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Cartels, board gender composition and gender quotas

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Abstract
Cartel busting often results in the restructuring of boards of directors, presumably to remove individuals (both executive and non-executive members) who may have been involved in the cartel. This study employs 2 exogenous changes—cartel busting and binding board gender quotas policies—to examine their impact on board gender composition using DiD and Staggered DiD methods. In countries with binding quotas, boards are already undergoing restructuring to include more women, even without the shock of cartel busting. Furthermore, boards increase the percentage of women in non-cartelized firms only when countries introduce binding gender quotas. Binding board gender quota regulations are effective in improving gender balance on corporate boards. Additionally, in countries without binding board gender quotas, only firms sanctioned for cartel conduct show an increase in the percentage of women after cartel busting, compared to non-sanctioned firms. Thus, board gender quota regulations and anti-cartel policies interact to influence the gender composition of sanctioned firms: binding gender policies are effective in achieving more balanced board gender composition, and cartel busting drives more balanced boards in sanctioned firms regardless of whether their countries have binding board quota regulations or not.

Keywords Antitrust · Cartels · Gender · Board gender quota regulations · Corporate boards

JEL Classification L2 · L4 · K42 · J16 · D22

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1 Introduction

The literature on anti-cartel policy enforcement has focused recently on the role of board members, senior managers, and directors in cartel conduct: leniency and whistleblower programs, together with the sanctions to board members, senior managers, and directors, have become effective tools in cartel discovery and prosecution (Shaffer and Nesbitt, 2015; Borrell et al., 2016; Apesteguia et al., 2007; Campello et al., 2017; Beaton-Wells, 2017; Dijkstra & Frisch, 2018).

It is important to bear in mind that behind firms' conduct stand their employees in key positions responsible for making decisions. Indeed, some studies on prosecuted cartels point out that the decision to engage in cartel activities is usually taken by individuals at the very top level of the corporate hierarchy and its implementation and monitoring is relied on lower-level managers (Connor & Lande, 2012; Gallo et al., 2000; Harrington, 2006; Stephan, 2010).[1] Harrington (2020) shows that board of directors, the main executives in the board (Executive Chairperson or CEO), top executive senior managers, and even junior management may have different roles in coordinating prices with competitors. As Harrington (2020) argues, "senior managers do not coordinate on final prices but rather prices that influence final prices".

Therefore, a better understanding of the role of corporate board members is crucial to find means to prevent and detect anticompetitive decisions taken within the top corporate decision-taking and management bodies. And one of the factors that may affect cartel activity is the gender composition on corporate boards.

There is a growing literature that shows that there seems to be gender differences particularly in the average response of women/men when they face risk situations. This differential response is critical for the board's decision-making process. Although evidence is somewhat mixed, some studies show that women are, on average, more risk averse than men (Eckel & Grossman, 2002; Jianakoplos & Bernasek, 1998), more receptive to moral and ethical norms (Gerasymenko, 2018), and more prone to whistleblowing (Brabeck, 1984; Miethe & Rothschild, 1994). There is already evidence on the impact of gender diversity on corporate decision making showing that the increase of women on senior management positions increases firms' performance (see, for instance, Adler, 2001; Carter et al., 2003; Terjesen et al., 2016; and Bennett et al., 2020) and decreases illegal activities such as financial misconduct and corruption (Arnaboldi et al., 2021; Wahid, 2019).

These gender differences have encouraged research analyzing board gender diversity, and the impact of measures aimed at improving it, such as regulatory policies on board gender composition, and the introduction of board gender quotas around the world. In Europe 2 different gender quota regulations have been implemented: binding or mandatory legislative measures (i.e., quotas with sanctions for non-compliance) and non-binding legislative measures (i.e., quotas with no sanctions

[1] Those top managers are characterized by having certain discretionary powers in corporate decision making on market strategies. They are liable for competition infringement either for being personally involved in the working of the cartel or for being aware of and allowing those illegal activities to take place.

or simply recommendations). Studies on the impact of gender quotas regulations have especially focused on how their effects on the gender composition of corporate boards affect firms' performance, reaching mixed evidence (Ahern & Dittmar, 2012; Eckbo et al., 2022; Fedorets et al., 2019; Ferrari et al., 2022; Soare et al., 2022).

This paper aims to analyze whether the interaction between anti-cartel policies and gender quota regulations lead to greater board gender diversity. In order to do so, we exploit 2 exogenous shocks, such as cartel busting, which is usually followed by board restructuring, and the implementation date of the gender quota regulations, to analyze whether more women are incorporated to the board of directors.

To address these questions, we use a database of sanctioned firms in European cartels, formed and broken between 2010 and 2019, from Connor (2020). For each cartelized firm in our sample, we identified and collected information of a similar firm with no evidence of participation in any cartel during the period under consideration, as part of our empirical strategy. We refer to these as "non-cartelized firms". The main advantages of this database are twofold: on the one hand, we have been able to gather information on the gender composition of the board of directors of these firms for each year; and on the other hand, it comprises firms from different European countries, thus providing variation in the gender quota policies implemented across these countries.

Specifically, considering the available information regarding the composition of the boards of directors and the type of gender quota implemented in the countries to which the companies in the sample belong, our analysis focuses, whenever possible,[2] on the gender composition of the supervisory board. This decision is supported by the fact that a large number of gender quota regulations in the countries included in the sample apply exclusively to the supervisory board and not to the executive board. Furthermore, although it is true that the executive board is more likely to be closely linked to cartel behavior than the supervisory board, this does not necessarily absolve the supervisory board of responsibility, either for also participating in the behavior or, if they did not, for neglecting to prevent it, thereby failing in their assigned duties within the company.

Concerning this matter, the literature findings, such as the positive impact of gender diversity on boards' monitoring ability (Adams & Ferreira, 2009; Wahid, 2019), or on the frequency of misconduct fines imposed on firms in some white-collar crimes (Arnaboldi et al., 2021), may have been embodied within the corporate organization of companies when making changes to their boards.

Using all this information, we empirically analyze 2 main questions: (i) how cartel busting impacts the gender composition of the boards of directors; (ii) the effect of binding and non-binding gender quota regulations on board gender composition, and their interaction with the cartel busting shock.

[2] It is important to highlight that in those countries in the sample, such as Spain or the United Kingdom, where companies traditionally have a "one-tier" corporate structure, which does not distinguish between the supervisory and executive board, we have opted to consider the effect on the corporate board understood as a single, monolithic entity.

We find strong evidence that binding gender quotas drive an increase in the percentage of women on corporate boards, resulting in a non-significant difference between cartelized sanctioned firms after cartel busting and non-cartelized matched firms in the same period. Additionally, we find causal evidence that cartel busting leads to a statistically significant difference in the percentage of women on corporate boards between cartelized sanctioned firms and non-cartelized firms in countries with non-binding gender quotas. Specifically, cartel busting substantially enhances the presence of women on corporate boards of cartelized firms compared to their non-cartelized matched firms. This effect may reflect sanctioned firms' efforts to decrease illegal activities (Arnaboldi et al., 2021; Wahid, 2019) and/or to improve their reputation by increasing female representation on their boards, as suggested by the literature (Brammer et al., 2009; Fleitas-Castillo, 2024; Navarro-García et al., 2022).

Finally, when comparing sanctioned cartelized firms from countries with binding gender quotas to those from countries with non-binding quotas, our results indicate no significant differences in board gender composition. However, significant differences emerge when comparing non-cartelized firms between these groups of countries. In the former case, the percentage of women on corporate boards increases either due to the binding policy or as a result of cartel busting. In contrast, in the latter case, the binding policy appears to be the primary driver. Thus, we conclude that binding gender quotas and anti-cartel policies interact to influence the gender composition of sanctioned firms' corporate boards.

2 Literature review

2.1 Corporate board and antitrust enforcement

Modern anti-cartel enforcement has introduced mechanisms aimed to change the structure of incentives at the source of the cartel behavior and individuals within the corporate structure such as board members, senior managers, and directors engaged in cartel activity.

Leniency and whistleblower programs, together with the individual sanctions to firms' employees held liable for playing a key role in cartel organization and performance, have become effective tools in cartel discovery, prosecution and play a key role of antitrust effectiveness (Aubert et al., 2006; Borrell et al., 2014; Apesteguia et al., 2007; Dijkstra & Frisch, 2018; Caliskan, 2019).

Given the crucial role individuals play in cartel formation and operation, the advisability of imposing criminal sanctions on individuals responsible for the cartel behavior is increasingly a topic of research (Beaton-Wells, 2017; Borrell et al., 2016; Ginsburg & Wright, 2010; Shaffer & Nesbitt, 2011).

Some recent studies indicate that cartel sanctions lead to restructuring management positions (Artiga González et al., 2019; Campello et al., 2017; Rosenboom, 2012). In the case of Rosenboom (2012), the author shows that Dutch managers involved in cartel conduct experience negative effects on their career development,

finding a lower probability of getting a representative function[3] at the same company or another, after cartel prosecution.[4]

Campello et al. (2017) provide empirical evidence that U.S.-based companies involved in international cartels with a higher proportion of independent directors on the board are more likely to cooperate with authorities under leniency programs, but these independent directors are also more likely to lose their board positions if the firm is sanctioned for cartel conduct.

Artiga González et al. (2019), using listed U.S. cartel firms, find that top corporate senior managers would see benefits in terms of job security or revenues if they participate in cartel behavior; and cartel sanctioned companies are more reluctant to replace exiting directors. In fact, the involvement of senior managers in cartel activities could be interpreted as a poor performance or lack of compliance with the corporate board's obligations.

2.2 Gender, crimes and firms' performance

Research on gender and white-collar crime highlights that a smaller number of women compared to men are usually involved in this type of crime (Benson, 2021; Daly, 1989; Holtfreter, 2015; Steffensmeier & Allan, 2000). Women's under-representation is more acute in "high level" corporate crime (Davies, 2003; Steffensmeier et al., 2013).[5] Two different non-exclusive broad perspectives have been considered in the literature to explain the observed gender gap in white-collar crime (Benson & Harbinson, 2020).

One perspective emphasizes gender-based sociological mean differences that makes it more unlikely for women to engage in illegal behavior in comparison to men. Some studies show that women, on average, are more risk averse than men (Eckel & Grossman, 2002; Jianakoplos & Bernasek, 1998), although other recent studies provide mixed evidence on this relationship (Eckel & Grossman, 2008; Filippin & Crosetto, 2016). Regarding the former, Damgaard et al. (2011) provide experimental evidence that the manager's decision on whether to participate in a cartel or not depends, not only on financial incentives, but also on the degree of risk aversion and social preferences to minimize costs to other people in the economy.[6]

From the point of view of ethics, UNIFEM (2008) and Gerasymenko (2018) found that women are more receptive to moral and ethical norms on average,

[3] Rosenboom (2012) defines a representative job as a management function or a function in the board of directors.

[4] She uses a sample of cartel-involved firms sanctioned by the Dutch Competition Authority.

[5] There is a generally accepted view that white-collar crime can be classified into occupational crime and corporate crime. Occupational crime is the type of crime for personal benefit of the employee or group of employees committing the crime and does not benefit the firm at all. Corporate crime are those crimes committed by or on behalf of the firm to increase profits which can benefit both the firm and its shareholders.

[6] Grosch and Rau (2017) focus on a situation where dishonest behaviour pays off at somebody else's cost and experimentally show that women are significantly more honest and have higher social value orientation tendencies than men.

showing more empathy, generosity and less prone to risky behaviors (see also Fehr et al., 2006; or Croson & Gneezy, 2009). Feldman and Lobel (2010) state that women are more likely, on average, to report corporate misconduct or misconduct related to financial fraud to law enforcement. In the same vein, Brabeck (1984) and Miethe and Rothschild, (1994) suggest that women are, on average, more prone to whistleblowing.

Numerous papers have shown that firms that have more women than men as board members perform better (see, for instance, Adler, 2001; Carter et al., 2003; Terjesen et al., 2016; and Bennett et al., 2020). Some authors point out that the improvement in firm's performance would be explained by more effort spent on monitoring tasks in firms where women hold board positions (see, for instance, Campbell & Mínguez-Vera, 2008; Adams & Ferreira, 2009; and Post & Byron, 2015).

The meta-analysis by Post and Byron (2015) studies the relationship between female board representation and 2 types of measures of firm financial performance: accounting-based measures[7] and market-based measures.[8] They find that there is a clear positive relationship of female board representation with accounting-based measures of better firm performance and with the fulfillment of boards' 2 primary responsibilities.

Wahid's (2019) findings support the hypothesis that firms with gender-diverse boards commit fewer financial reporting mistakes and engage in less fraud because of the positive impact of gender diversity on boards' monitoring ability. Nevertheless, they also find a nonlinear relationship between board gender diversity and their ability to monitor management and, specifically, control potential financial misconduct. More recently, Arnaboldi et al. (2021) find that a larger presence of women on boards of directors of European listed banks reduces the frequency of misconduct fines imposed on them by all U.S. regulators.

Also, Fleitas-Castillo et al. (2024) find an inverted U-shaped relationship between female directors and corporate social irresponsibility (CSI), using a sample of Spanish listed non-financial firms for the period 2014–2022. The authors find that dominant owners might appoint a small number of female directors symbolically to create a 'halo effect' or to enhance their public image and divert attention away from CSI episodes.[9] However, the appointment of a critical mass of female directors does evidence dominant owner commitment to move away from irresponsible corporate practices. Another perspective in criminology stresses that there is a lack of opportunities for women to get involved in white-collar crimes (Benson & Simpson, 2018; Dodge, 2009). Women have historically been excluded from occupying high level corporate positions. They have therefore had fewer opportunities than men to commit certain types of corporate crime, such as cartels, which involve the participation

[7] This category includes measures such as return on assets, return on equity, employee productivity, and return on invested capital.

[8] This category includes measures such as market-to-book ratio, Tobin's Q, stock performance, and shareholder returns.

[9] Brammer et al. (2009) and Navarro-García et al. (2022) find evidence of a corporate reputation effect associated with a female presence on boards.

of top-level managers. Under this approach, women do not necessarily have to be more risk averse, more moral, or ethical than men. Thus, the achievement of gender parity at top level management positions could close the gender gap in white-collar crime involvement rather than deter such type of crime.

2.3 Corporate board and gender quota regulations

Promoting unbiased selection procedures and increasing corporate board diversity have recently become a major priority for most governments and international institutions. Females share of seats on boards of directors of publicly listed companies hosted in OECD countries only increased slightly from 16.8% in 2013 to 20% in 2016 (OECD, 2017). In fact, Tyrowicz et al. (2020) point out that there are no women on approximately 70% of the European companies' supervisory boards, and 60% of their management boards.

The improvements in women's participation in firm's decision-making positions, even though it has not generally been very important, are most probably linked to the impact of regulatory policies on board gender composition, and the introduction of board gender quotas in many countries. The application of these policies, when necessary and effective, would affect the corporate boards' composition and, therefore, could affect their decisions on whether or not to engage in cartel behavior.

As previously noted, 2 different gender quota policies have been implemented in Europe: binding legislative measures (i.e., quotas with sanctions for non-compliance) and non-binding legislative measures (i.e., quotas with no sanctions or simply recommendations). Norway was the first country to introduce a 40% female mandatory quota in 2003, for compliance by 2006 for state-owned firms and 2008 for publicly traded firms. It is followed by Spain, which adopted a non-binding voluntary board gender quota in 2007. Many other European countries, including Finland, Iceland, France, Belgium, Italy, the Netherlands, and more recently Germany, Portugal, and Austria, have introduced gender board quotas.

Understanding the corporate system within a country is essential for assessing the impact and scope of quota regulations. The literature on corporate governance usually differentiates between one-tier and 2-tier, or monolithic and dualistic corporate structures. One-tier systems are frequently identified within Anglo-Saxon contexts, where executive and non-executive boards form a single joint board. Conversely, the dualistic board model is prevalent in continental Europe, as observed in Germany. Within 2-tier systems, executive and non-executive boards maintain strict separation (Gabaldon et al., 2017).

Thus, the typical 2-tier corporate system of some countries allows them to prescribe quota regulations that refer to supervisory boards only (e.g., Austria, Norway, Iceland, France, and Germany), while others with a one-tier system establish a gender quota for both supervisory and executive boards (e.g., Italy, Portugal, the United Kingdom, and Spain). The studies on the impact of mandatory gender quotas on firms' financial performance provide mixed results. Ahern and Dittmar (2012) show a significant negative effect on firm value and new less experienced women directors

led to a decline in operating performance. However, Eckbo et al. (2022) show that the findings by Ahern and Dittmar are not robust.

Soare et al. (2022) estimate, using a difference-in-difference approach, the effects of the implementation of a gender quota for Belgian listed companies. They find that the increase in gender diversity appears to negatively affect firm performance.

Ferrari et al. (2022) show that the Italian law improved the quality of the board directors and companies' governance, but they do not find any significant effect on firms' performance. Fedorets et al. (2019) find a significant effect of the German quota on the share of women on the supervisory boards affected by the quota law, but no effect on the rate of women serving on the management board which is not affected by the quota obligations. Furthermore, they do not find a negative effect of gender quota on firm financial performance.

Casaca et al. (2022) analyze the first stage of the gender quota law in Portugal, by providing a comparative portrait of the profile of men and women in the boardrooms of listed company. The authors find out that men and women appointed as board members after the mandated gender quota law are similar in professional attributes, forming a more homogeneous boardroom.

There are other authors that study the impact of non-mandatory gender quota regulations on board diversity. Both Mateos de Cabo et al. (2019) and Conde-Ruiz et al. (2020), focusing on the Spanish case, indicate that general lack of commitment of government and firms for implementing non-binding gender quota measures has yielded worse gender parity results than other countries with mandatory gender quotas.

Bennouri et al. (2020) use a difference-in-difference approach to analyze the impact of binding vs non-binding gender quotas regulation. They study the boards of 2 countries with mandatory regimes (France and Italy) and one with an advisory regime (United Kingdom). Their results show that both the share of women on corporate boards and the quality of the board, interpreted as the evolution of several indicators, increase more under mandatory regime than under advisory one.

2.4 Gender and collusion

However, there is a gap in research on how public policies should consider gender issues when designing enforcement tools, specifically in competition policy (see Santacreu-Vasut & Pike, 2019). In fact, there are few studies that consider the relationship between gender and cartel involvement. A pioneering study by Hamaguchi et al (2009) includes gender information on each subject participating in laboratory experiments as a proxy of social background to evaluate the impact of several versions of leniency programs on collusive agreements. Their results indicate that fewer men dissolved their cartels than women.

Boulu-Reshef and Monnier-Schlumberger (2019) also provide experimental evidence that females are less prone to accept collusive agreements than males. However, gender differences and risk aversion do not affect the behavior of a subsample of those individuals who are most likely to form a cartel, called "hotheads" (cartel formation rate greater than 70%). They find that "hotheads" are

less sensitive to fines than the other subjects and advocate for developing instruments that contribute to excluding them from key decision-making bodies, such as the disqualification of company "hotheads" directors for a long period. Haucap et al. (2024) experimentally analyze gender differences in situations where individuals could cooperate at the cost of an external and passive third party. Their results show that women cooperate significantly less than men when outsiders are harmed. This effect is driven by women who are averse to guilt and shame. Additionally, men are significantly less cooperative when aware that their interaction partner is female. These findings suggest that increasing the representation of women in management positions may contribute to reducing harmful cooperative practices, such as cartels.

Christopher and Andrews (2018) calculate the share of women involved in cartel conduct in a database of cartel cases prosecuted by the Australian competition authority and international cartel cases from Connor's data set (Connor, 2020). They find that only the 4.4% of 1,023 individuals included in the consolidated database were women. Abate and Brunelle (2022) explore how male-dominated informal networks, or "boys' clubs", influence cartel formation and maintenance across industries. Analyzing 50 cartel decisions by the French competition authority and conducting a literature review, they establish a correlation between the prevalence of "boys' clubs" in various economic sectors and cartel conduct. Women participating in cartels are likely to have minor "outsiders" roles; only 1.69% of their sample's full cartel members were women. Haucap and Heldman (2023) analyze 15 cartels fined by the German competition authority, focusing on the personal characteristics of cartel members, cartels' communication methods and frequency, and internal organizational structures. Their findings reveal that cartel members display high homogeneity and often depend on existing industry networks. Notably, among the 158 individuals involved in these 15 cartels, only 2 were female, suggesting a gender-related factor in cartel formation.

As far as we know, there is only one empirical paper, Alawi (2018), that shows firms engaging in cartels sanctioned in the UK had less women in executive and board positions than other similar firms (mean difference comparison).

There is still a gap in the literature aimed at identifying and quantifying econometrically how the presence of women on corporate boards changes over the lifespan of cartels in countries with binding and non-binding gender quota regulations. This study aims to address this gap by analyzing the effects of anti-cartel policies and gender quota regulations on women's participation in corporate boards, while considering the potential interplay between these policies. The focus is on identifying how these policies influence the percentage of women on corporate boards and exploring any interaction between them that contributes to changes in gender composition on corporate boards. To achieve this, the composition of boards of directors of companies sanctioned for cartel agreements (treatment group) and their evolution is compared to boards of firms that have not been sanctioned for cartel participation (comparison group). This approach enables causal identification of the impact of anti-cartel enforcement and gender quota regulations on gender board composition.

3 Database and descriptive analysis

To explore how anti-cartel policies and gender quotas impact the gender composition of the boards of directors, we have worked with a dataset composed by European firms sanctioned by different competition authorities, due to their engagement in cartel cases, fromConnor (2020).[10] Concretely, our database contains:

i) Data on European firms that have engaged in cartel activity (and have been sanctioned) since 2010. We have only been able to track back information on firm corporate board members' gender for European firms for the last 10–11 years. So, starting from 449 international firms that have engaged in cartel activity since 2010, we selected a random subsample of 52 cartelized European firms for which we have been able to obtain the relevant information explained hereafter. The maximum cartel duration in our sample is 6 years and the average cartel duration is about 2.5 years.
ii) Firms' financial information using the AMADEUS/ORBIS database (Bureau Van Dijk): operating revenues, total assets, long-term debt, leverage, number of employees and average cost by employee.
iii) For each cartelized firm we have looked for a similar *non-cartelized* firm based on its operating revenues in 2019, the country and the NACE sector. These mirror non-cartelized firms are artificially assigned the same cartel period as the cartelized firm for which they are being used as a comparison firm.
iv) We have manually collected from each firm website or annual reports information about the gender composition of the boards of directors for all those selected (cartelized) and matched firms (non-cartelized firms). As previously mentioned, based on the available information regarding the composition of boards of directors and the type of gender quota implemented in the countries where sample companies are headquartered, our analysis primarily focuses on the gender composition of supervisory boards. In cases where there is a one-tier or unitary board structure and data do not distinguish between executive and supervisory board members, we consider the gender composition of the boards as a whole.

One question to highlight is that we consider the firm to be non-cartelized if it has never been sanctioned by a competition authority due to a cartel case. Some firms in the comparison group may have also been engaged in covered cartel activity but have never been discovered nor sanctioned. This makes our task of estimating the interaction of gender composition and cartel activity more difficult, as the estimates may be downward biased if firms in the comparison group have effectively engaged in, but never sanctioned for, cartel activities. Our estimates will then factor in the effect of being effectively caught and sanctioned as a cartel member, compared to not being caught and sanctioned.

[10] Further information available at: https://purr.purdue.edu/publications/2732/2

We end up with an unbalanced panel data of around 40 to 50 firms per group (cartelized and non-cartelized firms), depending on the year, from 2010 to 2019. In our analysis, we compare the gender composition in supervisory boards (or one-tier boards, when applicable) of cartelized firms, with respect to their counterpart. We also analyze how the boards of these 2 groups compare before, during and after the cartel period.

Table 1 shows that cartelized and matched firms significantly differ at the mean covariates of operating revenues, total assets, long term debt, leverage and number of employees when considering the whole sample period. These differences may be explained partially by the participation in the cartel. In any case, we control for these differences using covariates not only when estimating the equation models but also in the descriptive analysis. These differences are slightly smaller when looking at the first period of the sample (year 2010, see Table 6 at Appendix).

Our main variable of interest is the presence of women on supervisory boards of directors (or on corporate boards in the case of a one-tier board structure), measured as the number of women over the total number of members on the respective boards in any given year. Figure 1a shows the average percentage of women on the corresponding boards of directors over time during the period 2010–2019, for the cartelized and non-cartelized firms included in our sample.

On average, the percentage of women on European supervisory boards (including entire corporate boards where applicable) has increased from around 12% in 2010 to around 32% by 2019. Thus, the presence of women on corporate boards has shown a clear increasing trend during the 2010–2019 period. Additionally, we can examine whether this trend differs for cartelized and non-cartelized firms. In cartelized firms, the percentage of women on these boards has increased from

Table 1 Descriptive statistics of the European database. *Source* Authors' own elaboration

Covariates	Obs	*Cartelized firms*		*Non-cartelized firms*		Mean Differences *t-test* (Cartelized vs non-cartelized firms)
		Mean	Std. Dev	Mean	Std. Dev	
% women on boards	870	0.23	0.12	0.19	0.14	**0.04*** **
# women on boards	870	3.26	1.92	2.35	1.91	**0.91*** **
# board members	870	14.16	3.73	11.22	3.94	**2.93*** **
Operating revenues	870	31,300,000	50,100,000	12,500,000	17,400,000	**18,700,000*** **
Total assets	870	109,000,000	232,000,000	18,600,000	34,600,000	**90,900,000*** **
# employees	870	101,722	122,306.6	43,233.11	58,409.36	**58,488.9*** **
Long-term debt	801	10,900,000	16,400,000	3,132,070	8,259,982	**7,766,644*** **
Leverage	786	118.94	112.78	112.26	129.87	**6.68**
Avg. cost per employee	777	72.34	69.74	68.47	43.87	**3.87**

t-test compares treated versus control firms

Obs, Observations; *Std. Dev*., Standard Deviation; *Min*, minimum; *Max*, maximum

*$p<0.10$, **$p<0.05$, ***$p<0.01$

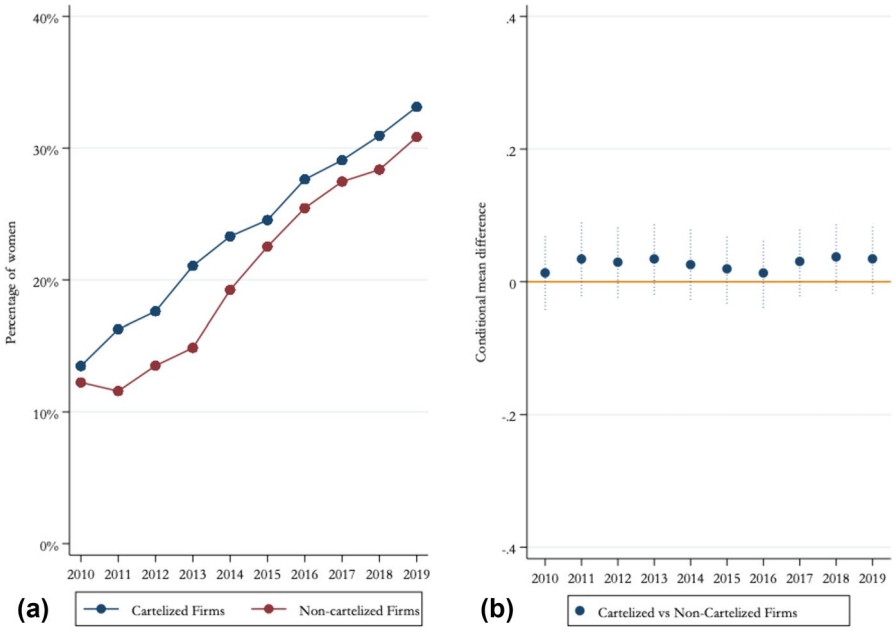

Fig. 1 Presence of women on boards in cartelized and non-cartelized firms over time. *Note* **a** (left) represents the average presence of women on boards by type of firm (cartelized vs non-cartelized firms).**b** (right) depicts the conditional mean differences in the presence of women on boards in cartelized versus non-cartelized firms. *Source* Authors' own elaboration

12.5% in 2010 to 33.9% in 2019, while in non-cartelized firms, these figures have increased from 11.4% to 30%.

While the presence of women seems to be slightly higher in cartelized firms than in non-cartelized firms, we check whether this difference is statistically significant or not in Fig. 1b. We find that the mean difference in the share of women on analyzed boards is not statistically significant when comparing European cartelized versus non-cartelized firms by year.[11]

The question of interest is to know how the presence of women on boards of directors of cartelized firms changes over the cartel life, whether there exist differences with respect to non-cartelized firms. Thus, Fig. 2 below shows the percentage of women on boards for cartelized and for non-cartelized firms for each period before, during and after the cartelization period, and the conditional mean difference between the 2 groups for each period.[12] [13]

[11] These differences have been estimated using a regression including firms' characteristics and country fixed effects as controls.

[12] Not all cartels last for all the periods represented nor do we have information for all the periods before or after cartelization, so there is sample attrition as the number of periods increases.

[13] These differences have been estimated using a regression including country fixed effects and firms' characteristics as controls.

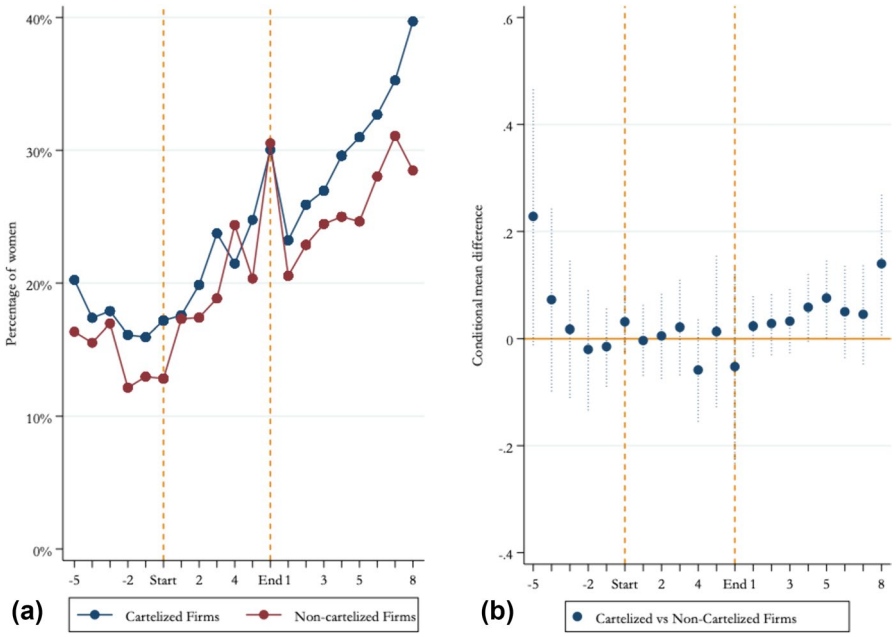

Fig. 2 Presence of women on boards in cartelized and non-cartelized firms over cartel life. *Note* **a** (left) represents the average presence of women on boards by type of firm and cartel life. **b** (right) depicts the conditional mean differences in the presence of women on boards in cartelized versus non-cartelized firms over the cartel period. *Source* Authors' own elaboration

It should be noted that cartel breakup date refers to the earliest of these events: cartel breakup date identified by competition authorities, or when competition authorities provide notice of the investigation to the alleged cartel participants that drives the final stage to the breakup of cartels. We are interested in analyzing whether having information coming internally from the cartel break up or externally from the authority's investigation notice may have an impact on the composition of the board. Looking at the early stage of cartel breakup or disclosure of cartel engagement will allow us to assess whether this information has any short-run or long-run impact on corporate board gender composition.

Figure 2 shows that when analyzing the cartel life, the presence of women is similar in both groups of firms before the cartel starts; while during the cartel period, the presence of women increases in both groups. However, after the cartel breakup, the presence of women is higher in the group of cartelized firms than in the group of non-cartelized firms. These differences between the 2 groups are not statistically significant in most of the cases before the cartel starts nor during the cartel period. By contrast, some weak significant mean differences are found after the cartel breakup, which indicates that cartelized firms have a higher presence of women on boards than non-cartelized firms just after breakup or disclosure.

Thus, this graphical analysis shows that statistically significant differences in the percentage of women on the boards of firms that engaged in cartels and were sanctioned appear only after the cartel is busted and ended, not before or during

cartel engagement. Therefore, there exist differences in the gender composition of boards after cartel investigation is publicly announced or the cartel breaks up: cartelized firms have more women on boards after the cartel is busted, compared to non-cartelized firms. Our result is related to the recent studies discussed earlier that identified that cartel sanctions lead to management restructuring.

The driver explaining the increase in the presence of women on boards over time could be the implementation of target quotas in the countries of our sample. Bennouri et al. (2020) show that while the percentage of women on boards generally increases after the introduction of the regulation, this effect is stronger in mandatory regimes.

As we have exposed before, 2 different types of gender quota policies have been implemented in Europe: binding legislative measures (quotas with sanctions) and non-binding legislative measures (quotas with no sanctions or simply recommendations).

Concretely, regarding the countries included in our sample, there exists binding quotas of minimum percentage of women on corporate boards in France (2014, 2017), Italy (2015), Germany (2016), Belgium (2017), Portugal (2018 and 2020) and Austria (2018), where the years in brackets represent the target compliance year. On the contrary, targets are non-binding in Spain (2015), United Kingdom (2015 and 2020) and Sweden, where again the years in brackets represent the target compliance year when they were stipulated.

However, the regulations were passed in: Sweden in 2005; Spain in 2006 and 2007; Belgium in 2009 and 2011; Germany in 2010 and 2015; France in 2010 and 2011; Italy in 2011; United Kingdom in 2011 and 2015; Portugal and Austria in 2017. While there was no gender policy in Switzerland in the period 2010–2019.[14] In fact, average quotas (binding and non-binding) in our European firms' database, calculated according to countries' target compliance year, have increased from 0% in 2010 to close to 30% in 2019.

Table 2 provides detailed information on the binding nature of quota regulations, the dates of their approval and compliance, as well as the boards and firms affected by these regulations, subject to specific criteria, for each country in our sample (see also Table 7 at Appendix for more details).

It is important to note that we have consistently controlled for all relevant specifications of the quota regulations from the countries in which the firms included in our sample are based, both when building our sample and in our empirical analysis.[15] As mentioned before, we focus our analysis on supervisory boards and one-tier boards (when applicable).

Figure 3 includes the presence of women on boards but differentiating between boards affected by binding quota regulation and those not affected. It can be seen

[14] Regulation passed in September 2020, and compliance year is 2021. Switzerland is treated as a non-binding quota country for our purposes, although results do not change significantly when excluded from the sample.

[15] In accordance with the criteria determining which firms would be subject to gender quota regulations, some firms in our sample, both cartelized and non-cartelized, would not be subject to binding regulations if they do not meet the required criteria. These firms have been excluded from the sample.

Table 2 Quota Regulation specifics for each sample country

Country	Binding	Regulation year	Compliance year	Affected boards	Affected companies
Austria	Yes	2017 †	2018	Supervisory boards	Listed companies and companies with over 1000 employees whose boards consist of at least six seats
Belgium	Yes	2009* and 2011 †	2017	Boards of directors in a one-tier system (more usual system in Belgium) and supervisory boards only in a 2-tier system	Listed and state-owned companies
France	Yes	2010* and 2011 †	2014 and 2017	Non-executive directors	Listed companies and non-listed companies with revenues or total assets over 50 million euros, or employing at least 500 persons for 3 consecutive years
Germany	Yes	2010* and 2015 †	2016	Supervisory boards	Listed companies to which full co-determination law applies (more than 2000 employees)/Companies that are either listed or fully co-determined
Italy	Yes	2011 †	2015	Both executive and supervisory boards	Listed and state-owned companies
Portugal	Yes	2017 †	2018 and 2020	Both executive and supervisory boards	Listed and state-owned companies
Spain	No	2006‡ and 2007 †	2015	Boards of directors (one-tier board structure)	Listed and state-owned companies. Large companies (more than 250 employees and 11.4 mill in assets)
Sweden	No	2005*	–	Requirement to strive for gender balance on all boards	Listed companies
United Kingdom	No	2011 and 2015 (voluntary approach based on reports)	2015 and 2020	Boards of directors (one-tier board structure)	Listed companies

† Legislative regulations

*Code of Corporate Governance

‡Spanish National Securities Market Commission's (CNMV) recommendation

Authors' own elaboration based on public information

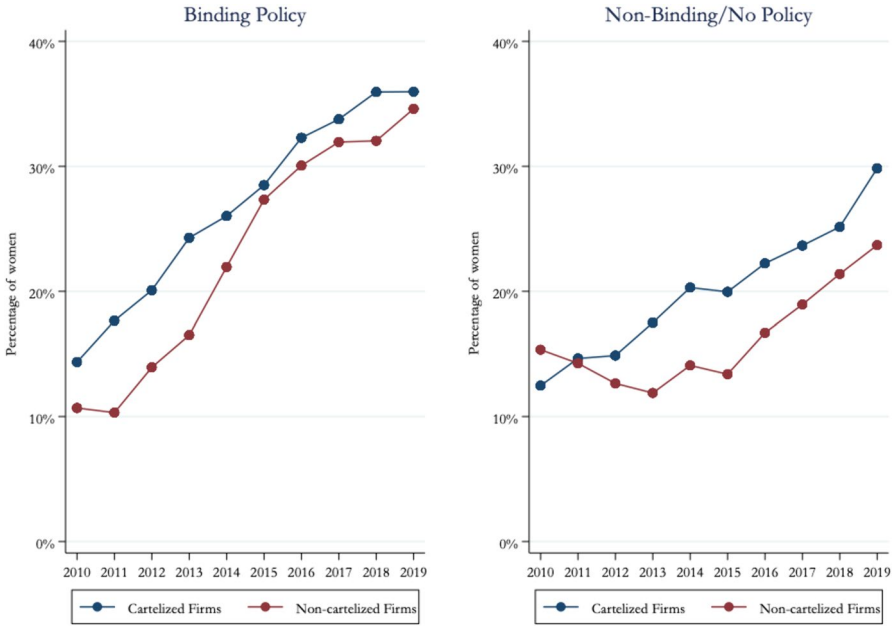

Fig. 3 Presence of women on boards in cartelized and non-cartelized firms over time. *Source* Authors' own elaboration

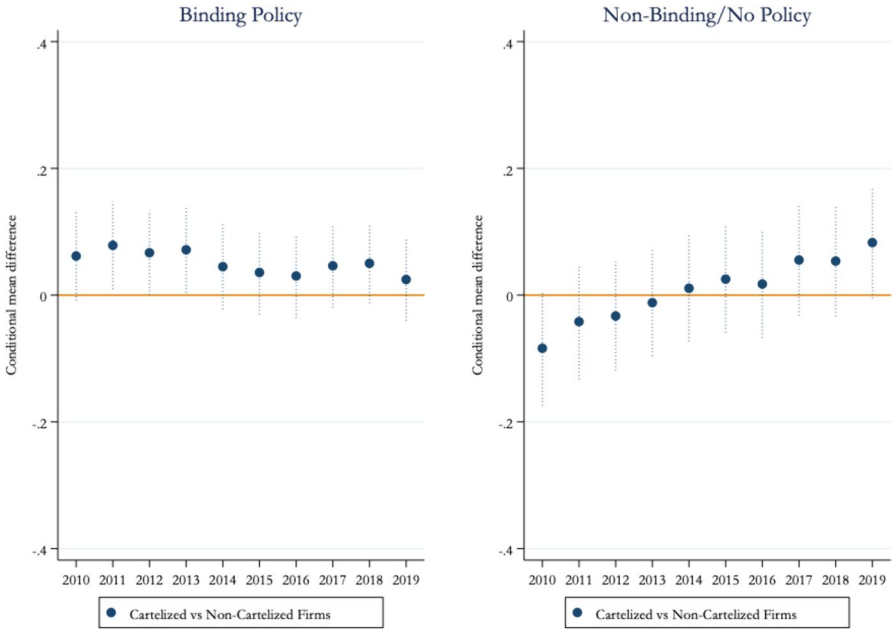

Fig. 4 Conditional mean differences in the presence of women on boards over time in cartelized vs non-cartelized firms in countries with binding and non-binding policies. *Source* Authors' own elaboration

that firms had similar starting points in the year 2010, but the presence of women on boards increased more in firms affected by the binding policy, as the quotas are mandatory, regardless of whether the firms have been involved in a cartel agreement or not. In countries with non-binding policies, the evolution of the presence of women on boards of directors seems to be slightly different in cartelized firms compared to non-cartelized firms.

Moreover, Fig. 4 focuses on this same analysis (binding vs. non-binding quotas) but obtaining the conditional mean differences of the presence of women over time in cartelized vs non-cartelized firms. We find that, while in countries with binding quotas the differences between cartelized and non-cartelized firms do not vary significantly over time, in countries with non-binding quotas, the percentage of women on boards in cartelized firms increases over time compared to non-cartelized firms. However, these differences are not statistically significant.

Figures 5 and 6 show a similar analysis than previous one but considering the entire cartel life. The former describes the evolution of the variable of interest, while the latter includes the conditional mean differences between cartelized and non-cartelized firms of the evolution of the presence of women on boards over the entire cartel life, distinguishing between countries with binding and non-binding quotas.

It shows that the percentage of women on boards is significantly higher in cartelized firms than in non-cartelized firms after the cartel breaks up in countries with binding quotas, although these differences are not statistically significant. However, when analyzing countries with non-binding quotas, the presence of women

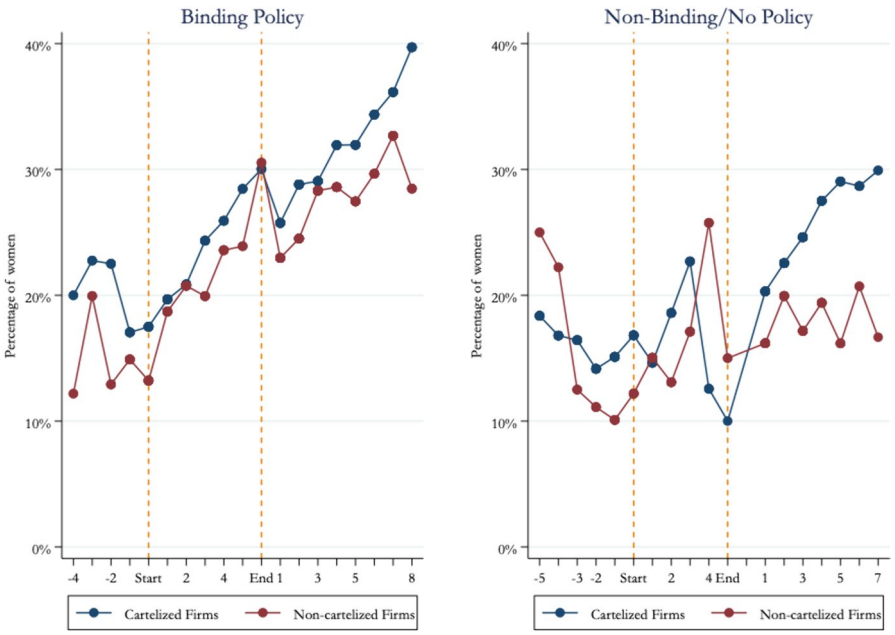

Fig. 5 Presence of women on boards in cartelized and non-cartelized firms over cartel life. *Source* Authors' own elaboration

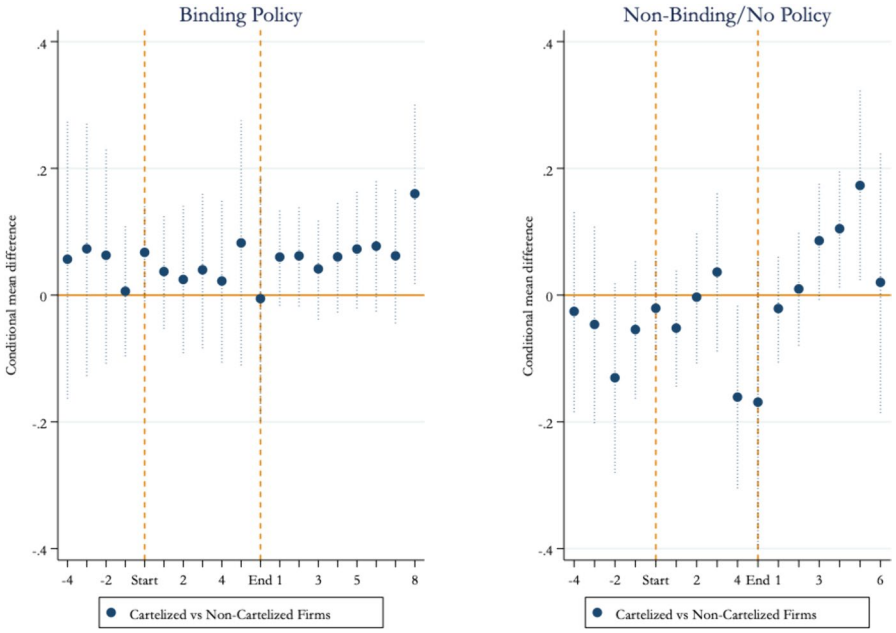

Fig. 6 Conditional mean differences in the presence of women on boards in cartelized vs non-cartelized firms in countries with binding and non-binding policies. *Source* Authors' own elaboration

on boards also appears to be higher in cartelized firms compared to non-cartelized firms, showing statistically significant differences in some periods after the breakup.

Summarizing, the descriptive analysis shows that the presence of women on boards is higher in cartelized than in non-cartelized firms after the cartel breakup. Moreover, the presence of women on boards is higher in both groups of firms in the countries that have implemented binding gender quotas. It might be due to greater anticipated scrutiny from authorities on the compliance of gender quotas by the sanctioned firms following the breach of the anti-cartel laws. The following section will explore whether the effect is driven by binding gender quotas or by cartel busting, or whether binding gender policies and anti-cartel policies interact and reinforce each other.

4 Estimates and results

To further analyse our question of interest, we estimate a difference-in-differences model to assess the impact of cartel breakup on the percentage of women on supervisory boards or one-tier boards when applicable. We do also analyse whether there exists heterogenous effects regarding countries with binding and non-binding gender quotas.

Over the long run, it might also be the case that cartel sanctions affect corporate board composition, as suggested by the literature cited previously. We are interested

in knowing whether the impact differs between countries with binding gender quotas and those with non-binding quotas. We may observe significant changes in the percentage of women on boards once cartels are uncovered and sanctioned, as discussed previously.

The exact timing of cartel busting has a random component. It is measured by the first public notice of the cartel investigation or any evidence of the date of cartel breakup (whatever occurs first). This randomness of cartel end date may eventually qualify cartel breakup date as an exogenous variable when studying changes across time in the percentage of women on boards. This allows us to attribute causality in the difference-in-difference estimate of the impact of cartel busting on the percentage of women on analyzed boards.

On the other hand, the date of the implementation of the gender quotas regulation also qualify as an exogenous change. Therefore, we take advantage of this issue and use the staggered[16] difference-in-differences estimator to quantify the impact of this policy on the presence of women on boards.

4.1 The effect of cartel busting

The difference-in-differences estimator is applied to understand if the presence of women on boards increases during the cartelization period or after the cartel breakup, compared to non-cartelized firms and compared to the pre-treatment period. The following regression is run on the constructed matched sample:

$$\begin{aligned} Y_{ijt} = \beta_0 + \beta_1 Cartelized_i + \beta_2 CartelPeriod_t + \beta_3 Cartelized_i * Period_t \\ + \beta_4 PeriodAfter_t + \beta_5 Cartelized_i * After_t + \sum_{h=6}^{12} \beta_h w_{hit} + \alpha_j + u_{ijt} \end{aligned} \quad (1)$$

where Y_{ijt} is the percentage of women on the board of directors analyzed in firm i, in country j, in a given year t; $Cartelized_i$ takes value 1 if the firm has ever been cartelized in the sample period and 0 otherwise; $CartelPeriod_t$ takes value 1 the years in which the treatment took place (cartel) and 0 before and after; $Cartelized_i * Period_t$ is the interaction of the previous 2 dichotomous variables, so it takes value 1 for the cartelized firm during the period in which it was cartelized and 0 before and after; $PeriodAfter_t$ takes value 1 the years after the cartel breakup and 0 before and during the cartel; $Cartelized_i * After_t$ is the interaction of *cartelized* and *period after*, so it takes value 1 for the cartelized firms after the cartel breakup and 0 otherwise; w_{it} represents firms' observable characteristics in each year[17]; α_j represents country fixed effects, constructed as a dummy variable representing each

[16] To analyze the effect of cartel busting we use the difference-in-differences estimator, as for each cartelized firm we identify a similar non-cartelized firm used as counterfactual. Therefore, we are able to impute the cartelization period to the control group. However, when we analyze the effect of the implementation of gender quotas regulations in different countries, we use the staggered difference-in-differences estimator to deal with the fact that some countries have not implemented these policies.

[17] Control variables described in Table 1.

country, which takes value 1 for the corresponding country and 0 otherwise; and u_{ijt} is the error term. Note that the variable $Period_t$ takes value 1 for the *non-cartelized* firm whenever it takes value 1 for its counterpart in the treatment group.

The coefficients of interest are β_3 and β_5 tells us how much the presence of women on boards increases during the cartel period or after the cartelized breakup, respectively, for cartelized firms compared to non-cartelized firms. Thus, it gives the average treatment effect on the treated.

The basic identifying assumption of the difference-in-differences estimator is that the trends in the 2 groups are the same in the absence of intervention. The figures included in the previous section (Sect. 3) show that there is no significant difference in the outcome of interest between the 2 groups (cartelized and non-cartelized firms) in the period before the cartel starts. Therefore, we can focus the analysis on the question of whether there is a significant change in board gender composition during the period when firms engaged in cartel activity (cartel period) or after this period (period after cartel).

In order to further explore the question of interest, we estimate Eq. (1) considering alternative specifications with respect to the baseline model. Thus, we include variables related to the gender quotas implemented in different countries in separate models. We consider the following variables: *binding quota*, which takes value 1 if the country has implemented a binding policy during the analyzed period and 0 if the policy is non-binding;[18] *target quota*, which takes the value of the target quota for all countries, with binding quota or not, from the compliance year onwards; and the interaction of the previous 2 variables. These model specifications will allow us to understand whether the effect on the presence of women on boards comes only from binding quotas or the corresponding target, or also from the cartel engagement. Table 3 includes the estimation of Eq. (1).

Results show that the cartelization period does not cause a significant increase nor decrease in the presence of women on boards of cartelized firms with respect to non-cartelized firms when considering the whole sample. In addition, we find that it is cartel breakup that has a significant increase in the presence of women on boards of cartelized firms compared to non-cartelized firms [see *DiD after Cartel* coefficient, Model (4)].

It is unclear whether this effect comes only from cartelization, or also from implementing different board gender quotas policies at country level. Separate estimations for countries with binding and non-binding quotas are presented in Table 4.

Results are slightly weaker, due to the small sample, but we can confirm 2 different effects. In the case of countries with binding quotas, the presence of women significantly increases in the period after the cartel breakup in both groups of firms (cartelized and non-cartelized firms). This may be due to the fact that the dates of the implementation of the policy coincides with the years included in the period

[18] Exactly, this binding quota variable takes value 1 if the country applies a binding board gender quota AND the firm is affected by this binding quota, and 0 if the country does not apply a binding board gender quota OR the firms from countries with binding board gender quotas are not affected. For this reason, we drop out those firms of the sample.

Table 3 Difference-in-differences estimator

	Model (1)	Model (2)	Model (3)	Model (4)
Cartelized	0.009	0.009	0.012	−0.005
	(0.027)	(0.027)	(0.025)	(0.025)
Cartel period	0.027	0.027	0.017	0.012
	(0.025)	(0.025)	(0.023)	(0.023)
DiD Cartel period	−0.008	−0.008	−0.01	0.009
	(0.032)	(0.032)	(0.029)	(0.029)
Period after Cartel	0.083***	0.083***	0.01	0.018
	(0.024)	(0.024)	(0.024)	(0.023)
DiD after Cartel	0.032	0.032	0.037	0.058***
	(0.03)	(0.03)	(0.028)	(0.028)
Binding quota		0.024		
		(0.03)		
Target quota			0.351***	
			(0.037)	
Binding*Target quota				0.392***
				(0.038)
Constant (β_0)	0.114***	0.090***	0.145***	0.138***
	(0.033)	(0.029)	(0.031)	(0.031)
Firms' characteristics	Yes	Yes	Yes	Yes
Country effects (α_j)	Yes	Yes	Yes	Yes
R^2	0.352	0.352	0.447	0.457
N	559	559	559	559

Percentage of women on corporate boards

Standard errors in parentheses

*$p<0.10$, **$p<0.05$, ***$p<0.01$

after the cartel. Moreover, the binding policy results in a non-significant difference between cartelized and non-cartelized firms regarding the presence of women on boards, as the quotas are mandatory.

In the case of countries with non-binding quotas, we find that cartel busting significantly increases the presence of women on boards of cartelized firms, compared to their mirror-firms (the control group, non-cartelized firms that are like the cartelized ones). The breakup of a cartel yields a causal impact on a significant change in the gender balance of corporate boards in sanctioned firms, increasing the percentage of women on boards. The quantitative size of this change is 11.7 percentage points. The presence of women on boards is almost doubling from the benchmark average percentage of women on boards of firms in non-binging countries before cartel breakup (14.8%). This is likely due to efforts by these firms to improve their monitoring abilities and thus decrease illegal activities (Adams & Ferreira, 2009; Arnaboldi et al., 2021; Wahid, 2019), and/or to enhance their reputation (Brammer et al., 2009; Fleitas-Castillo, 2024; Navarro-García et al., 2022).

Table 4 Difference-in-differences estimator

	Non-binding countries	Binding countries
Cartelized	−0.06	0.048
	(0.04)	(0.038)
Cartel Period	−0.002	0.033
	(0.038)	(0.033)
DiD Cartel Period	**0.026**	**−0.005**
	(0.045)	**(0.044)**
Period after Cartel	−0.001	0.119***
	(0.038)	(0.031)
DiD after Cartel	**0.117*** **	**0.01**
	(0.044)	**(0.042)**
Constant	0.101***	0.082**
	(0.03)	(0.039)
Firms' characteristics	Yes	Yes
Country Effects	Yes	Yes
R^2	0.374	0.32
N	216	343

Bold values indicate the most relevant variable

Percentage of women on corporate boards. Countries with binding or non-binding gender quotas

Standard errors in parentheses

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

4.2 The effect of binding board gender quotas

In our analysis, companies are affected by a maximum of 2 treatments: the cartel period and breakup, and the implementation of the binding board gender quotas. This is, we can distinguish between cartelized and non-cartelized firms (during the sample period) and also between countries that apply binding board gender quotas or non-binding quotas. In this setting, we can also analyze the impact of implementing binding gender quotas on comparable cartelized firms, separately from the impact on similar non-cartelized firms. This is the purpose of this section.

Figure 7 depicts the evolution of the presence of women on boards for cartelized firms and non-cartelized firms. The left-hand-side panel shows that the board gender composition has become more balanced in cartelized firms, both in countries that have implemented binding quotas and in countries that have passed non-binding quotas. While cartelized firms have a similar starting point in 2010, the increase in the presence of women on boards of directors is higher in the countries with binding quotas than in countries with non-binding quotas.

Similar conclusions can be obtained from the right-hand-side panel, which shows that the presence of women has increased from 15.3% in 2010 to 23.7% in 2019 in

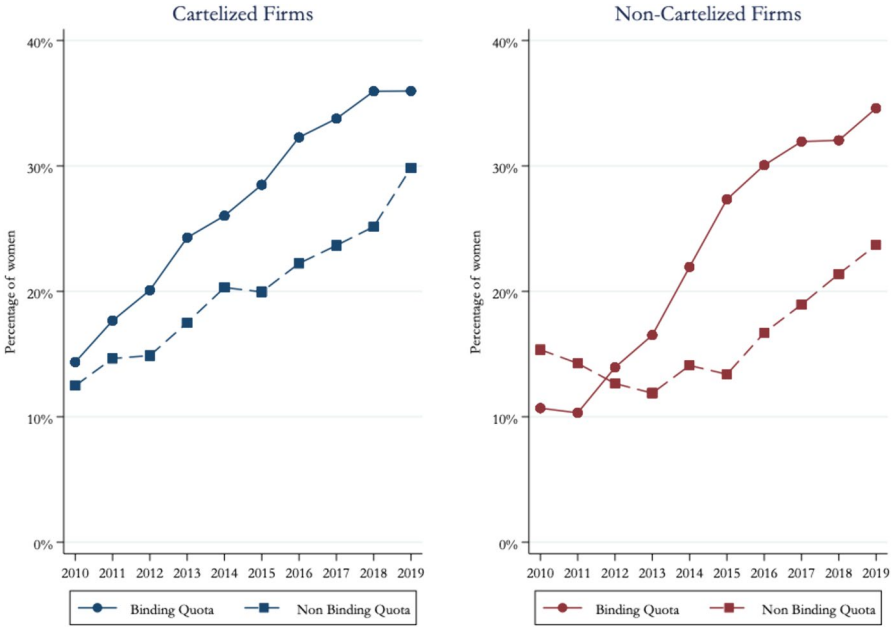

Fig. 7 Presence of women on boards in cartelized and non-cartelized firms over time. *Source* Authors' own elaboration

Table 5 Staggered difference-in-differences estimator. *Source* Authors' estimates

	All Firms		Non-cartelized firms		Cartelized firms	
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
ATT	**0.036** (0.016)**	**0.039** (0.021)*	**0.049** (0.025)**	**0.099** (0.06)*	**0.024** (0.02)	**0.023** (0.028)
Firms' characteristics	No	Yes	No	Yes	No	Yes
N	679	535	272	194	407	323

Bold values indicate the most relevant variable

Percentage of women on corporate boards

Standard errors in parentheses

*$p<0.10$, **$p<0.05$, ***$p<0.01$

countries with non-binding quotas, while it has increased from 10.7% to 34.6% in 2019 in countries with binding quotas.

Applying the staggered difference-in-differences methodology by Callaway and Sant'Anna (2021),[19] given that countries implement the quota in different moments

[19] As these authors explain, the traditional Two-Way Fixed Effects (TWFE) model is not an appropriate method to identify the Average Treatment on Treated if the treatment effects are heterogeneous and the timing of the treatment varies across countries, in this case. For this reason, the authors develop a new methodology to deal this question (CSDID Stata command, see the cited reference).

in time, we obtain the following results (Table 5) Please check and confirm if the inserted citation of Table 5 is correct.

Results show that binding quotas increase the presence of women on boards of firms, in comparison with countries with non-binding quotas or no policy at all. When considering cartelized firms, there is no significant impact of the binding quotas on the percentage of women on boards. This result does not mean that binding gender quotas do not have an impact, but rather that sanctioned firms, either through compliance with binding board gender quotas or through efforts to improve their reputation after cartel busting (the presence of women on boards increases significantly after the cartel breakup compared to non-cartelized firms), increase the presence of women on boards even when they are not obliged to do so.

However, when considering non-cartelized firms, we find a significant impact of the implementation of binding quotas on the presence of women on boards (in comparison with countries which have no binding quota or no policy at all). This means that the policy is effective, especially when isolating the effect from the cartel busting. Binding quotas is driving the presence of women on corporate boards in non-cartelized firms by 9.9 percentage points (model 4 with firm's characteristics). This is a similar impact as the one estimated previously regarding the effect of cartel busting on the percentage of women in boards of cartelized firms in non-binding countries. Both policies (quotas and cartel busting) have similar effect on the percentage of women on corporate boards.

5 Concluding remarks

Cartels are one of the most harmful competition restraints for consumers and the economy in general. The literature on anti-cartel policy enforcement has recently focused on the role of board members, senior managers, and directors in cartel activity. Our research paper contributes by explaining how cartel engagement and anti-cartel policies impact the gender composition of the supervisory boards of directors, and how board gender quota regulations affect the presence of women on these boards of cartelized firms.

The evidence from a European sample of firms sanctioned due to cartel engagement and comparison firms not sanctioned shows a statistically significant impact of cartel busting on corporate board restructuring. In countries with binding gender quotas, the policy results in greater gender balance in board positions in both cartelized and non-cartelized firms.

Binding board gender quotas seem to drive the increase in the percentage of women on supervisory boards in both cartelized and non-cartelized firms. The impact of the policy is clear when comparing these firms to similar ones in countries with non-binding policies.

Moreover, there is sound evidence that firms sanctioned by competition authorities as members of cartels are seizing the opportunity to restructure their boards, most likely to enhance their reputation, especially in countries with non-binding board gender quotas. Under this type of regulation, we observe a statistically significant differential increase in the percentage of women on corporate boards after cartel busting in sanctioned cartelized firms compared to non-cartelized matched firms.

The main takeaway of our results is that board gender quota regulations and anti-cartel policies interact and influence the gender composition of supervisory boards in firms sanctioned by competition authorities. The empirical evidence suggests a compelling lesson: cartel sanctioning and prosecution are effective tools for corporate restructuring, and binding gender policies are also effective means to achieve more balanced board gender composition. Therefore, board gender quota regulations and anti-cartel policies interact and increase the presence of women on corporate boards.

We think that future research should be directed to some of the following questions: (1) Case studies of cartelized firms that restructured their boards of directors after cartel breakup might offer more nuanced and detailed explanations of the interplay between anti-cartel policy enforcement and compliance with gender policies; (2) As more countries adopt binding gender policies, new research may be directed to study how anti-cartel policy may make corporate board restructuring more effective; (3) New research should analyse whether gender quotas also lead to firms forming fewer cartels and whether replacing male by female board member may be part of an effective antitrust compliance program, as suggested by the previously cited research that women cooperate significantly less in collusive arrangements than men when outsiders are harmed, as they are more averse to guilt and shame; (4) Finally, data on the gender balance not only of supervisory board members, but also of management boards and senior managers, should also be studied, as lower levels of management appear to be engaged in cartel conduct. However, this last point, as we have explained previously, is currently difficult to address due to the lack of available information for a sufficiently representative sample of companies.

Appendix

See Tables 6 and 7.

Table 6 Descriptive statistics of the European database for 2010. *Source* Authors' own elaboration

Covariates	Obs	Cartelized firms		Non-cartelized firms		Mean differences *t-test* (Cartelized vs non-cartelized firms)
		Mean	Std. Dev	Mean	Std. Dev	
% women on boards	79	0.13	0.09	0.11	0.09	**0.02**
# women on boards	79	2.02	1.78	1.24	1.06	**0.78****
# board members	79	14.59	4.19	11.36	3.59	**3.22*****
Operating revenues	79	28,600,000	46,400,000	11,000,000	13,900,000	**17,600,000****
Total assets	79	91,300,000	212,000,000	14,300,000	23,200,000	**77,000,000****
# employees	79	97,684.4	121,300.4	42,037.3	53,669	**55,647.06****
Long-term debt	71	8,110,366	11,200,000	3,239,592	6,943,854	**4,870,774****
Leverage	71	120.36	134.11	136.71	201.42	**16.35**
Avg. cost per employee	72	67.20	75.33	60.89	49.88	**6.31**

Bold values indicate the most relevant variable

t-test compares treated versus control firms

Obs, Observations; *Std. Dev*., Standard Deviation; *Min*, minimum; *Max*, maximum

*$p<0.10$, **$p<0.05$, ***$p<0.01$

Table 7 Quota Regulation specifics for each sample country

Country	Corporate governance structure		Code of Corporate Governance with recommendations on gender diversity	Binding	Legislative Regulation	Compliance year	Target %	Binding	Sanctions	Affected boards	Affected companies
	One-tier	Two-tier									
Austria	Also possible	Common	2009 and 2015	NO	2011 (Government)	2013 2018	25–35	YES	NO (Empty chair)	Board of directors	Majority State-owned companies
					2017	2018	30	YES		Supervisory boards	Listed companies and companies with over 1000 employees whose boards consist of at least six seats. Exemption for "single gender" companies (workforce with less than 20% employees of one sex)

Table 7 (continued)

Country	Corporate governance structure		Code of Corporate Governance with recommendations on gender diversity	Binding	Legislative Regulation	Compliance year	Target %	Binding	Sanctions	Affected boards	Affected companies
	One-tier	Two-tier									
Belgium	Common		2009	NO	2011	2012: state owned companies. 2017: large listed companies	33	YES	YES	Boards of directors in a one-tier system (more usual system in Belgium) and supervisory boards only in a 2-tier system	Listed and state-owned companies

Table 7 (continued)

Country	Corporate governance structure		Code of Corporate Governance with recommendations on gender diversity	Binding	Legislative Regulation	Compliance year	Target %	Binding	Sanctions	Affected boards	Affected companies
	One-tier	Two-tier									
France	Common	Also possible	2010	NO	2011	2014 (intermediate goal) 2017	20 40	YES	YES (In case of non-compliance with the law, the appointments of directors shall be considered as null and void. Moreover, failure to comply with the law will lead to the non-payment of the board attendance fees to the board members.)	Non-executive directors	Listed companies and non-listed companies with revenues or total assets over 50 million euros, or employing at least 500 persons for 3 consecutive years

Table 7 (continued)

Country	Corporate governance structure		Code of Corporate Governance with recommendations on gender diversity	Binding	Legislative Regulation	Compliance year	Target %	Binding	Sanctions	Affected boards	Affected companies
	One-tier	Two-tier									
Germany		Common	2010	NO	2015	2016	30	YES	YES	Supervisory boards	Listed companies to which full co-determination law applies (more than 2000 employees)/ Companies that are either listed or fully co-determined

Table 7 (continued)

Country	Corporate governance structure		Code of Corporate Governance with recommendations on gender diversity	Binding	Legislative Regulation	Compliance year	Target %	Binding	Sanctions	Affected boards	Affected companies
	One-tier	Two-tier									
Italy	Also possible	Common (hybrid model)	2018	NO	2011 (Obligatory for 3 mandated board terms, until 2022. After this, the law will lapse, and companies will be free to determine the gender composition of the board)	2012 (intermediate goal) 2015	20 (1/5) 33.3 (1/3) Legislative directives apply for publicly listed companies from the first term renewal of board of directors (executive board), and from one year after promulgation of the law for statutory auditors (supervisory board)	YES	YES	Both executive and supervisory boards	Listed and state-owned companies

Table 7 (continued)

Country	Corporate governance structure		Code of Corporate Governance with recommendations on gender diversity	Binding	Legislative Regulation	Compliance year	Target %	Binding	Sanctions	Affected boards	Affected companies
	One-tier	Two-tier									
Portugal	Latin one-tier	Also possible (hybrid model)	2016	NO	2017	2018 2020	20 (1/5) 33.3 (1/3)	YES	YES	Both executive and supervisory boards	Listed and state-owned companies
Spain	Common		2006	NO	2007	2015	40	NO	NO	Boards of directors (one-tier board structure)	Listed and state-owned companies. Large companies (more than 250 employees and 11.4 mill in assets)
Sweden	Mixed model (Nordic system)		2005	NO	–	–	–	–	–	Requirement to strive for gender balance on all boards	Listed companies

Table 7 (continued)

Country	Corporate governance structure		Code of Corporate Governance with recommendations on gender diversity	Binding	Legislative Regulation	Compliance year	Target %	Binding	Sanctions	Affected boards	Affected companies
	One-tier	Two-tier									
Switzerland	Common	De facto 2-tier	2014 and 2016	NO	2021	2026 (obligation to report for board of directors) 2031 (obligation to report for executive boards)	30 (board of directors) 20 (executive board)	"YES"	NO	Board of directors and executive boards	Companies that in 2 consecutive years have a balance sheet of more than 20 million Swiss francs (about US$22 million) or whose sales revenue exceeds 40 million Swiss francs, or that have an annual average of more than 250 full-time positions are required to include information on the gender quota in their annual remuneration report. If the quota is not met, the companies are required to comply or to explain why, and to describe the measures that have been and will be taken to increase the numbers for the underrepresented gender

Table 7 (continued)

Country	Corporate governance structure		Code of Corporate Governance with recommendations on gender diversity	Binding	Legislative Regulation	Compliance year	Target %	Binding	Sanctions	Affected boards	Affected companies
	One-tier	Two-tier									
United Kingdom	Common		2012	NO	2011–2015 (voluntary approach based both on reports)	2015 2020	25–33	NO	NO	Boards of directors (one-tier board structure)	Listed companies

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Declarations

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