ERASMUS UNIVERSITY ROTTERDAM

ERASMUS SCHOOL OF ECONOMICS

MSc Economics & Business

Specialization Strategy Economics

ERASMUS UNIVERSITY ROTTERDAM

The effect of female board representation on innovation investments

Author: L.M.E. van Rijsewijk

Student number: 456032

Thesis supervisor: dr. TLPR Peeters

Second reader: A.B. Wismans

Date: 14-06-2022

Abstract

This research examines the effect of female board representation on innovation investment by using a gender quota in California introduced in 2018. The dataset consists of companies included in the S&P 500 from 2016 to 2021. The level of female board representation is defined as the percentage of female board members compared to the total number of board members. The main findings suggest a significant relationship between the gender quota in California and the percentage of female board members. In addition, this research finds a significant effect of female board representation on R&D expenditures. Due to statistically insignificance, it is not able to conclude on the effect of the gender quota in California on the board size. This research serves as an important contribution to existing research regarding female board representation. It could serve as a foundation for further research on the impact of gender quotas on several measurements and the relation between female board representation and innovation aspects.

Keywords: Female board representation, California gender quota, Innovation performance, Innovation investments, R&D expenditures

JEL Classification: C21, J26, 032

Table of content

List of tables and figures

1. Introduction

There has been an ongoing debate about gender equality in the corporate world. As of 2020, in the largest publicly listed European companies, only 29.5% of board seats were covered by female board members, and in firms listed on the S&P 500, this was only 26.5% (Catalyst, 2021). Board gender inequality raises concerns as board gender diversification encourages better decision-making and increases firm value (Griffin et al., 2021). Khosa (2017) argues that a gender diverse board will improve the decision-making process as there is a wider range of different ideas, experiences and business knowledge. According to Hillman and Dalziel (2003), women are able to improve the alignment between board incentives and shareholder incentives. Pfeffer and Salancik (2003) argue that firms need to maximize available resources to increase their financial performance. Having a gender diversified board helps to add new resources and increases the firm efficiency (Burke and Mattis, 2000). Governments have started to look at ways to improve the board gender diversification by introducing compulsory gender quotas, putting firms under pressure to have a certain number of female board members in their board room (Thomas, 2021). Norway is the first country which mandated that the board of directors should exist of 40% female board members, after which several European countries followed. California is the first state to follow the European gender quotas. Firms headquartered in California must have at least one female board member in their board room by December 31, 2019 (Von Meyerink et al., 2019). However, governments and companies have an ongoing discussion about the effectiveness of gender quotas. Given how many countries have introduced gender quotas, it is important to investigate their effectiveness. In addition, this research uses the introduction of the gender quota in California in 2018 as a natural experiment to examine the effect of female board representation on innovation investments.

Business innovation describes introducing something new to facilitate new value and growth (MasterClass, 2021). According to Weill and Woerner (2015), innovation creates valuable opportunities and is the main engine of firm growth. Therefore, firms must have innovation high on the priority list and have specific firm characteristics encouraging innovation performance. Previous literature has researched which firm characteristics could influence innovation performance. Østergaard et al. (2011) provide evidence of a positive effect of employee gender diversity on innovation performance. In addition, age diversity could encourage innovation as the combination of old and young people will lead to a dynamic view and high adoption capacity (Ng and Feldman, 2013). This paper adds to the literature about the relationship between firm characteristics and innovation performance by focusing on female board representation. The research question is as follows:

Does the 2018 introduction of gender quota in California reveal a positive relationship between female board representation and innovation investments for firms included in the S&P 500?

This research takes another approach than most literature about the effect of female board representation on innovation performance by using the gender quota in California as a natural experiment. This increases the reliability of the outcome by eliminating other endogenous effects that could lead to higher female board representation. In addition, the research question is politically relevant as it could support the introduction of quotas in the past period, which could justify the introduction of new rules enhancing board gender equality. Furthermore, the outcome of this research could lead to intrinsic motivation for firms to hire female board members, which adds societal relevance to this paper.

The main result suggests that the gender quota in California has a significant positive effect on the percentage of female board members compared to the total number of board members. More specifically, the percentage of female board members is 5% higher for firms in California exposed to the intervention than firms from other states that are not exposed to the intervention. An additional analysis is done to examine the effect of the gender quota in California on the board size. Such an effect may be a concern since a significant change in board size could indicate that firms have chosen to add female employees to their board instead of replacing male board members with female board members, which is not in line with the goal of the gender quota. The results provide a positive effect of the gender quota on the board size. However, this effect is not significant at the 10% significance level. In addition, this research finds that an increase in female board representation by one unit leads to a significant increase in R&D expenditures by 31.8%.

The structure of this paper is as follows. The upcoming section discusses the literature on board gender diversification and innovation performance. Then, the data and methodology are discussed in sections 3 and 4, after which section 5 analyses the results. The research ends with a discussion and conclusion in section 6.

2. Theoretical framework

In the existing literature, extensive research relates to the positive effects of board gender diversification on several firm aspects. In this research, board gender diversification is seen as the percentage of female board members compared to the total number of board members and is called female board representation. Very few women are included on the board of directors worldwide. Governments are trying to promote the presence of women in the board room by introducing quotas requiring a minimum percentage of female board members. This section will first dive into the effectiveness of such a gender quota. The second part of the theoretical framework highlights the theory about the effect of board gender diversification on innovation performance.

2.1 Female board representation and effectiveness of gender quota

Gender diversity has been a widely discussed topic (Terjesen et al., 2009). It is a central topic of business ethics as female representation in firms could signal openness and commitment to social responsiveness. Gender awareness in the strategic framework of firms is often seen as an indicator of the extent to which firms put a value on broader social issues (McCabe et al., 2006; Kelan, 2008). Gender diversification is not just a social issue but also a value driver in firms. A large strand of literature has focussed on female representation on the board of directors (Schultz, 1995; Cassell, 1997; Bear et al., 2010; Khosa, 2017). Board gender diversification could serve as the starting point of an inclusive culture (Schultz, 1995). Further, board gender diversification is associated with gaining competitive advantage and long term company success (Cassell, 1997). According to Bear et al. (2010), board gender diversification could strengthen the board human capital based on board members' collective experience and expertise. Khosa (2017) argues that gender diversification in board positions will improve decision-making due to different backgrounds, ethics, and business knowledge. The Catalyst study of Fortune 500 companies shows that companies with board gender diversification perform better than those with mainly male board members. The boards with the highest number of female board members outperform those with the least by 53 per cent in terms of return on equity and by 42 per cent in terms of return on sales (Merchant, 2011). However, very few women have a seat in the boardroom (Burgess and Tharenou, 2002). Governments have introduced gender quotas to enhance the number of female board members. Norway was the first country that came with a respond to board gender inequality by mandating a quota where the board of directors should exist of 40% female board members. Several other countries followed with similar quotas.

However, there is an ongoing debate about the effectiveness of such quotas since there are several disadvantages related to a gender quota. Quotas could lead to female board members being less respected and less influential. The attitude could arise that women only have a board seat because of the quota, not because of their qualities (Merchant, 2011; Gill, 2012). This would deter women from taking a seat in the boardroom. Gertsberg et al. (2021) investigate the gender quota in California and find that incumbent female directors receive more support than incumbent men while the support for new female directors, after introducing the gender quota, is equal to that of new male directors. This may indicate a changed attitude towards female directors because of the gender quota. Merchant (2011) highlights another disadvantage by stating that firms will find a new way around the rules due to the external pressure of the quota. In the context of the effectiveness of gender quotas, a difference can be made between a soft and a hard quota. A soft quota is a non-binding instrument, and a firm that does not meet the requirements receives warnings as only punishment. In contradiction, a hard quota is a binding instrument leading to fines if the gender quota is not met. De Cabo et al. (2019) provide evidence of a higher increase in the number of female board members across countries if the government introduced a hard quota compared to a soft one. However, whether fines lead to sufficient internal motivation for firms to appoint female board members is often questioned.

This research seeks to contribute to the debate about the effectiveness of gender quotas by examining whether introducing a gender quota in California has positively affected the number of female board members in California. Despite the several proposed disadvantages of gender quotas, the numbers related to the effect of the gender quota in California are positive. When introducing the gender quota, 25% of all publicly held corporations in California had no female directors on their boards (California Secretary of State, 2022). By the end of 2019, just five companies did have an all-male board. Additionally, in 2016, the average share of female board members in California was 12.9%. When the gender quota officially was signed, this percentage increased to 15.8%, and 23.2% in 2020 (Gertsberg et al., 2021). However, these studies have no design that allows drawing causal conclusions. To empirically test whether the favourable rates are a result of the introduced gender quota or a result of other external pressures such as the social awareness, the first hypothesis is as follows:

H1: The gender quota in California positively affects the percentage of female board members.

As already mentioned above, one of the drawbacks of a gender quota could be that firms will find a new way around the quota rules. One of the solutions to satisfy the quota while keeping the current board members is to add internal female employees as new female board members while not changing their function of power in the company. In that case, female board members do not replace male board members. Instead, firms choose to expand their board size. However, expanding the board size is related to lower firm value and financial performance (Yermack, 1996). There is thus a certain trade-off for firms between replacing male board members with female board members or accepting the negative effect of expanding the board size while keeping all current male board members. Casteuble et al. (2019) find that the board size of firms in Norway, Belgium, France, Italy and Germany remain constant after introducing a gender quota. Ahern and Dittmar (2012) provide evidence of a no change in board size after introducing the gender quota in Norway. Thus, these firms have chosen to comply with the law at the cost of replacing male board members. However, Naaraayanan and Nielsen (2020) examine the effect of the Indian gender quota on the board composition of firms. They find that most firms tend to comply with the gender quota by expanding the board size. Furthermore, their results show that an increase in the board size is related to negative stock price reactions. Contradictory, firms not adjusting their board size but replacing male board members to satisfy the gender quota face positive stock price reactions. These findings confirm the negative effect of an increase in board size on the firm value. This paper uses the gender quota in California to examine the effect of gender quota on board size. Smith (2022) highlights criticism from legal members and firms in California after the 2018 introduction, pointing out a patriarchal environment which indicates a culture where men dominate. Naarayann and Nielsen (2020) suggest that boards with strong patriarchal views are more likely to satisfy the gender quota by expanding board size. Taking this together, hypothesis 2 examines whether the introduced gender quota in California leads to a higher number of board members. An increase in board size mismatches the goal of the gender quota in California since the quota wishes to incentive firms to choose women over men if there are not enough female board members. Hypothesis 2 is as follows:

H2: The gender quota in California positively affects the number of board members.

2.2 California gender quota

The empirical setting of this research uses the gender quota in California to examine the hypotheses. The details of this quota are as follows. On September 30, 2018, California was the first state introducing a gender quota by signing Senate Bill 826. This law requires having at least one female member in the boardroom by December 31, 2019. By December 31, 2021, the gender quota requires a minimum number of female board members depending on the size of the board. For example, a board with five members must have at least two female board members, and a board with six or more directors must have at least three women (Gertsberg et al., 2021). The quota applies to all national and foreign companies listed on the U.S. stock market and headquartered in California (Von Meyerinck et al., 2019). The gender quota in California is a hard quota. Once a firm violates the gender quota, it could face penalties and fines. A violation is defined as a "director seat required by this section to be held by a female, which a female does not hold during at least a portion of a calendar year" (Von Meyerinck et al., 2019). For a first violation, $100.000 is fined, followed by $300.000 for a second or subsequent violation. The maximum fine per year is $900.000.

2.3 The link between female board representation and innovation investments

Innovation has gained the interest of much literature and empirical research, which have led to different definitions describing innovation. Many researchers use the definition of the famous economist Schumpeter as starting point for their description of innovation. Schumpeter (1934) defines innovation as "any new policy that an entrepreneur undertakes to reduce the overall cost of production or increase the demand for its products". Based on Schumpeter and other literature, innovation in this thesis is described as “the introduction of something new to facilitate value and growth”. Barney (1991) and Artz et al. (2010) argue that innovation could serve as a source of competitive advantage, and it could provide solutions to business challenges. Furthermore, innovation can lead to specific competencies which enable first-mover advantages such as economies of scale and brand recognition (Lieberman and Montgomery, 1998). In addition, innovation allows firms to respond to market changes rapidly and is the main engine of growth (Teece et al., 1997; Griffin et al., 2021). Due to the positive effects of innovation on firm value, it is of great relevance for firms to understand which mechanism could optimize the innovation level.

According to Upper Echelon's Theory, board members view their situations through personal experiences and other human factors (Hambrick and Mason, 1984). Therefore, differences in strategic firm decisions arise because of board members' experiences, values, and personalities. Krishnan and Park (2005) argue that gender is one of the most determining characteristics as it affects the socio-cognitive base of board members. The board of directors fulfils three critical tasks: control, service, and strategic roles (Rejeb et al., 2019). There are several mechanisms through which female board representation could lead to higher innovation performance, which will be discussed based on the three main tasks of the board of directors.

The board's control role includes limiting managers' opportunism and aligning the interests between management and shareholders. Adams and Ferreira (2009) prove that female directors are more likely to join monitoring committees and have better attendance records than male directors. High participation of the board of directors will improve the limitation of self-thinking managers and the alignment of interests in the company. Self-thinking managers tend to favour short-term performance by conducting exploitative innovations. Exploitative innovations are opportunistic and will boost the current products and services in a short-time period. In contradiction, exploratory innovation yields new value in the future by replacing the existing products or services (Griffin et al., 2021). Through the control role, directors could foster long-term innovation, but only if managers have the security that they are not solely evaluated based on short-term results. This is enhanced by having female directors as they are more long-term orientated. Al Anezi and Alansari (2016) find that females score higher in terms of long-term orientation than males. In addition, Griffin et al. (2021) argue that a gender diverse board is more long-term orientated, which is reflected in the management incentive schemes made by the board of directors. Manso (2011) studies the optimal innovation-incentive scheme and finds that tolerance for early failure and long-term success rewards will improve innovation investments. Considering that females are more long-term orientated than males, a gender diverse board could lead to higher innovation performance. Furthermore, it is necessary for management to feel supported instead of being controlled (Hendry, 2002). Nielsen and Huse (2010) argue that female directors have a greater sensitivity, tend to accept others' positions and would rather collaborate with management than control them. Therefore, women will be better at providing management with support, which will give them trust in taking strategic risks by innovating.

The second main task of the board is the service role, which includes external service tasks by making use of the firm's network and internal services, including advising the management (Stiles and Taylor, 2001; Forbes and Milliken, 1999). Several papers exploit the relation between the board's service task and innovation. Pfeffer (1991) argues that the board's network could provide strategic information about market development and consumer needs, bringing management in the appropriate direction of innovation. This information minimizes the risks and costs (Wincent et al., 2010). Terjesen et al. (2009) argue that women have a more extensive network than men, allowing more diversified information about different stakeholders in the value chain. Furthermore, innovation requires various resources obtained by exploiting the board's human capital and social capital (Hillman and Dalziel, 2003). Female board members complement male board members in terms of human capital as they provide specific values, different viewpoints and a better atmosphere at work (Galia et al., 2015). In addition, gender diversity brings new knowledge and perspectives which encourage creativity, leading to effective decisions and innovation (Campbell and Vera, 2010). Ostergaard et al. (2011) emphasize that the interaction of different demographic profiles, such as gender differences, will boost innovation. The service role also includes the internal task of advising the management. Females are less overconfident than males, where overconfidence refers to the over-estimation of the likelihood of success (Croson and Gneezy, 2009). Furthermore, women tend to put lower weight on success and achievement and are less impulsive than men (Adams and Funk, 2012; Silverman, 2003). Therefore, a gender diverse board could positively influence the board's advisory task by downgrading managers' entrenchment.

Lastly, the board of directors use its knowledge and skills to optimize all levels of the strategic process. Innovation is closely linked to the strategic role. It involves searching for the alignment between the firm's mission and innovation opportunities, exploiting the firm's resources and eventually deciding to innovate in collaboration with management (Wu and Wu, 2014). Several digital developments and exogenous shocks, such as the Covid-19 crisis, have disrupted the business world in the last few years. These disruptions emphasize the need to be flexible in strategic decision making by adjusting to the new business environment. Akkaya and Üstgörül (2020) argue that females are more effective and agile leaders with a higher capacity to adjust their companies to new, complex business developments. In addition, the ability to detect innovation opportunities and strategic innovation-decision requires conflicting information processing and divergent thinking (Nijstad et al., 2014). This is often not in line with the embedded corporate culture. The board of directors often attaches to the current corporate culture, whereby they are resistant to change (Kouloukoui et al., 2020). However, Johnson et al. (2015) emphasize that minorities, female board members in this context, could inspire majorities, male board members, to new ways of thinking by sharing information. With this, the minorities are more likely to break traditions and could, therefore, positively affect the corporate culture. From the innovation perspective, this is especially relevant if the board of directors postpone innovation due to their risk or investment attitude towards innovation. The representation of females as a minority group could break this pattern by sharing information from their perspective. Furthermore, female board members contribute to the firm's strategic position by motivating a diverse labour force (Dezsö and Ross, 2012). Several papers provide evidence of a positive effect of a diverse inventor team on innovation performance. It brings different knowledge and perspectives, leading to a higher likelihood of breakthrough inventions due to a high level of creativity (Page, 2007).

Based on the board of directors' three main tasks, there are several mechanisms through which a gender diverse board could positively affect innovation performance. There are several innovation performance measures. This research needs to use an innovation measure that immediately covers the impact of female board representation on innovation performance. Therefore, it uses R&D expenditures, which are the innovation investments of a firm, as a proxy for innovation performance (Chen et al., 2019). To empirically test the expectation regarding the effect of a gender-diverse board on innovation investments, the hypothesis is as follows:

H3: Firms with more female board representation have higher innovation investments.

3. Data

The dataset includes S&P 500 firms in all states in the U.S. from 2016 to 2021. The companies partly included in the S&P 500 in the appropriate period are also included. The sample is panel data since each company has different observations over different periods. The dataset consists of two different parts: firm-level data and board-level data. Compustat is a database providing financial statements for publicly traded companies and is used to obtain firm-specific data. The database BoardEx provides information related to the board of directors and is used to exploit board-specific data. After removing all observations with missing variables for the variables: female board representation, R&D expenditure and state, and after removing three outliers from the variable R&D expenditure, 1251 unique year-company observations remain.

3.1 Variables

In this research, hypothesis 1 examines whether the gender quota in California has led to an increase in female board members. The dependent variable is *female board representation*, which measures the percentage of female board members based on the total number of board members. The effect of the gender quota is measured through three variables: *treatment, post-period* and an interaction term between *treatment* and *post-period.* First, the variable *state* is included in the dataset, which refers to the location in which the headquarters of a company is located. This is necessary to create the variable treatment since this variable is equal to 1 for the state of California and equals zero for other states. The variable treatment thus makes a distinction between the state that is affected by the intervention, California, and the other states that are not affected by the intervention. The variable post-period takes the value 1 if the observation falls in the period 2019-2021 and 0 if it falls in the period 2016-2018. The interaction variable between treatment and post-period indicates the effect of the policy intervention and is thus the main variable of interest.

Hypothesis 2 examines whether the gender quota in California has led to an increase in the board size. The dependent variable is the *number of directors*, which counts the number of board members for each board per year. The effect of the gender quota is the same as with hypothesis 1, measured through the variables *treatment, post-period* and an interaction variable between *treatment* and *post-period*, which is the main variable of interest.

Hypothesis 3 examines whether female board representation leads to higher R&D expenditures. The dependent variable is *R&D expenditure*, representing all costs incurred during the year to develop new products or services. R&D expenditure is a widely used measure by researchers that examine the effect of different firm characteristics on innovation performance (Love and Ashcroft, 1999; Chen et al., 2019). The main variable of interest is *female board representation,* the percentage of female directors relative to the total number of board members at the annual report date. The gender quota in California acts as an instrument for this variable. Control variables are included in the regression to better estimate the relationship between female board representation and R&D expenditures. Xin et al. (2019) provide evidence of leverage positively affecting R&D expenditures. Therefore, the first control variable is *leverage* which is the total debt divided by the firm's total assets. Another firm-specific control variable added to the regression is firm size, measured through the amount of total assets. According to Chauvin and Hirschey (1993), large firms could afford R&D investments on a larger scale than small firms. In addition, the regression includes two other board characteristics. Nielsen and Nielsen (2013) find that other diversity measures, beyond board gender diversification, could influence the R&D expenditures. Therefore, both age- and national diversity are added. *Age diversity* is the standard deviation of age in the board of directors, and *national diversity* is the percentage of directors from other nationalities compared to the firms' headquarters nationality.

Industry-fixed effects are added to eliminate time-invariant industry characteristics in all three regressions. *Industry code* is a categorical variable based on the primary codes of the Standard Industry Classification (SIC). The companies are divided into different categories depending on their SIC code. Year-fixed effects are not added in the regression since they will perfectly align with the post-period variable.

3.2 Descriptive statistics

Table 3.1 shows the descriptive statistics of the variables used in this research. The upper part of this table contains the descriptive statistics for the total sample. The middle and bottom parts contain the descriptive statistics for California and the other states. The data sample contains 360 firms headquartered in California and 891 firms from other states. Over the total sample, the average female board representation is 0.21, indicating that the percentage of female board members compared to the total number of board members is, on average in this sample, 21%. The minimum female board representation is 0%, and the maximum is 61.5%. The average female board representation for California is 22%, which is about equal to the average female board representation in the other states, 21%. A board in this sample consists on average of 10 board members with a minimum of 2 and a maximum of 23. The average R&D expenditures of the firms included in this sample are approximately $62 billion. There is a significant difference between the average R&D expenditures for California, $110 billion, and the average R&D expenditures for the other states, $42 billion. An explanation for this difference could be that California is located in the Silicon Valley, the centre for high-tech innovations. The industry that is by far most represented in this research is the Manufacturing industry, followed by the Service Industry.

Table 3.1
Descriptive statistics of the variables

California and other states	**N**	**Mean**	**Sd.**	**Min**	**Max**
Female board representation	1251	.212	.107	0	.615
Number of directors	1251	10.434	2.357	2	23
R&D expenditures	1251	61.555	209.097	0	2215.942
Leverage	937	.334	.184	0	.991
Firm size	1251	3309.546	7020.432	1.717	57337.805
Age diversity	1247	6.97	2.131	0	17.3
Nationality diversity	1228	.176	.212	0	.9
California					
Female board representation	360	.22	.116	0	.615
Number of directors	360	10.681	2.755	5	23
R&D expenditures	360	110.497	285.099	0	1930.228
Leverage	263	.314	.188	0	.991
Firm size	360	3581.329	7362.438	1.863	56065
Age diversity	359	6.897	2.154	1.5	16.7
Nationality diversity	352	.164	.207	0	.9
Other states					
Female board representation	891	.21	.106	0	.591
Number of directors	891	10.432	3.272	2	21
R&D expenditures	891	41.78	165.105	0	2215.942
Leverage	675	.342	.182	0	.932
Firm size	891	3199.734	6878.64	1.717	57337.805
Age diversity	888	7	2.121	0	17.3
Nationality diversity	876	.181	.214	0	.9

4. Methodology

This section elaborates on the empirical methods used to examine the effect of the gender quota in California on the composition of the board of directors and the effect of female board representation on innovation investments.

4.1 Difference-in-difference regressions

To empirically test hypotheses 1 and 2, this research performs multiple ordinary least square specifications in a difference-in-difference model. The multiple linear regression model has several assumptions which need to be satisfied. A critical assumption of linear regression is the absence of endogeneity, which is an important issue related to economic studies and is the case when explanatory variables are correlated with the error term in the regression (Roberts and Whited, 2013). In this research, endogeneity concerns arise as female board representation is not an exogenous variable, meaning that there are several reasons why certain companies assign female board members. In the case of endogeneity, it is not possible to obtain unbiased parameters from the multiple OLS regression as the error term is correlated with the dependent variable and thus with female board representation. To solve this problem, the multiple linear regression will take a difference-in-difference approach, where the gender quota introduced in California will serve as a natural experiment. Another assumption states that all numeric variables should have a normal distribution. The variables firm size and R&D expenditures do not have a normal distribution. Therefore, the natural logarithm of these variables is taken. In addition, an OLS model requires a smooth process for the dependent variable. Figure 1 of Appendix B shows no peak at the value 0 for the variable female board representation, indicating that a difference-in-difference approach within an OLS model is the appropriate model. Another assumption is the absence of multicollinearity among the variables, which is controlled by the correlation matrix in Table 2 of Appendix A. There is no multicollinearity since there is no correlation coefficient of 0.70 or higher, which is the threshold used by many researchers (Tabachnick and Fidell, 2007). Lastly, robust standard errors are added to the regression to avoid heteroskedasticity.

As mentioned above, the multiple linear regression will take a difference-in-difference approach to solve endogeneity. A difference-in-difference model is a model whereby a certain intervention occurs in the population. Hereby, two groups are natural designed: the treatment group exposed to the intervention and the control group not exposed to the intervention.

Suppose the trend of the control group is a valid counterfactual for the treatment group in the absence of the intervention. In that case, the deviation in the trend of the treatment group related to the trend in the control group is the causal impact of the intervention. In this research, the gender quota in California is used as a policy intervention to measure the impact of female board representation on the number of female board members and the board size. A difference-in-difference method has two important assumptions: the parallel trend assumption and the SUTVA assumption (Roberts and Whited, 2013). The parallel trend assumption indicates that the trends of the treatment group, which is California, in the absence of the treatment in the post-intervention period should be parallel to the trend of the control group, which are the other states in the sample. In the sense of this research, it is thus necessary to have similar trends for female board representation and board size before the intervention. However, it is allowed to have different value levels for female board representation and board size, as long as the trends are parallel. The parallel trend assumption is tested by plotting the mean of female board representation and board size against the sample years for both the treatment group and the control group, shown in Figure 4.1 and Figure 4.2. In the pre-treatment period, which is before 2019, both the treated and control companies appear to follow the same trend for both variables. Therefore, the parallel trend assumption holds.

Figure 4.1
Histogram of the variable female board representation for the parallel trend assumption

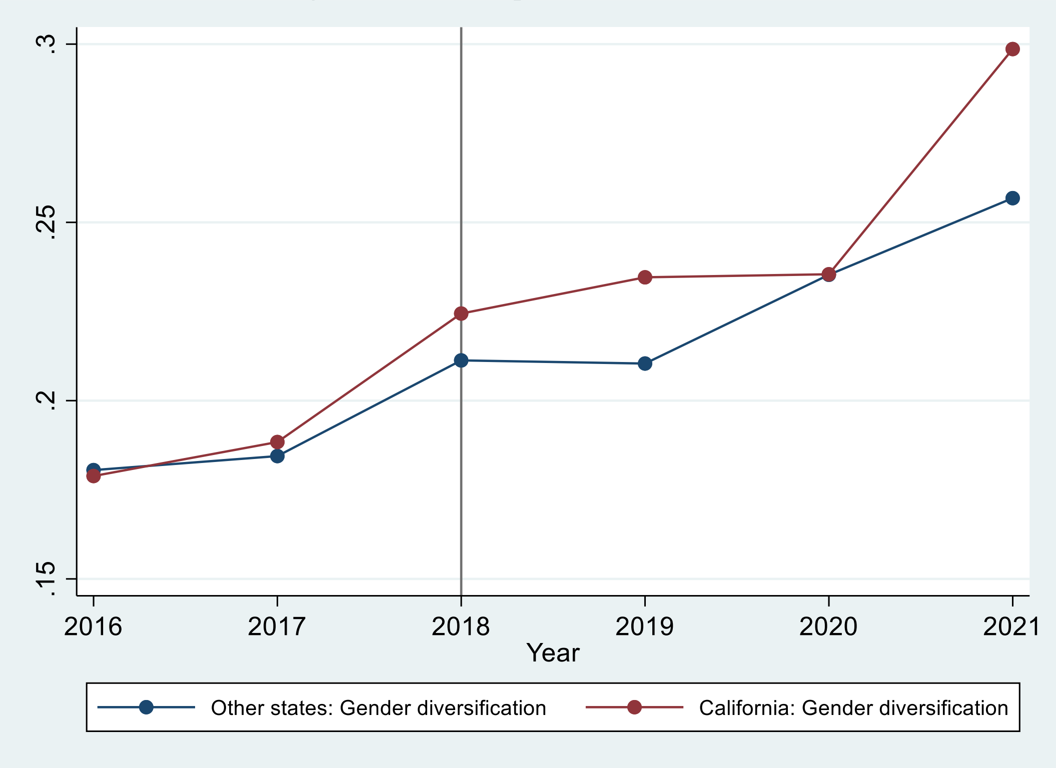
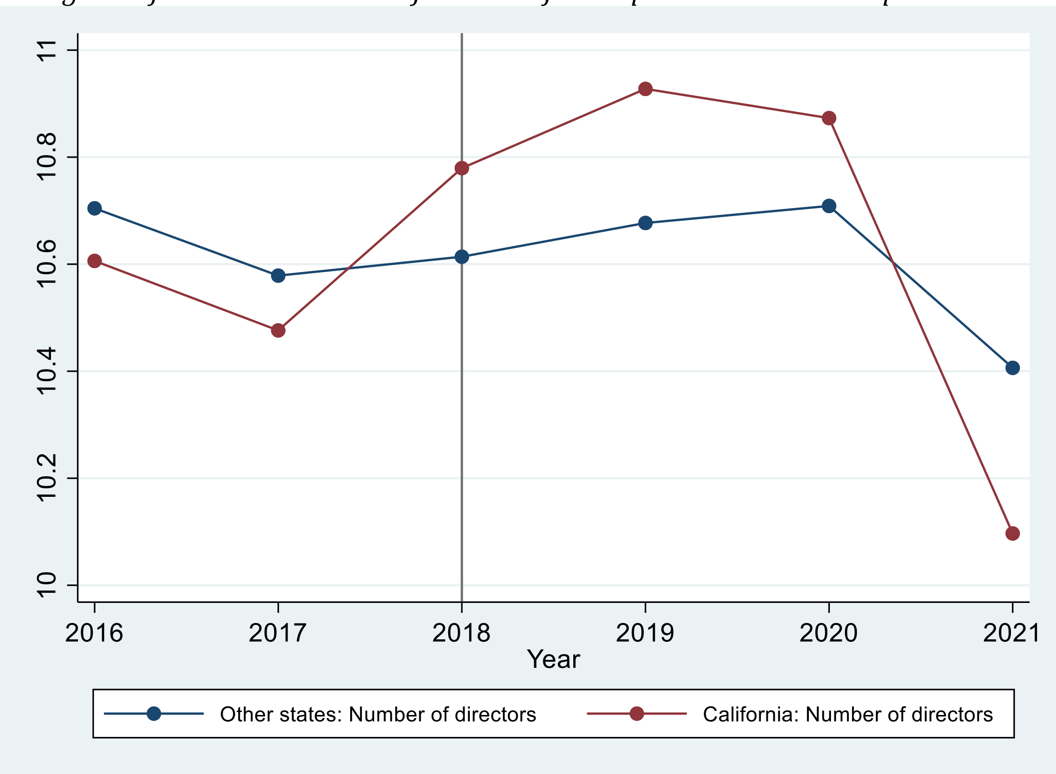


Figure 4.2

Histogram of the variable board of directors for the parallel trend assumption



The SUTVA assumption means that potential outcomes for each firm are unrelated to the treatment status of other firms. It is likely for the SUTVA assumption to hold because the policy intervention of California does not impact firms headquartered in other states. Therefore, a change in policy does not disrupt the entire U.S. and firms will not automatically start adding female board members to respond to the gender quota in California. Furthermore, since the gender quota is introduced on a centralised level, all publicly listed companies with their headquarters in California will experience the same treatment.

Hypothesis 1 examines the effect of the gender quota in California on the percentage of female board members. To analyse whether the gender quota in California will lead to a higher percentage of female board members, the following regression is performed:

$$Female\ board\ representation_{i,t} = \beta_0 + \beta_1 * Treatment + \beta_2 * Post - Period + \delta * Treatment\#Post - Period + I_{i,t} + \varepsilon_{i,t} \quad \text{(Formula 1)}$$

In this regression, the dependent variable is *female board representation*. This variable is obtained by dividing the number of female board members by the total number of board members per board per year. The variable *treatment* equals 1 for California and 0 for other states. The *post-period* variable takes the value 1 for the period after 2018 and 0 otherwise. The interaction variable between *treatment* and *post-period* measures the effect of the policy intervention. β_0 is the baseline average, β_1 is the difference between the treatment group and the control group in the pre-intervention period, β_2 is the time trend in the control group, and δ represents the difference-in-difference estimator and thus indicates the effect of the board gender quota on the number of female board members. Industry-fixed effects are controlled by $I_{i,t}$ and $\varepsilon_{i,t}$ is the regression's error term. The expectation is that the coefficient of the interaction variable between treatment and post-period is positive, which implies that the gender quota in California leads to a higher number of female board members.

Hypothesis 2 studies the relationship between the gender quota in California and the number of board members. The following regression is analysed:

$$Number\ of\ directors_{i,t} = \beta_0 + \beta_1 * Treatment + \beta_2 * Post - Period + \delta * Treatment\#Post - Period + I_{i,t} + \varepsilon_{i,t} \quad \text{(Formula 2)}$$

The initial dataset is an unbalanced panel data set, which means that some companies have gaps in the years of observations. To measure a change in the board of directors throughout the years, the firms in the initial dataset with time gaps are timely excluded from the dataset. The dependent variable is the *number of directors*. The independent variables are equal to the variables in hypothesis 1: *treatment*, *post-period*, and an interaction term between *treatment* and *post-period,* measuring the quota intervention's effect. Since firms often tend to add female board members to the board instead of replacing a male board member with a female board member, it is expected to have a positive coefficient for the interaction term between treatment and post-period.

4.2 Instrumental variable regression

Hypothesis 3 examines the effect of female board representation on innovation investments. There are likely several reasons firms would include female board members on their board. Therefore, it can be stated that female board representation is an endogenous variable, meaning that the variable is correlated with the error term. An instrumental variable regression is performed to estimate a causal effect of female board representation on R&D expenditures. An instrumental variable regression aims to isolate exogenous variation to estimate a causal effect (Roberts and Whited, 2013). The instrumental variable method has two important assumptions. The first assumption is the relevance assumption, implying that the instrumental variable must be correlated with the endogenous variable. The more relevant the instrument, the more variation in female board representation is explained by the instrument. Hypothesis 1 will test whether the instrumental variable, the gender quota in California, is correlated with the endogenous variable, female board representation. In addition, the relevance assumption requires a strong instrument. This is tested by looking at the F-test of the first stage, which must be higher than the threshold of 10. The F-test for the first stage regression with neither control variables nor fixed effects, the first stage regression with control variables, and the first stage regression with both control variables and fixed effects are shown in Table 3 of Appendix A. The different F-tests provide respectively numbers of 14.69, 12.31 and 11.91, which are all three higher than 10. Therefore, the relevance assumption holds. The second assumption is known as the validity assumption, which states that it is not allowed for the instrumental variable to be correlated with other determinants of the dependent variable. In this research, the validity assumption holds when the gender quota in California is uncorrelated with any other unobserved determinants of R&D expenditures. The only direct effect of the gender quota in California is a change in the gender composition of boards, and therefore, it is likely for the validity assumption to hold.

To examine the effect of female board representation on innovation investments, the following regressions are performed:

Stage 1: $Female\ board\ representation_{i,t} = \beta_0 + \beta_1 * Treatment + \beta_2 * Post - Period + \delta * Treatment\#Post - Period + Control\ variables_{i,t} + I_{i,t} + \varepsilon_{i,t}$

(Formula 3)

Stage 2: $R\&D\ expenditures_{i,t} = \beta_0 + \beta_1 * Female\ board\ representation + \beta_2 * Control\ variables_{i,t} + I_{i,t} + \varepsilon_{i,t}$

(Formula 4)

In the first stage regression, female board representation is estimated as a function of the gender quota in California. The first stage regression obtains the predicted values for female board representation. This exogenous variation is used to estimate the effect of female board representation on R&D expenditure and is plugged into the second stage regression. The first stage regression includes all explanatory variables from the second stage. Thus, if neither control variables nor fixed effects are included in the second stage regression, it is also the case for the first-stage regression. In contradiction, if the second stage regression includes control variables and fixed effects, this is also included in the first-stage regression. The regressions with control variables and fixed effects included are shown in formulas 3 and 4. In the second stage regression, the dependent variable is R&D expenditure, and the main variable of interest is female board representation. According to the theory, it is expected to have a positive coefficient for female board representation since female board members could positively affect the innovation investments through their control, service and strategic role. In the formula for the second stage, β_0 is the intercept with the y-axis and β_x is the slope for each coefficient. The control variables added in this regression are leverage, firm size, nationality diversity and age diversity.

5. Results

5.1 Main results

Hypothesis 1 states that the gender quota in California positively affects the percentage of female board members. To test the first hypothesis, the percentage of female board members compared to the total number of board members is regressed on two regression models, shown in Table 5.1. The first model is the regression model without industry-fixed effects. In this model, the percentage of female board members is 5% higher for firms in California exposed to the intervention compared to firms not exposed to the intervention. This is significant at the 1% level. The effect of the interaction variable is approximately the same in model 2, which includes industry fixed effects. These results confirm the rates related to female board members provided by the California Secretary of State (2022) and Gertsberg et al. (2021). Based on the significant interaction coefficients, the first hypothesis cannot be rejected, which means that the gender quota in California has led to an increase in female board members.

Table 5.1

Results of the difference-in-difference model on female board representation

Variables	(1)	(2)
Treatment	.001 (.009)	.001 (.009)
Post-period	.037*** (.007)	.038*** (.007)
Treatment#Post-period	.052*** (.013)	.049*** (.013)
Constant	.193*** (.005)	.21*** (.034)
Industry fixed-effects	No	Yes
Adjusted R^2	0.047	0.051

*Coefficients of the predictor variables included in the difference-in-difference regression, where * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.*

The second hypothesis, which states that the gender quota in California positively affects the number of board directors, examines whether the positive effect of the gender quota on the female board representation comes from adding female board members and, therefore, an increase in board size or whether the increase in female board members comes from the replacement of male board members. The results are shown in Table 5.2, where model 1 is the model without industry fixed effects and model 2 includes industry-fixed effects. In both models, the interaction coefficient between treatment and post-period is positive. The positive coefficients indicate a positive association between the gender quota and the board size. Firms in the sample have thus chosen to comply with the gender quota by expanding the board size instead of replacing male board members. However, hypothesis 2 cannot be accepted or rejected with certainty due to the insignificance. It is thus not possible to conclude whether the positive effect of the gender quota on female board representation is associated with an increase in board size or whether the positive effect of the quota originates from the replacement of male board members for female board members.

Table 5.2
Results of the difference-in-difference model on the number of directors

Variables	(1)	(2)
Treatment	.007	.004
	(.022)	(.021)
Post-period	-.009	-.009
	(.010)	(.011)
Treatment#Post-period	.019	.017
	(.022)	(.021)
Constant	2.177***	2.200***
	(.011)	(.068)
Industry fixed-effects	No	Yes
Adjusted R^2	0.005	0.007

*Coefficients of the predictor variables included in the difference-in-difference regression, where * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.*

The third hypothesis, which states that firms with more female board representation have higher innovation investments, is measured by using an instrumental variable for female board representation. The instrumental variable is the gender quota in California, measured through the three variables *treatment*, *post-period and* an interaction variable between *treatment* and *post-period.* For this hypothesis, R&D expenditure is tested on three regressions, shown in Table 5.3. Model 1 is the IV regression without control variables and industry fixed effects. In model 2, control variables are added, and in model 3, both control variables and industry-fixed effects are added. In model 1, the coefficient for female board representation is 0.276 and significant at the 5% significance level. Since this is a log-level model, an increase in the presence of female board members by one unit increases the R&D expenditures by 31.8%. This is in line with the hypothesis and can be explained from theory based on three different board of director roles. In the controlling role, female board members can add a more long-term orientated view lowering agency problems associated with innovation decisions. This will align the incentives of shareholders and management by focusing on long-term innovation instead of exploitative innovation (Griffin, Li and Xu, 2021). In the service role, female board members have a more extensive network and could bring diversified information, which helps create novel ideas (Terjesen et al., 2009). Lastly, female board members could improve innovation investments through their strategy role by, for example, increasing the capacity to adjust to new business environments (Akkaya and Üstgörül, 2020). When adding the control variables and industry-fixed effects, the female board representation coefficients are no longer significant. The control variable leverage is in models 2 and 3 negative and significant at the 1% significance level, which is not in line with the expectations. In addition, the coefficient for firm size is in both models 2 and 3 positive and significant, which is in line with the expectation since large firms could afford R&D investments on a larger scale than smaller firms.

Table 5.3
Results of the IV regression on R&D expenditures

Variables	(1)	(2)	(3)
Female board representation	.276**	0.145	.206
	(.043)	(.037)	(.036)
Leverage		-2.191***	-1.672***
		(.321)	(.428)
Firm size		.684***	.697***
		(.049)	(.048)
Age diversity		.053	.026
		(.038)	(.037)
Nationality diversity		.195	.091
		(.435)	(.421)
Constant	-.167	-2.49	-2.054
	(.937)	(0.898)	(0.963)
Industry-fixed effects	No	No	Yes
Adjusted R^2	.167	.132	.129

*Coefficients of the predictor variables included in the difference-in-difference regression, where * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.*

5.2 Robustness check

The main result for hypothesis 1 indicates that the gender quota in California positively affects the percentage of female board members. Additional analysis is performed to test the robustness of this result. The data sample is divided into two subsamples: one with firms that had no female board members by 2018 and one with firms that had one or more female board members on their board by 2018. By doing this, a distinction is made between the firms that were not meeting the gender quota before the 2018 introduction and firms that already satisfied the requirement of one female board member. The subsamples are analysed through a multiple OLS regression with a difference-in-difference approach. The results can be obtained from Table 5.4, where model 1 is the subsample with firms not satisfying the quota before 2018 and model 2 relates to the firms having the threshold of 1 female board member by 2018. The results of the robustness check are as follows. In model 1, the interaction variable between treatment and post-period provides a coefficient of 0.07, significant at the 1% significance level. The interaction coefficient in model 2 is 0.02 and significant at the 1% significance level. The increase in female board members in firms where the quota threshold was satisfied before 2018 could be explained by the announcement that in 2021, the gender quota was elaborated, and therefore, a higher number of female board members is required. Firms could decide to plan ahead for this. Another explanation could be that these firms add female directors voluntarily to the board of directors as they realize the value of this. The positive interaction coefficients in both models support the main results and the belief that the gender quota in California positively affects the percentage of female board members.

Table 5.4

Results of the robustness check for hypothesis 1

Variables	(1)	(2)
Treatment	.105	.132
	(.115)	(.103)
Post-period	.587***	.281***
	(.092)	(.007)
Treatment#Post-period	.071***	.015***
	(.016)	(.013)
Constant	2.007***	2.092***
	(.397)	(.374)
Industry fixed-effects	Yes	Yes
Adjusted R^2	0.035	0.029

*Coefficients of the predictor variables included in the difference-in-difference regression, where * indicates significance at 10% level, ** indicates significance at the 5% level and *** indicates significance at the 1% level.*

6. Conclusion and discussion

This study examines the link between female board representation and innovation investments, which is done by using the gender quota in California as a natural experiment. The gender quota requires firms to have at least one female member in the boardroom by December 31, 2019, and by December 31, 2021, to have a minimum number of female board members dependent on the board size. A dataset including S&P 500 firms between 2016 and 2021 is used to determine the effectiveness of the gender quota in California and the relation between female board representation and innovation investments, based on three main variables: female board representation, R&D expenditures, and the interaction variable between treatment and post-period.

The significant findings for hypothesis 1 suggest that the gender quota positively affects the percentage of female board members. Firms in California exposed to the intervention compared to firms from other states not exposed to the intervention have, on average, 5% more female board members on their board. In addition, the robustness check suggests that firms already meeting the gender quota by 2018 also experience a positive influence of the gender quota on the percentage of female board members. This can be explained by firms already anticipating the elaboration of the quota by December 31, 2021, or firms voluntarily adding female board members. Thus, the state of California achieved its goal since the presence of women in the board room is increased. For hypothesis 2, there were no significant findings. Therefore, it is not possible to conclude whether the increase in the percentage of female board members originates from growth in board size or from the replacement of male board members by female board members. Hypothesis 3 states that firms with more female board representation have higher innovation investments. Existing literature provides much support for this hypothesis. Female board members could contribute to a firm's innovation perspective by, for example, their long-term orientation, extensive network, and ability to adjust to new and complex business developments. This research empirically supports a positive effect of female board representation on R&D expenditures. An increase in the presence of female board members by one unit increases the R&D expenditures by 31.8%.

This research faces some limitations. First, the California gender quota only relates to publicly listed firms and does not set requirements for private firms. Therefore, publicly listed firms in California most affected by the gender quota due to having a low number of female board members could delist after 2018. Since the dataset includes firms that are partly included in the

S&P 500 between 2016-2021, it could be the case that firms in California are randomly deleted from the dataset. As a result, the analysis could suffer from a selection bias since the dataset in the pre-treatment period contains firms with lower gender progressiveness than the dataset in the post-treatment period. However, since the maximum fine for firms not meeting the gender quota by December 31, 2019, is $900.000, it is unlikely that firms choose to delist above paying the fine. Especially since there are high requirements to become a public listed company. The second shortcoming of this research is the limited post-treatment period. Although it is possible for firms to easily adjust their R&D expenditures, it could take some time before new female board members influence the amount of R&D expenditures. Having a longer post-treatment period could allow controlling for this gap between the appointment of a female board member and the chance for female board members to make a critical difference in the firm's innovation strategy. The last limitation relates to the relevance assumption of the instrumental variable regression. Since the F-tests provide relatively low numbers, the gender quota in California might not be a really strong instrument. However, the threshold used in many papers is 10, which is below the provided F-statistics of this research.

Despite the limitations, this study has important implications and is a bridge for further research. In this research, empirical evidence is provided of the success of the gender quota in California, which can serve as an advisement for countries or legislators considering implementing a board gender quota. In addition, this research supports the introduced quota in the past period, and justifies the introduction of new rules enhancing board equality. Furthermore, the positive effect of female board representation on R&D expenditures could lead to intrinsic motivation for firms to hire female board members. This study could serve as an inspiration for follow-up research. It could be interesting to examine the effect of the gender quota on other measurements of female contribution in the board room. In the long-term, follow-up research could repeat the examination of the link between female board representation and R&D expenditures with a longer post-treatment period.

References

Adams, R. B., & Ferreira, D. (2009). Women in the boardroom and their impact on governance and performance. *Journal of Financial Economics*, *94*(2), 291-309.

Adams, R. B., & Funk, P. (2012). Beyond the glass ceiling: Does gender matter?. *Management Science*, *58*(2), 219-235.

Ahern, K. R., & Dittmar, A. K. (2012). The changing of the boards: The impact on firm valuation of mandated female board representation. *The Quarterly Journal of Economics*, *127*(1), 137-197.

Akkaya, B., & Üstgörül, S. (2020). Leadership styles and female managers in perspective of agile leadership. *Agile Business Leadership Methods for Industry 4.0*.

Al Anezi, A., & Alansari, B. (2016). Gender differences in Hofstede's cultural dimensions among a Kuwaiti sample. *European Psychiatry, 33*(S1), S503-S504.

Artz, K. W., Norman, P. M., Hatfield, D. E., & Cardinal, L. B. (2010). A longitudinal study of the impact of R&D, patents, and product innovation on firm performance. *Journal of Product Innovation Management*, *27*(5), 725-740.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, *17*(1), 99-120.

Bear, S., Rahman, N., & Post, C. (2010). The impact of board diversity and gender composition on corporate social responsibility and firm reputation. *Journal of Business Ethics*, *97*(2), 207-221.

Burgess, Z., & Tharenou, P. (2002). Women board directors: Characteristics of the few. *Journal of Business Ethics*, *37*(1), 39-49.

Burke, R. J., & Mattis, M. C. (2000). Women on corporate boards of directors: Where do we go from here?. *Women on Corporate Boards of Directors* (pp. 3-10). Springer, Dordrecht.

California Secretary of State. (2022). *Women on Boards.* Retrieved from: https://www.sos.ca.gov/business-programs/women-boards

Campbell, K., & Minguez Vera, A. (2010). Female board appointments and firm valuation: Short and long-term effects. *Journal of Management & Governance, 14*(1), 37-59.

Carter, D.A., Simkins, B.J. and Simpson, W.G. (2003). Corporate Governance, Board Diversity, and Firm Value. *The Financial Review*, *38*, 33–53.

Cassell, C. (1997). The business case for equal opportunities: implications for women in management. *Women in Management Review*.

Casteuble, C., Lepetit, L., & Tran, T. T. (2019). Women on boards: do quotas affect firm performance? *HAL Open Science.*

Catalyst. (2021). *Woman on corporate boards.* Retrieved from: https://www.catalyst.org/research/women-on-corporate-boards/

Chauvin, K. and Hirschey, M., 1993. Advertising, R&D Expenditures and the Market Value of the Firm. *Financial Management, 22*(4), 128-140.

Chen, J., Leung, W. S., Song, W., & Goergen, M. (2019). Why female board representation matters: The role of female directors in reducing male CEO overconfidence. *Journal of Empirical Finance*, *53*, 70-90.

Croson, R., & Gneezy, U. (2009). Gender differences in preferences. *Journal of Economic Literature, 47*(2), 448-74.

De Cabo, R. M., Terjesen, S., Escot, L., & Gimeno, R. (2019). Do 'soft law' board gender quotas work? Evidence from a natural experiment. *European Management Journal*, *37*(5), 611-624.

Dezsö, C.L. and Ross, D.G. (2012), "Does female representation in top management improve firm performance? A panel data investigation", *Strategic Management Journal*, *33*(9), 1072-1089.

Forbes, D. P., & Milliken, F. J. (1999). Cognition and corporate governance: Understanding boards of directors as strategic decision-making groups. *Academy of Management Review*, *24*(3), 489-505.

Galia, F., Zenou, E., & Ingham, M. (2015). Board composition and environmental innovation: does gender diversity matter?. *International Journal of Entrepreneurship and Small Business*, *24*(1), 117-141.

Gertsberg, M., Mollerstrom, J., & Pagel, M. (2021). Gender quotas and support for women in board elections (No. w28463). *National Bureau of Economic Research.*

Gill, M. (2012). *Quotas for women on boards: all the pros and cons in one place.* Retrieved from: https://www.newstatesman.com/business/economics/2012/09/quotas-women-boards-all-pros-and-cons-one-place

Griffin, D., Li, K., & Xu, T. (2021). Board gender diversity and corporate innovation: International evidence. *Journal of Financial and Quantitative Analysis*, *56*(1), 123-154.

Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, *9*(2), 193-206.

Hendry, J. (2002). The principal's other problems: Honest incompetence and the specification of objectives. *Academy of Management Review, 27*(1), 98-113.

Hillman, A.J. and Dalziel, T. (2003), "Boards of directors and firm performance: integrating agency and resource dependence perspectives", *Academy of Management Review, 28*(3), 383-396.

Johnson, A. R.; R. van de Schoot; F. Delmar; and W. D. Crano. "Interpersonal Processes and Team Performance over Time Using Bayesian Model Selection." *Journal of Management, 41* (2015), 574–606.

Kelan, E. K. (2008). The discursive construction of gender in contemporary management literature. *Journal of Business Ethics, 81*(2), 427-445.

Khosa, A. (2017). Independent directors and firm value of group-affiliated firms. *International Journal of Accounting & Information Management*.

Kouloukoui, D., Marinho, M. M. D. O., Gomes, S. M. D. S., de Jong, P., Kiperstok, A., & Torres, E. A. (2020). The impact of the board of directors on business climate change management: case of Brazilian companies. *Mitigation and Adaptation Strategies for Global Change*, *25*(1), 127-147.

Krishnan, H. A., & Park, D. (2005). A few good women—on top management teams. *Journal of Business Research*, *58*(12), 1712-1720.

Lieberman, M. B., & Montgomery, D. B. (1998). First‐mover (dis) advantages: retrospective and link with the resource‐based view. *Strategic Management Journal*, *19*(12), 1111-1125.

Love, J. H., & Ashcroft, B. (1999). Market versus corporate structure in plant-level innovation investments. *Small Business Economics*, *13*(2), 97-109.

Manso, G. (2011). Motivating innovation. *The Journal of Finance*, *66*(5), 1823-1860.

MasterClass (2021). *Why Innovation Is Essential for Business Success.* Retrieved from: https://www.masterclass.com/articles/why-innovation-is-essential-for-business-success#what-does-innovation-mean-in-business

McCabe, A. C., Ingram, R., & Dato-On, M. C. (2006). The business of ethics and gender. *Journal of Business Ethics*, *64*(2), 101-116.

Merchant, N. (2011). *Quotas for women on board are wrong.* Retrieved from: https://hbr.org/2011/09/quotas-for-women-on-boards-are

Naaraayanan, S. L., & Nielsen, K. M. (2020). Winds of Change: Gender Quota on Boards in the face of Patriarchy. *SSRN.*

Ng, T. W., & Feldman, D. C. (2013). A meta‐analysis of the relationships of age and tenure with innovation‐related behaviour. *Journal of Occupational and Organizational Psychology*, *86*(4), 585-616.

Nielsen, S., & Huse, M. (2010). Women directors' contribution to board decision‐making and strategic involvement: The role of equality perception. *European Management Review*, *7*(1), 16-29.

Nielsen, B. B., & Nielsen, S. (2013). Top management team nationality diversity and firm performance: A multilevel study. *Strategic Management Journal*, *34*(3), 373-382.

Nijstad, B. A., Berger-Selman, F., & De Dreu, C. K. (2014). Innovation in top management teams: Minority dissent, transformational leadership, and radical innovations. *European Journal of Work and Organizational Psychology*, *23*(2), 310-322.

Østergaard, C. R., Timmermans, B., & Kristinsson, K. (2011). Does a different view create something new? The effect of employee diversity on innovation. *Research Policy*, *40*(3), 500-509.

Page, S. E. The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies. Princeton, NJ: *Princeton University Press* (2007).

Pfeffer, J. (1991). Organization theory and structural perspectives on management. *Journal of Management*, *17*(4), 789-803.

Pfeffer, J., & Salancik, G. R. (2003). The external control of organizations: A resource dependence perspective. *Stanford University Press.*

Rejeb, W. B., Berraies, S., & Talbi, D. (2019). The contribution of board of directors' roles to ambidextrous innovation: do board's gender diversity and independence matter?. *European Journal of Innovation Management*.

Roberts, M. R., & Whited, T. M. (2013). Endogeneity in empirical corporate finance1. In *Handbook of the Economics of Finance* (Vol. 2, pp. 493-572). Elsevier.

Schultz, T. P. (Ed.). (1995). Investment in women's human capital. *University of Chicago Press.*

Schumpeter, J. (1934). Innovation: The theory of economic development. *Entrepreneurship, Edward Elgar, Cheltenham*.

Silverman, I. W. (2003). Gender differences in delay of gratification: A meta-analysis. *Sex Roles*, *49*(9), 451-463.

Smith, A. (2022. *Patriarachy strikes again with California's women on boards law.* Retrieved from: https://societymaster.online/2022/05/25/abcarian-patriarchy-strikes-again-with-californias-women-on-boards-law/

Stiles, P., & Taylor, B. (2001). Boards at work: How directors view their roles and responsibilities: How directors view their roles and responsibilities. *OUP Oxford.*

Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. (2007). Using multivariate statistics. *MA Pearson*, 481- 498.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509-533.

Terjesen, S., Sealy, R., & Singh, V. (2009). Women directors on corporate boards: A review and research agenda. *Corporate Governance: An International Review*, *17*(3), 320-337.

Thomas, D. (2021). UK boards face pressure to increase female directors under FCA plans. *Financial Times.*

Vadali, S. (2017, 29 December). *Data transformation – Skewness, normalization and much more.* Retrieved from: https://medium.com/@TheDataGyan/day-8-data-transformation-skewnessnormalization-and-much-more-4c144d370e55

Von Meyerinck, F., Niessen-Ruenzi, A., Schmid, M., & Solomon, S. D. (2019). As California goes, so goes the nation? Board gender quotas and the legislation of non-economic values.

Weill, P., & Woerner, S. L. (2015). Thriving in an increasingly digital ecosystem. *Sloan Management Review, 56*(4), 27.

Wincent, J., Anokhin, S., & Örtqvist, D. (2010). Does network board capital matter? A study of innovative performance in strategic SME networks. *Journal of Business Research*, *63*(3), 265-275.

Wu, J. and Wu, Z. (2014), "Integrated risk management and product innovation in China: the moderating role of board of directors", *Technovation*, *34*(8), 466-476.

Xin, K., Sun, Y., Zhang, R., & Liu, X. (2019). Debt financing and technological innovation: Evidence from China. *Journal of Business Economics and Management*, *20*(5), 841-859.

Yermack, D. (1996). Higher market valuation of companies with a small board of directors. *Journal of Financial Economics*, *40*(2), 185-211.

Appendix A

Table A1

Variable description of the variables used in the regression analysis

Variable	Explanation
Female board representation	The percentage of female board members compared to the total number of board members
Number of directors	Indicates the board size
R&D expenditures	all costs incurred during the year related to developing new products or services
Treatment	Takes the value 1 for California and 0 for other states
Post-period	Takes the value 1 for observations after 2018 and 0 otherwise
Leverage	The debt rate measured by the total debt divided by the firm's total assets
Firm size	The size of the firm measured by the firm's total assets
Age diversity	The standard deviation of age in the board of directors
Nationality diversity	The percentage of directors from different countries compared to the headquarters country
Industry	Assigns companies to different industries based on the primary codes of the Standard Industry Classification

Table A2

Correlation matrix of all numeric variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Female board representation	1.000						
(2) Number of directors	0.013	1.000					
(3) R&D expenditures	0.033	-0.010	1.000				
(4) Leverage	0.027	-0.011	-0.309	1.000			
(5) Firm size	0.012	-0.012	0.238	0.034	1.000		
(6) Age diversity	0.017	0.057	0.017	-0.036	-0.009	1.000	
(7) Nationality diversity	0.010	-0.017	-0.017	0.022	-0.008	-0.011	1.000

Table A3

F-test for the first stage regressions on female board representation

Variables	(1)	(2)	(3)
Treatment	.006 (.009)	.004 (.011)	.002 (.01)
Post-period	.039*** (.007)	.042*** (.008)	.042*** (.008)
Treatment#Post-period	.055*** (.011)	.051*** (.011)	.048*** (.011)
Leverage		.004 (.019)	.011 (.02)
Firm size		.000 (.001)	.002 (.001)
Age diversity		.001 (.002)	.001 (.002)
Nationality diversity		-.003 (0.016)	-.005 (.016)
Constant	.192 (.005)	.182 (.017)	.193 (.036)
Industry-fixed effects	No	No	Yes
F-test	14.69	12.31	11.91

Appendix B

Figure B1

Histogram of the variable female board representation