0.4412)	-0.5530 (1.4325)	-0.0368 (0.4201)	-0.1108*** (0.0303)	-0.1402*** (0.0376)	0.0039 (0.0120)
R-squared (adj.)	0.2386	0.2315	0.0141	0.0132	0.0106	0.0035	0.1101	0.3586
Number of firms	2,828	2,968	2,717	2,392	2,564	2,821	3,431	2,685
Number of observations	15,935	14,977	14,692	12,378	13,499	15,251	17,703	14,357
Mean dependent var.	11.0091	16.7707	5.9739	9.4196	3.7893	0.4667	7.0269	8.3758
<i>Panel B: Post-period defined as 2014 and later</i>								
Treated x Post announcement	-0.0864** (0.0342)	-0.0933*** (0.0329)	-0.6413 (0.3980)	-0.6460 (1.2658)	-0.1113 (0.3856)	-0.0832*** (0.0246)	-0.1276*** (0.0328)	0.0041 (0.0106)
R-squared (adj.)	0.2171	0.1954	0.0105	0.0090	0.0072	0.0023	0.0922	0.3170
Number of firms	2,828	3,024	2,718	2,418	2,575	2,828	3,437	2,685
Number of observations	20,942	20,122	19,348	16,297	17,813	20,049	23,471	18,894
Mean dependent var.	11.0091	16.7707	5.9739	9.4196	3.7893	0.4667	7.0269	8.3758
<i>Panel C: Pre-trend estimation (≤ 2015)</i>								
Treated x Year	-0.0358*** (0.0079)	-0.0258*** (0.0096)	-0.2904 (0.2964)	-0.3134 (0.8951)	-0.5205* (0.2899)	0.0266* (0.0159)	-0.0344*** (0.0072)	0.0078 (0.0048)
R-squared (adj.)	0.0760	0.0910	0.0084	0.0088	0.0078	0.0001	0.1162	0.1174
Number of firms	2109	1882	1940	1699	1772	2031	2035	1856
Number of observations	5,414	4,566	4,847	4,176	4,360	4,997	4,867	4,570
Mean dependent var.	11.0091	16.7707	5.9739	9.4196	3.7893	0.4667	7.0269	8.3758

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions include firm fixed-effects, year fixed-effects, and a constant. Financial outcomes are adjusted to 2010 values. To reduce the impact of outliers, the lowest and highest percentile has been removed. Standard errors are clustered at the firm level.

Table C.6: Gender quota and board turnover

Dependent variable	Supervisory board turnover (1)
Treated x Post introduction	0.0007 (0.0139)
R-squared (adj.)	0.0071
Number of firms	327
Number of observations	2,530
Mean dependent var.	0.1302

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at the firm level. All regressions include a control variable for board size, firm fixed-effects, year fixed-effects and a constant.

Table C.7: Estimation results for balanced samples

Dependent variable	Supervisory board		Executive board
	Complying firms (1)	Share of women (2)	Share of women (3)
Treated x Post introduction	0.3235*** (0.0600)	0.0759*** (0.0176)	0.0020 (0.0124)
R-squared (adj.)	0.2885	0.4120	0.0503
Number of firms	144	144	144
Number of observations	1,675	1,675	1,670
Mean dependent var.	0.2569	0.1861	0.0298

Notes: *** p<0.01, ** p<0.05, * p<0.1. All regression control for year and firm fixed-effects as well as for the respective board size. All regressions include a constant. The dependent variable is the share of firms complying with the reform (Column (1)), the share of women on a firm's supervisory board (Column (2)), and the share of women on a firm's executive board (Column (3)). Standard errors are clustered at the firm level.