GENDER INCLUSIVE COMPETITION POLICY

OECD

Project #4

Gender bias in cartel engagement

The role of gender in management boards and how to take the role of gender into account when designing competition law enforcement[1]

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Joan-Ramon Borrell[2] **Carmen García**[3] **Juan Luis Jiménez**[4] **José Manuel Ordóñez-de-Haro**[5]

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[2] Universitat de Barcelona, Secció de Polítiques Públiques – Dept. Econometria, Estadística i Economia Aplicada; Grup de Governs i Mercats (GiM) - Institut d'Economia Aplicada (IREA), Carrer John M. Keynes 1-11, Barcelona; University of Navarra, IESE Business School, Public-Private Sector Research Center. jrborrell@ub.edu

[3] Universidad de Las Palmas de Gran Canaria. Facultad de Economía, Empresa y Turismo. Room D. 3-15. 35017. Las Palmas de Gran Canaria, Spain. carmen.garciagalindo@ulpgc.es

[4] Universidad de Las Palmas de Gran Canaria. Facultad de Economía, Empresa y Turismo. Room D. 2-12. 35017. Las Palmas de Gran Canaria, Spain. juanluis.jimenez@ulpgc.es

[5] Dep. de Teoría e Historia Económica y Cátedra de Política de Competencia, Universidad de Málaga, Pl. El Ejido, s/n. 29013. Málaga, Spain. jmoh@uma.es

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Executive summary

Cartels are one of the most harmful competition restraints for consumers and the economy in general. The literature on 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 (Campello et al, 2017; Dijkstra and Frisch, 2018; Artiga González et al, 2019).

The role of criminal sanctions to individuals is also a hot topic of study (Ginsburg and Wright; 2010; Shaffer and Nesbitt, 2015; Borrell et al, 2016; Beaton-Wells, 2017). Therefore, increasing the 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.

The institutional details regarding the number of governing top corporate decision-taking and management bodies of companies and their duties differ slightly from one firm and another, and from one country to another. Our analysis will focus on the top decision-taking board of directors of the firms including executive and non-executive members. Research on how cartels operate such as the one by Harrington (2016, 2019 & 2020) show that engagement of the 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 prices but rather prices that influence prices”.

Given the role that the board of directors may have in cartel engagement, and the role of its executive and non-executive members, one of the factors that may affect cartel activity is the gender composition of board members. 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 decision-making process. Although evidence is somewhat mixed, some studies show that women are, on average, more risk averse than men. In addition, women seem to be more receptive to moral and ethical norms, and more prone to whistleblowing.

These differences in risk taking responses have encouraged research analysing board gender diversity, and the effect of gender quotas on corporate boards that have been introduced in several countries around the globe. We show that gender diversity of corporate boards has gradually and moderately increased, so analysing the impact of this gender policy on cartel activity is also of interest. There is already evidence on the impact of gender diversity on corporate decision making showing that the increase in women on senior management positions increases firms’ performance and decreases illegal activities such as financial misconduct and corruption.

This paper aims to explain the relationship between board gender diversity and cartels. Building on earlier research (Santacreu-Vasut and Pike, 2019), our starting hypothesis was that women in the company’s board of directors, senior management positions or director posts may have a significant effect in reducing the firm’s misbehavior, and correspondingly having women as board members may reduce cartel engagement..

Although some papers have tried to deal with this question (Hamaguchi et al, 2009; Combe and Monnier-Schlumberger, 2016; or Boulu-Reshef and Monnier-Schlumberger, 2019), this research differs as it focusses on the econometric impact of gender on cartel engagement.

In recent years, the issue of women’s presence on boards has been playing a key role in the European political agenda. Measures to improve gender diversity improvements have included regulatory policies on board gender composition, and the introduction of board gender quotas in many countries. Two different 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).

Our paper focusses on the following research questions: is there a gender bias in cartel engagement? Do firms change course in cartel engagement when there is greater gender equality in board members? Should cartel policy enforcement design consider such gender bias? How? Are binding or non-binding quotas effective in promoting gender diversity and encouraging anti-cartel behavior? Should cartel busting measures include driving corporate board restructuring and promoting gender balance at senior management positions in firms?

To answer these questions, two sources of information regarding cartel engagement at firm level are used. On the one hand, the Private International Cartels data set, by Professor John Connor, which comprises the largest collection of legal and economic information on price fixing cartels. It covers from 1990 to 2019, for all companies in the world (Connor, 2020), although restrains on data availability on board members has forced us to focus on European firms only in the 2010 to 2019 period. On the other hand, we have also the detailed database of sanctioned cartels in Spain, prepared by the authors for this project, for the 1998 to 2018 period and data for board members changes throughout this period.[6]

Starting from these two databases on cartelized firms, we have created two new databases, which not only include the information for those European and Spanish cartelized firms but also the information for matched similar non-cartelized firms. We have also collected and added information on the composition of corporate boards of directors (executive and non-executive directors), or appointments and/or dismissals for both cartelized and matched non-cartelized firms.

Using this information, we empirically analyzed whether more women in corporate boards have any clear-cut impact on firm's cartel engagement and cartel break-up; and also how cartel formation and cartel busting impacts on the gender composition of the boards of directors.

We factor in the effect of gender quota policies (binding and non-binding quotas) on the empirical analysis of these issues.

Our findings are the following:

> **Finding 1**: the study and control groups (cartelized vs non cartelized) have statistically similar percentages of gender participation, before and during the cartel's life. This is clear at least in the case of European firms, where there are data on overall board composition, but also in the case of Spanish firms where there are not significant differences in gender in appointments nor dismissals in the two groups of firms.
>
> **Finding 2**: Cartel busting leads to board of directors restructuring, presumably to remove persons (executive and non-executive members) that may have had a role in the cartel.
>
> **Finding 3**: When a board of directors is restructured, more women are appointed to fill vacancies in countries with binding gender quotas than in countries with non-binding quotas.

Contrary to our starting hypothesis, we do not find enough evidence that more women in corporate boards have any statistically significant effect on cartel formation and cartel breakup. However, we find strong evidence that cartel busting leads to corporate board restructuring, which in countries with binding gender quotas, drives a significant increase of the percentage

[6] Data availability on cartelized and non-cartelized similar firms has forced us to analyze two different timeframes. Going back as long as 20 years in the Spanish data base, but only as long as 10 years in the European data base.

of women in the boards of cartel sanctioned firms with respect to the percentage of women in the boards of non-cartelized firms.

These results are in line with some studies that show that cartel sanctions lead to senior management positions restructuring (Rosenboom, 2012; Campello et al. 2017; Artiga González et al., 2019). The sanctioned cartelized firms might be trying to clean the reputation after being sanctioned by anti-cartel authorities, and the restructuring is balancing gender composition in counties with binding gender quotas. However, it is not so clear in our data whether corporate board composition matters for cartel engagement, or even whether it takes an active part in the cartel conduct.

The main take-away of our research paper is that binding gender policies and cartel policies interact and influence gender board composition of sanctioned firms. Binding gender quotas of board composition seem to be driving a statistically significant differential increase in the percentage of women on corporate boards of cartelized sanctioned firms in Europe with respect to non-cartelized matched firms. However, this is not the case with non-binding gender policies. The Spanish case, with non-binding gender policies, shows that gender and anti-cartel policies do not have a clear-cut effect on the board and senior management gender composition of sanctioned firms.

1. Introduction

Cartels are one of the most harmful competition restraints for consumers and total economic welfare. Cartels are treated differently from other competition infringements given the seriousness of their impacts on economic welfare, and the private damages they involve. Although other anticompetitive practices are addressed case-by-case based on their effect on competition, cartels are prohibited *per se* and severely sanctioned in most jurisdictions.

However, the very covert and secret nature of these anticompetitive practices makes their detection, investigation, and prosecution very difficult for the authorities concerned (Werden, 2009). In fact, one of the main goals of competition policy is to address the drivers of cartels' formation and their stability and to improve the effectiveness of antitrust enforcement against cartels (Borrell and Jiménez, 2008).

The enforcement of competition law focuses on the prevention of firms' anticompetitive behaviors in the market to promote consumer welfare. But 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 corporate hierarchy and its implementation and monitoring is relied on lower-level managers (Gallo et al. 2000; Harrington, 2006; Stephan, 2010; Connor and Lande, 2012).[7]

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, 2017; Dijkstra and 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 (Ginsburg and Wright; 2010; Shaffer and Nesbitt, 2011; Borrell et al., 2016; Beaton-Wells, 2017).

Combe and Monnier-Schlumberger (2020) note that managers' decision to engage in cartel activities derive from their evaluation of the associated expected costs and benefits. These costs and benefits would also include the consequences that the firm's involvement in cartel activity would have on its managers' professional careers.

Some recent studies indicate that cartel sanctions lead to restructuring management positions (Rosenboom, 2012; Campello et al. 2017; Artiga González et al., 2019). 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[8] at the same company or another, after cartel prosecution.[9] 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.

[7] Those 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 to those illegal activities to take place.

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

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

Artiga González et al. (2019) use a sample of 248 listed U.S. cartel firms and 833 control companies matched on size and industry. Their results suggest that top corporate senior managers would see benefits in terms of job security or revenues if they participate in cartel behavior. They also find that directors resign or retire more frequently in cartel sanctioned companies compared to control companies, but cartel sanctioned companies are more reluctant to replace exiting directors. This companies' reluctance could be uncovering a corporate governance strategy for concealing the anticompetitive behavior that partly helps managers of these firms to obtain the aforementioned benefits.

Corporate governance mechanisms are closely related to firms' internal incentives to participate in cartels (Thépot, 2019). The duties of the corporate board include ensuring internal monitoring and controlling of management decisions, selecting, and appointing best candidates for top management positions, and participating in the design of appropriate schemes of remuneration that do not promote any misconduct or illegal behavior,[10] achieving the best interests for the company and shareholders.

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. Therefore, increasing the understanding of the composition and characteristics of corporate boards is crucial, to find means to prevent and detect anticompetitive decisions from being taken within the management bodies.

We refer to "management boards" in a broad way including all the boards governing firms including the supervisory board of directors, the decision-taking board of directors but also the lower management boards including just executive directors and senior managers of the firms. The institutional details regarding the number of governing top corporate decision-taking and management bodies of companies and their duties differ slightly from one firm and another, and from one country to another.

Our analysis will focus on the top decision-taking board of directors of the firms including executive and non-executive members. Research on how cartels operate such as the one by Harrington (2016, 2019 & 2020) show that engagement of the 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) argue "senior managers do not coordinate on prices but rather prices that influence prices", and according to outlined cartel theory, paradoxically, "that they do not have full control over the final prices is what will make collusion work". As detailed in the European Commission (2016) decision on sanctioning the truck cartel, the top senior managers colluded with regards to gross list prices: [11]

> *"The top management of the parties' headquarters (…) discussed their pricing intentions, the future gross price increases (…) and occasionally agreed their respective gross price increases."*

According to Harrington (2020), although firms count with multi-unit pricing councils formed by junior managers, senior executive managers have a large influence in an early stage of the pricing. We thus focus on the board of directors that are influencing directly or indirectly the conduct of the top senior executives of the firm that have a say on strategic decisions such as pricing that have such an important role on cartel activity.

The present paper studies the relationship between gender diversity on corporate boards of directors and cartel activity, and how the implementation of public policies can promote, either

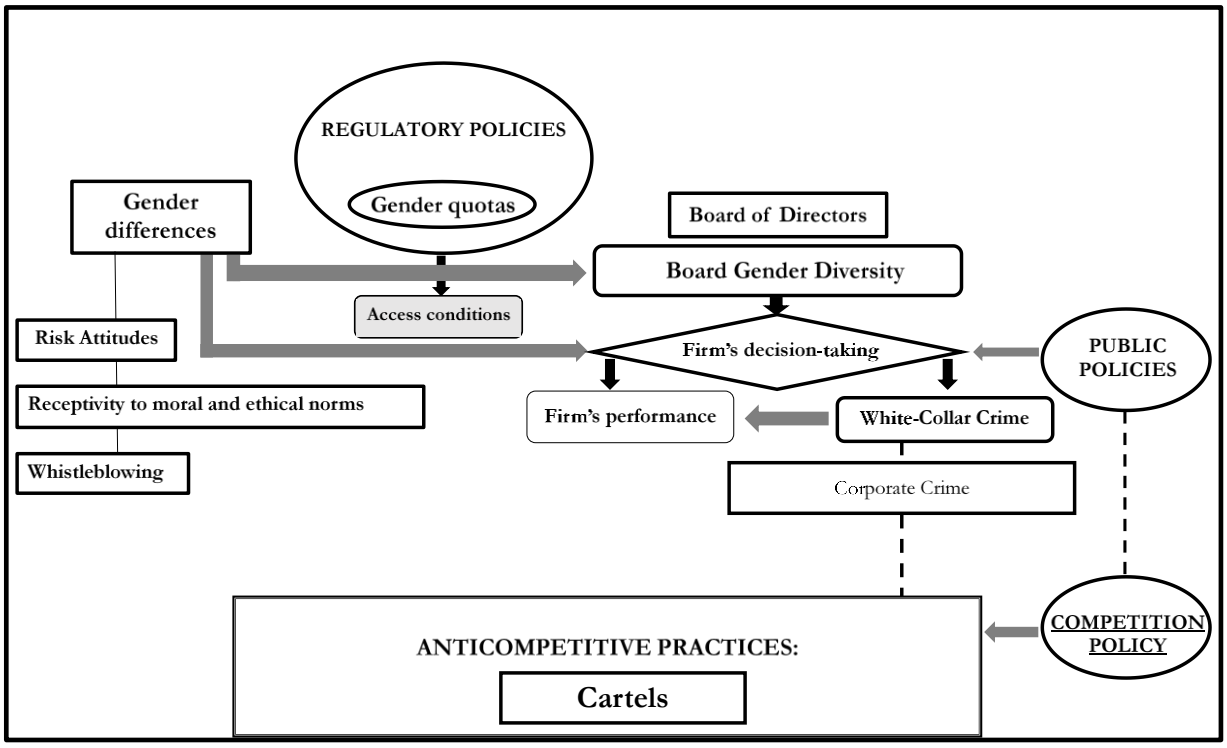
[10] Several studies have shown that some compensation schemes contribute to create and sustain collusive agreements (Spagnolo, 2000, 2005; Buccirossi and Spagnolo, 2008; Aubert, 2009).

[11] https://ec.europa.eu/competition/antitrust/cases/dec_docs/39824/39824_8754_5.pdf

directly or indirectly, changes in women's representation in corporate governance structures and whether that affects cartel formation and sustainability.

There is a gap in research on how public policies should consider gender issues when designing enforcement tools. Specifically in competition policy, we follow the proposals of Santacreu-Vasut and Pike (2019) that highlight a gap in the literature studying how gender may affect anti-competitive conduct by firms. The following figure shows a summary of the research areas on corporate board gender diversity that is most relevant to our study.

Figure 1. Research areas on corporate board gender diversity



The literature shows that there are gender differences particularly in the response of women/men when they face risk situations. These gender-related differences are critical in corporate decision-making, which has encouraged research on the effects of board gender composition on firms' performance, as well as on the commission of white-collar crime. White-collar crime includes cartels as a type of corporate crime. Research on public regulatory policies is also relevant because they affect board gender composition, and they should take into account gender issues when designing effective competition enforcement tools.

Source: Authors' elaboration.

Our study is related to the recent literature on gender and white-collar crime (see Figure 1). Although its definition has varied over time, the category of white-collar crime would include violations of securities law and antitrust law, bribery, false statements, tax offenses, financial fraud, or embezzlement (Weisburd et al., 1991).

Existing 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 (Daly, 1989; Steffensmeier and Allan, 2000; Holtfreter, 2015; Benson, 2020). Women's under-representation is more acute in

"high level" corporate crime (Davies, 2003; Steffensmeier et al. 2013).[12] Two different non-exclusive broad perspectives have been considered in the literature to explain the observed gender gap in white-collar crime (Benson and 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. The differences in the responses between men and women when they face risk situations are critical for their decision-making processes. Some studies show that women, on average, are more risk averse than men (Jianakoplos and Bernasek, 1998; Eckel and Grossman, 2002), although other recent studies provide mixed evidence on this relationship (Eckel and Grossman, 2008; Filippin and Crosetto, 2016). Gender differences in risk attitudes will affect the board members' decisions on whether or not to engage in corporate misconduct or illegal activities.

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. Grosch and Rau (2017) focus on a situation where dishonest behavior 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.

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, showing more empathy, generosity and less prone to risky behaviors (see also Fehr et al, 2006; or Croson and 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.

Based on the above research, ethical, social orientation and responses to risk decisions differ between women and men. Therefore, gender diversity of board members and management positions are like to impact how a firm makes ethical, social and risk related decisions. Particularly, it suggests that a more female representation on firms' boards would reduce the incidence of corporate misconduct.

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). Adler (2001) uses three different measures of profitability, based on data from the 1999 Fortune list: profits as a percent of revenues, assets, and stockholders equity. He finds that the 25 Fortune 500 firms with a high number of women executives outperformed their industry median firms on all three measures. Carter et al. (2003) study a market-based measure of firm performance for a sample drawn from the Fortune 1000 firms. They find a statistically significant positive relationship between the presence of women on the board of directors and firm value, as measured by Tobin's Q.

Terjesen et al. (2016), based on data from 3,876 listed firms in 47 countries in 2010, use two proxies for firm performance: Tobin's Q as a market valuation indicator and return on assets as an accounting-based indicator. Their results show that firms with a higher percentage of female directors on the board have better market and accounting-based firm performance. Bennet et al. (2020) use a difference in difference approach to analyze the effects of facilitating women's participation in the workforce by implementing Paid Family Leave (PFL) laws on firm performance. Based on data from a large sample of U.S. public and private firms, they find that,

[12] 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.

following the adoption of state PFL laws, treated firms experience improved productivity and operating performance (as measured by their return on assets), reduced turnover and an increase in the fraction of female named executive officers, compared with control firms.

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 and Mínguez-Vera, 2008; Adams and Ferreira, 2009; and Post and Byron, 2015). Campbell and Mínguez-Vera (2008) argue that gender board composition can affect the quality of board's monitoring performance and thus the financial firm performance. Based on a sample of Spanish listed non-financial firms, they find a positive relationship between gender diversity (as measured by the percentage of women and the Blau and Shannon indices) and firm value (as measured by a proxy of Tobin's Q), although they do not include any measure of boards' monitoring activities.

By using a large sample of U.S. firms, Adams and Ferreira (2009) analyze the impact of gender on board inputs by considering two observable measures: attendance behavior and committee assignments. They study committee assignments since many monitoring-related activities are carried out by board committees. Their findings indicate that gender-diverse boards allocate more effort to monitoring. However, they only find a positive effect of board gender diversity on firm performance in firms that otherwise have weak governance. They suggest that in firms with strong governance, greater board gender diversity could lead to over-monitoring which could decrease those firms' value.

Post and Byron (2015) review the literature findings and conduct a meta-analysis of 140 studies to primarily study the relationship between female board representation and two types of measures of firm financial performance: accounting-based measures[13] and market based measures[14]. They also analyze the relationship between female board representation and two boards' activities, monitoring and involvement in the strategic decision-making process, which are considered their primary responsibilities.[15] 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' two 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. Further their results suggest that female directors are more influential when they reach a critical mass and are supported by other women in corporate leadership positions.

If the results that come from this approach apply to the competition policy domain, we should expect that women in the company's board of directors, senior management positions or

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

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

[15] In particular, board monitoring activities include measures of time spent devoted to board activities or tasks, board's demand for audit effort, and the extent to which boards control or influence firms' activities. Strategy involvement activities include measures of the extent to which boards influence strategy such as strategic control or strategic tasks.

director posts may have a significant effect in reducing the firm's anticompetitive behaviour, and correspondingly having women as board members may reduce cartel engagement.

Another perspective in criminology stresses that there is a lack of opportunities for women to get involved in white-collar crimes (Dodge, 2009; Benson and Simpson, 2018). 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 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.

From this second perspective, and contrary to the other view, it would follow that there is no reason to expect that a greater participation of women in corporate positions would lead to a lower incidence of cartel activity.

Promoting unbiased selection procedures and increasing corporate board diversity have recently become a major priority for most governments and international institutions. Although the gender diversity in boards has globally increased in the last two decades, women remain underrepresented in companies' supervisory and management boards.

The 2017 OECD report on gender equality points out that the share of women sitting on public listed companies' boards of directors rose between 2013 and 2016 in 80% of OECD countries. However, in most of these countries, this increase was small (OECD, 2017). Female 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.

Tyrowicz et al. (2020) analyze women's prevalence in management and supervisory boards considering a broad sample of public and private firms across 41 advanced and emerging European economies and covering a period of 20 years. Their findings 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 they have 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.[16] 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.

Two different gender quota policies have been implemented in Europe: binding legislative measures (i.e., quotas with sanctions) 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.

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

[16] According to Kirsch (2018), the literature on board gender composition covers four major research lines: potential differences between men and women on boards; factors influencing the board gender composition; the effects of board gender composition on firm performance; and policy measures regulating the composition by gender of boards.

new less experienced women directors led to a decline in operating performance. However, Eckbo et al. (2016) show that the findings by Ahern and Dittmar are not robust.

Soare et al. (2021) 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. (2018) 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.

There are other authors that study the impact of non-mandatory gender quota regulation 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 two 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.

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 sub-sample 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.

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 found that only the 4.4% of 1,023 individuals included in the consolidated database were women. They review the more relevant literature on white collar crime to find possible explanations for this low rate of women engaged in cartels.[17]

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

[17] These explanations include the lack of opportunities for women to get involved in competition law breaches, gender-based sociological and ethical differences that makes it more unlikely for women to engage in cartel behaviour in comparison to men, and a different and more lenient treatment for women by investigators and prosecutors.

We estimate econometrically the effects of women's participation in corporate boards on cartel activity, while considering the interplay between competition law enforcement and gender quota regulations. This issue together with the fact that significant changes in the gender balance of management boards are being observed, motivate this analysis. There is still a gap in the literature aiming at identifying and quantifying econometrically the effect of corporate board gender composition on cartel activity. We aim to fill this gap by identifying if changes in gender composition of firms' boards have any impact on cartel activity.

To this end, the composition of the boards of directors of companies sanctioned by cartel agreements (treatment group) and their evolution with respect to boards of firms that have not been sanctioned for participation in cartels (comparison group) are analyzed. This will make it possible to determine the causal identification of the effects of having women on boards of directors.

The managers' degree of risk aversion, as well as their adherence to moral and ethical business values, are key issues in evaluating the costs and benefits of their cartel involvement. Based on existing findings from previously discussed studies, the gender factor and particularly gender representation on corporate boards should be analyzed as a significant variable to be considered when assessing company's risk to become involved in a cartel.

Our hypothesis is that women in the company's board of directors, senior management positions or director posts may have a significant effect in reducing the firm's misbehavior, and correspondingly having women as board members may reduce cartel engagement as Santacreu-Vasut and Pike (2019) highlighted.

2. European cartels

2.1. Database

To explore the relationship between gender composition of corporate boards and cartel activity, we have worked with a dataset composed by European firms sanctioned by different competition authorities, due to their engagement in cartel cases. This information comes from the Connor (2020) database, which contains information on international cartels.

In the Connor (2020) database, a cartel is defined as "international" if either one or more alleged participant (corporate or individual) resides in, or is a national of, a different country to the investigation authority or at least two members have different nationalities.

From Connor (2020) database, we have restricted our sample to only European firms that have engaged in cartel activity since 2010 as 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.

We have added the firms' financial information using the AMADEUS database (Bureau Van Dijk) to the information already provided by Connor (2020) regarding cartelized firms. We obtained from AMADEUS database some control variables such as each firm's operating revenues, total assets, long-term debt, leverage, number of employees, average cost by employee and number of board members and senior executives in the year 2019.

In addition, 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.

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 engaged in covered cartel activity, but it has never been detected.

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.

Finally, 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). We have only examined the period from 2010-2019 because we were able to obtain information regarding boards' composition for this period, but this information is not fully available for previous years.

After incorporating the information of boards' composition, 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 boards of cartelized firms, with respect to their counterpart. We also analyze how the boards of these two groups compare before, during and after the cartel period.

2.2. Descriptive statistics

The following figures show the descriptive statistics of the matched database we have created with cartelized and non-cartelized European firms for the period 2010 to 2019. Figure 2 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. Figure 3 shows the descriptive statistics for the period before the cartel start. Given that there exist some differences between the two groups, we should be careful when comparing one group and the other as we should condition the comparisons controlling on the differences in covariates.

Figure 2. Descriptive statistics of the European database

Covariates	Obs.	Mean	Std. Dev.	Mean	Std. Dev.	Mean Differences *t-test* (Cartelized vs non-cartelized firms)
		Cartelized firms		*Non-cartelized firms*		
Operating revenues	994	27,100,000.0	51,000,000.0	8,568,678	15,100,000.0	**18,500,000.0*** **
Total assets	970	39,400,000.0	62,800,000.0	1.0500000.0	23,600,000.0	**28,900,000.0*** **
Long-term debt	997	9,469,779.0	16,600,000.0	2,039,655.0	6,869,475	**7,430,124.0*** **
Leverage	964	115.9	115.6	101.6	122.0	**14.3***
# employees	948	85,601.2	119,024.4	28,080.7	50,611.9	**57,520.5*** **
Avg. cost per employee	921	75.2	69.5	71.3	45.2	**3.9**
# board members 2019	1,110	44.8	42.9	46.1	65.1	**1.3**

Source: Authors' own elaboration. Obs.: Observations. Std. Dev.: Standard Deviation. Min: minimum. Max: maximum. t-test compares treated versus control firms. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 3. Descriptive statistics of the European database (in the period before the cartel starts)

Covariates	Obs.	Mean	Std. Dev.	Mean	Std. Dev.	Mean Differences *t-test* (Cartelized vs non-cartelized firms)
		Cartelized firms		*Non-cartelized firms*		
Operating revenues	64	25,000,000.0	53,700,000.0	4,788,501.0	7,841,314.0	**20,200,000.0** **
Total assets	64	35,600,000.0	55,800,000.0	5,310,793.0	10,700,000.0	**30,300,000.0*** **
Long-term debt	60	7,325,587.0	10,100,000.0	1,297,065.0	3,532,246.0	**6,028,522*** **
Leverage	56	91.3	86.5	111.4	120.7	**-20.1**
# employees	64	53,012.2	77,357.8	21,702.5	47,267.2	**31,309.8***
Avg. cost per employee	63	81.7	87.9	67.1	48.8	**14.6**
# board members 2019	78	46.3	46.0	54.2	73.4	**-7.9**

Source: Authors' own elaboration. Obs.: Observations. Std. Dev.: Standard Deviation. t-test compares treated versus control firms. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

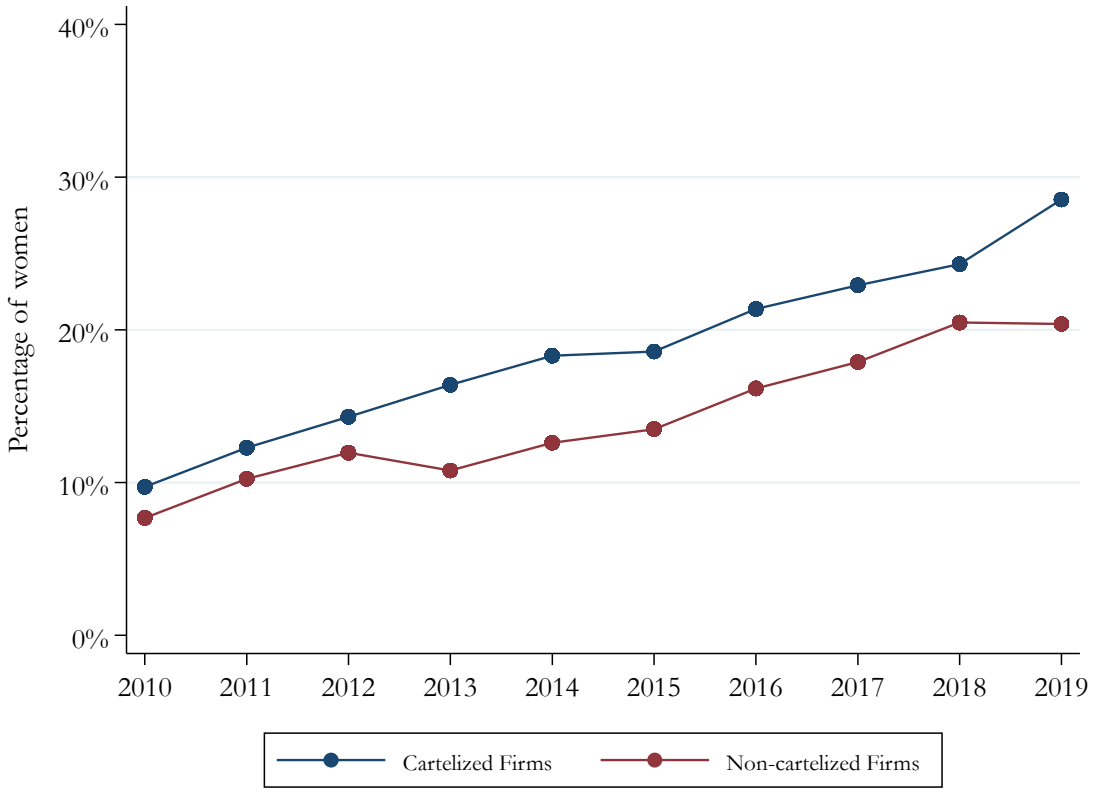
2.3. Gender composition of boards in cartelized and non-cartelized firms

Our main variable of interest is the presence of women on boards of directors, measured as the number of women over the total number of boards' members in any given year. Figure 4 shows the average percentage of women in boards of directors over time in the period 2010-2019, for the cartelized and non-cartelized firms included in our sample.

Our database allows us to offer a new estimate on the average percentage of women in a sample of European firms which have, according to Connor's (2020) database, whether engaged or not in cartel activity between 2010 and 2019.

On average, the percentage of women in European corporate boards has increased from around 9% in 2010 to around 25% by 2019. So, the presence of women in corporate boards has had a clear increasing trend during the 2010-2019 period. Additionally, we can have a look at whether this trend differs for cartelized and non-cartelized firms. In cartelized firms, the percentage of women in corporate boards has increased from 10% in 2010 to 29% in 2019, while in the case of non-cartelized firms these figures have increased from 8% to 20%.

Figure 4. Average presence of women on boards by type of firms

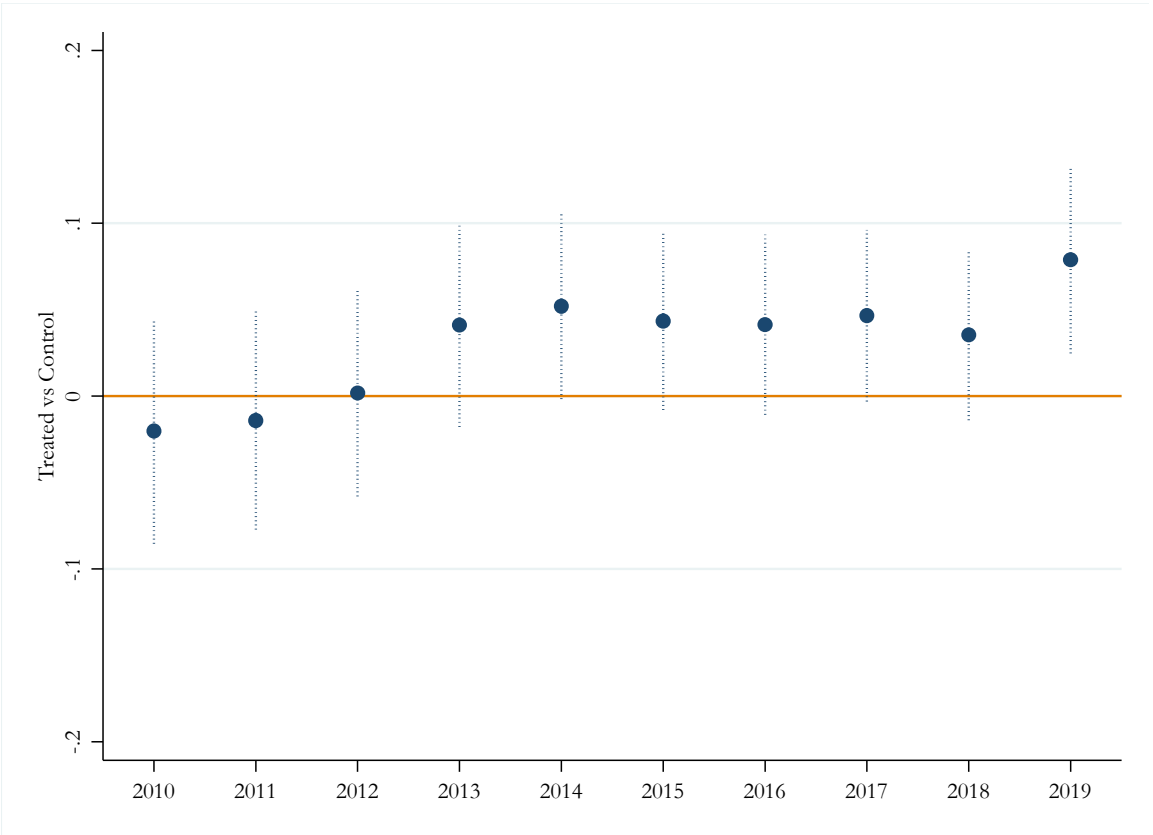


This figure represents the percentage of women on boards of directors of European cartelized and non-cartelized firms in our database over time. On average, the percentage of women in European corporate boards has increased from around 9% in 2010 to around 25% by 2019, showing a clear increasing trend during the 2010-2019 period. In cartelized firms, the percentage of women in corporate boards has increased from 10% in 2010 to 29% in 2019, while in the case of non-cartelized firms these figures have increased from 8% to 20%.

Source: Authors' own elaboration.

While the presence of women seems to be slightly higher in cartelized firms than in non-cartelized firms, we then checked whether this difference is statistically significant or not. We found that the mean difference in the share of women in corporate boards is not statistically significant when comparing European cartelized versus non-cartelized firms by year, except for the last year of the sample, 2019, as shown in Figure 5.[18]

Figure 5. Conditional mean differences in the presence of women on boards in cartelized versus non-cartelized firms.



The figure represents the conditional mean difference in the share of women in corporate boards of European cartelized versus non-cartelized firms by year. These differences have been estimated using a regression including firms' characteristics, country fixed effects and year fixed effects as controls, and they are not statistically significant, except for the year 2019.

Source: Authors' own elaboration.

Once we have this information, the next question of interest is to know how the presence of women in boards of directors of cartelized firms has changed before, during and after the cartel period, and whether there exist differences with respect to matched non-cartelized firms.

Figure 6 below summarizes the percentage of women on boards of cartelized and non-cartelized firms during the three different stages of the cartel life: before the cartel starts, during the cartelization period and after the cartel breakup.

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

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

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.

As discussed earlier, some recent studies indicate that cartel sanctions lead to management positions restructuring (Rosenboom, 2012; Campello et al. 2017; Artiga González et al., 2019). So, 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.

These non-controlled simple mean comparison statistics point out two different important facts that are novel. First, the presence of women increases over time, even during the cartel life. Second, only after the cartel breakup, the presence of women is significantly higher in cartelized firms than in non-cartelized firms. This is a very interesting and salient evidence coming from our novel matched database containing European firms, cartelized and similar non-cartelized firms, between 2010 and 2019.

Figure 6. Mean difference in the presence of women on boards in cartelized versus non-cartelized firms before, during and after cartel engagement

% women on boards	Cartelized	Non-Cartelized	Mean Differences. *t-test* (Cartelized vs non-cartelized firms)
Before Cartel	0.12 (0.10)	0.09 (0.10)	0.03 (0.02)
During Cartel	0.16 (0.10)	0.14 (0.12)	0.02 (0.01)
After Cartel	0.23 (0.16)	0.16 (0.13)	0.07 (0.01)***

Source: Authors' own elaboration. T-test compares mean equality of cartelized versus non-cartelized firms. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 7 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.19

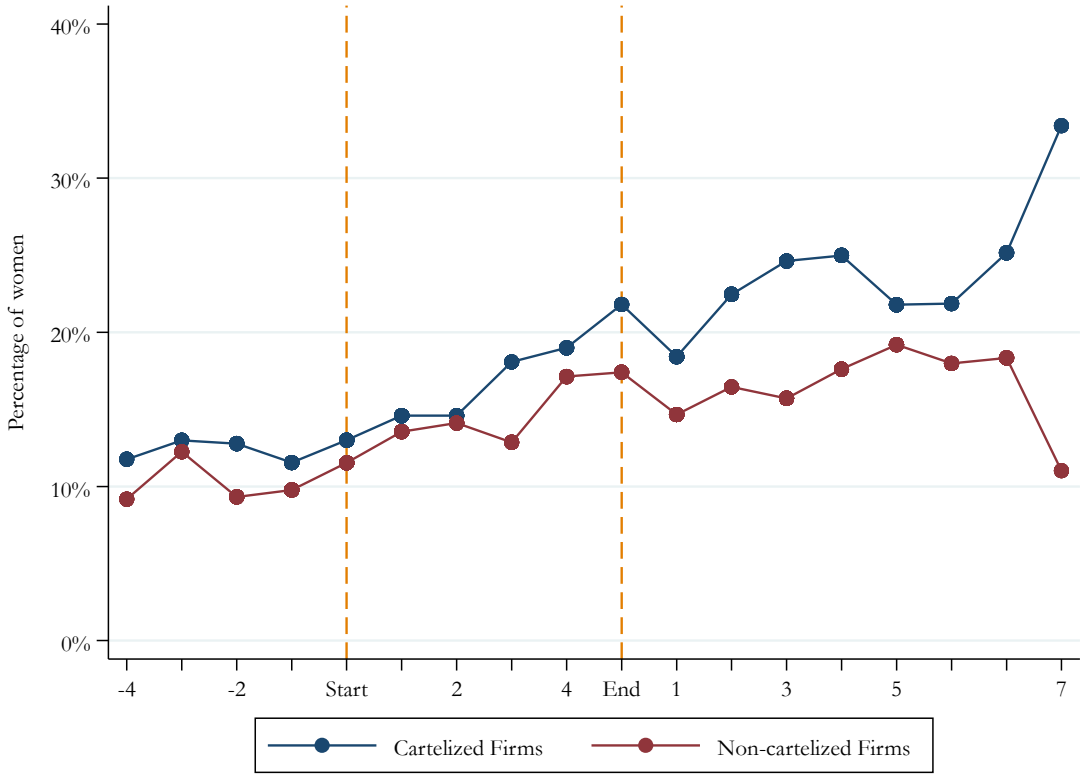
When analyzing the cartel life, the presence of women is similar in both groups of firms before the cartel starts; while during the cartel period, the presence of women increases in both groups. However, after the cartel breakup, the presence of women is higher in the group of cartelized firms than in the group of non-cartelized firms. And this is where the complementarities between competition policy and gender policy show up.

This graphical analysis is then not supporting our starting hypothesis that more women in corporate boards might reduce on average cartel engagement: this is because, (1) the percentage of women in boards seems to follow the same increasing trend in cartelized and non-cartelized firms before and during the periods in which the cartelized firms engage in the anticompetitive illegal conduct; and (2) differences in percentage of women between cartelized and non-cartelized firms are not statistically significant. So, there is no evidence of any difference in the balance of gender in boards, that might eventually have an impact on cartel engagement of firms.

By contrast, we do find differences in gender composition of boards after cartel investigation is publicly announced or the cartel breaks up: cartelized firms have more women in boards after the cartel is busted.

[19] 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.

Figure 7. Average presence of women on boards by group of firms and cartel life



The figure shows the percentage of women on boards for European cartelized and non-cartelized firms for each period before, during and after the cartelization period. The cartel end date refers to the earliest event: cartel breakup or authorities' first notice.

Source: Authors' own elaboration.

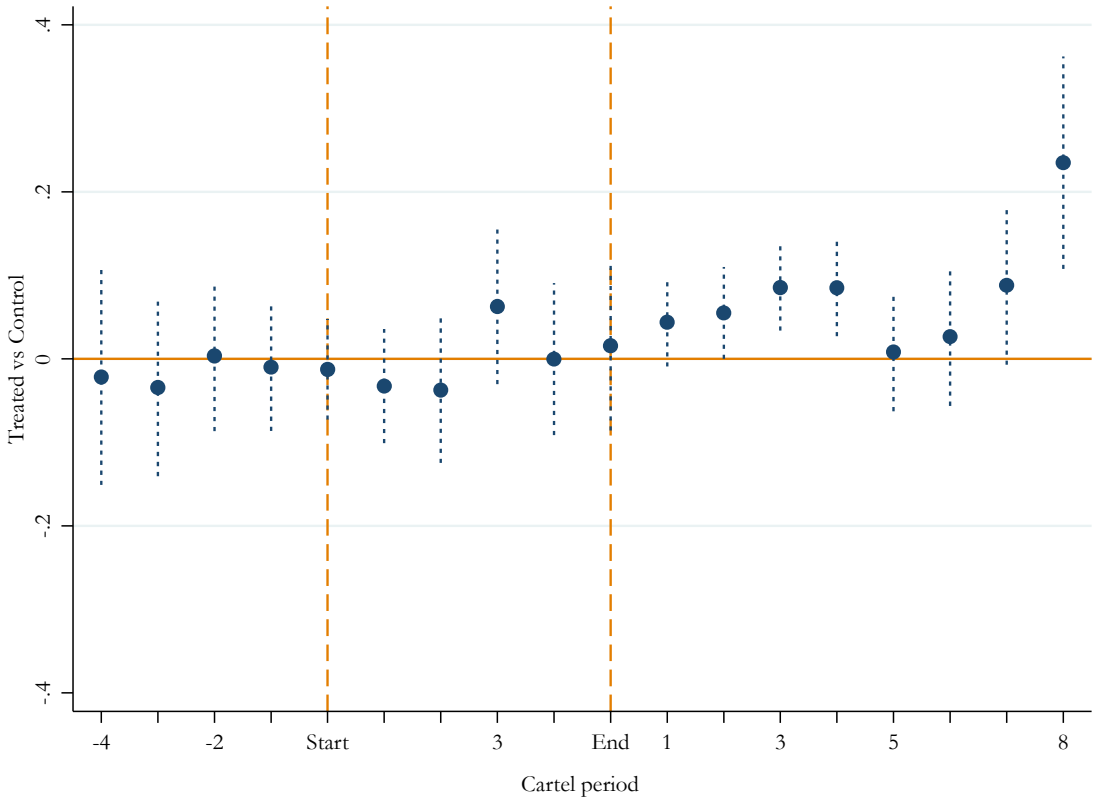
The following Figure 8 analyzes conditional mean differences in the percentage of women of cartelized and non-cartelized firms and whether they are significant in each period controlling for other covariates.[20]

The mean conditional differences between the two groups are not statistically significant before the cartel starts nor during the cartel period. However, significant mean differences are found after the cartel breakup (from the second year until the fourth year after the cartel breakup or disclosure), indicating that cartelized firms have a higher presence of women than non-cartelized firms just after breakup or disclosure.

This is a result we did not expect. Statistically significant differences in the percentage of women in the boards of those firms that engaged in cartels and were sanctioned appear only after the cartel is busted and ended, not before or during cartel engagement.

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

Figure 8. Conditional mean differences in the presence of women in cartelized vs non-cartelized firms by cartel period



The figure represents the conditional mean differences in the percentage of women of European cartelized versus non-cartelized firms. These differences have been estimated using a regression including country fixed effects and firms' characteristics as controls. The mean conditional differences between the two groups are not statistically significant before the cartel starts nor during the cartel period, while significant mean differences are found after the cartel breakup: years 2, 3, 4 & 8 after cartel ends. The cartel end date refers to the earliest event: cartel breakup or authorities' first notice.

Source: Authors' own elaboration.

2.4. Gender quotas

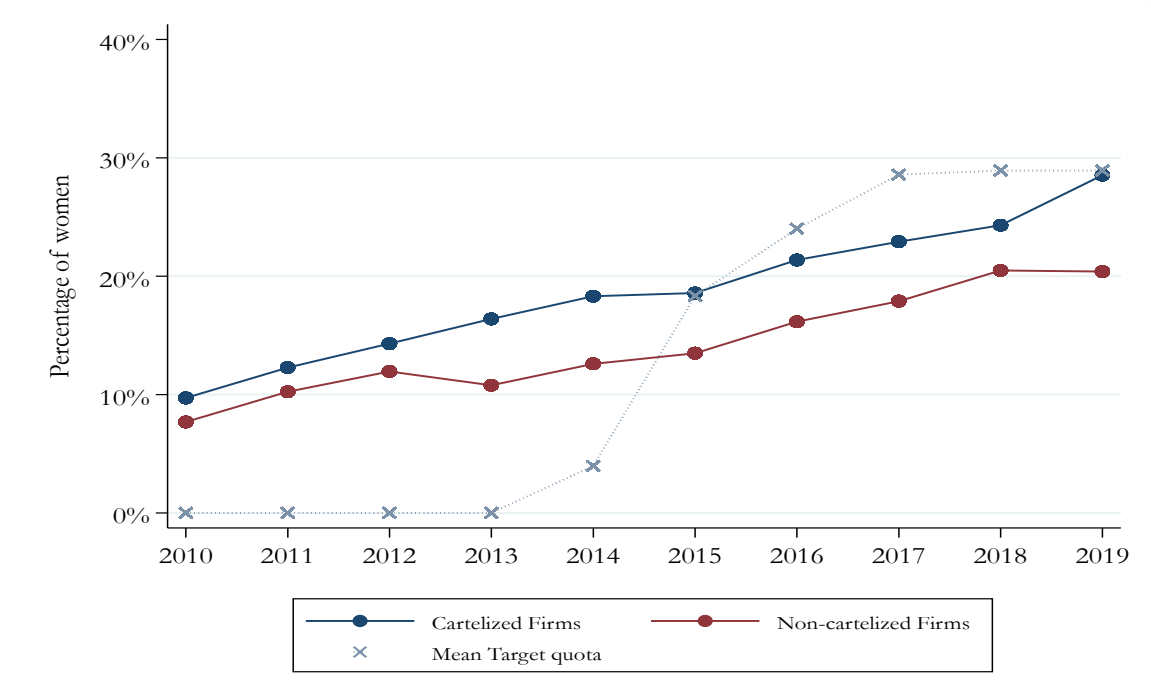
The driver explaining the increase in the presence of women on boards over time could be the implementation of target quotas in the countries of our sample. Bennouri et al. (2020) show that while the percentage of women on boards generally increases after the introduction of the regulation, this effect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

As we have exposed in the introduction section, two 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 in corporate boards in France (2014, 2017), Italy (2015), Germany (2016), Belgium (2017) and Portugal (2017), where the years in brackets represent the target compliance year. On the contrary, targets are non-binding in Austria (2018), Spain

(2015), United Kingdom (2015) and Sweden, where again the years in brackets represent the target compliance year. However, the regulations were passed in: Sweden in 2004; Spain in 2006; Austria, Belgium, and Germany in 2009; France in 2010; Italy in 2011; United Kingdom in 2012; Portugal in 2015. While there was no gender policy in Switzerland in the period 2010-2019[21]. 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, as represented in the following graph (Figure 9).

Figure 9. Average presence of women on boards by group of firms, and mean gender quotas



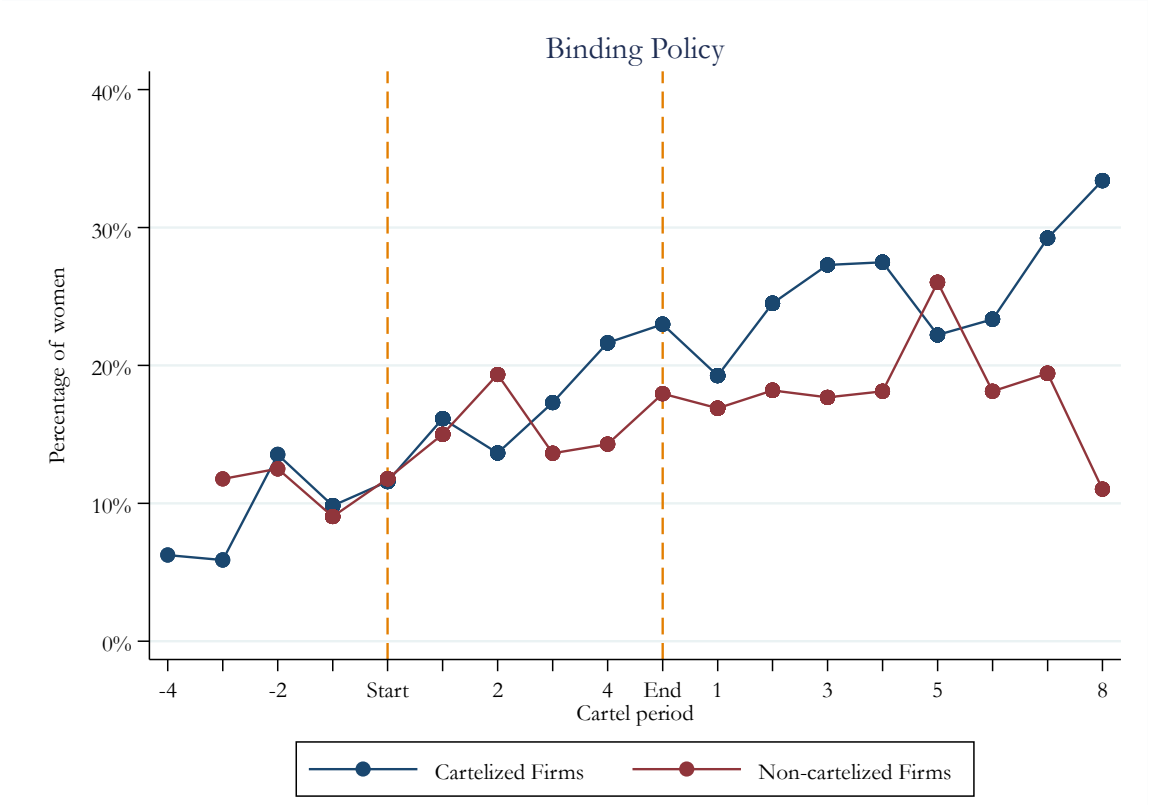
This figure represents the percentage of women on boards of directors of European cartelized and non-cartelized firms in our database over time. The percentage of women in European corporate boards shows a clear increasing trend during the 2010-2019 period. In cartelized firms, the percentage of women in corporate boards has increased from 10% in 2010 to 29% in 2019, while in the case of non-cartelized firms these figures have increased from 8% to 20%. Mean target quotas (binding and non-binding) in our European firms database, calculated according to the target compliance year, have increased from 0% in 2010 to close to 30% in 2019.

Source: Authors' own elaboration based on the information of country gender quotas gathered from Smith (2014 & 2018), Terjesen et al (2015), European Commission (2016) and country legislation.

Thus, a deeper analysis aiming at identifying the effects of binding and non-binding policy quotas is carried out in this subsection. To do so, we repeat the analysis developed in the previous section. We look at the evolution of the presence of women on boards over the cartel life, and at whether there exist significant differences between cartelized and non-cartelized firms. However, we now separate the analysis for firms from countries applying binding quotas and for firms from countries applying non-binding quotas.

[21] Regulation passed in September 2020, and compliance year is 2021.

Figure 10. Average presence of women on boards by group of firms and cartel life in countries with binding quotas

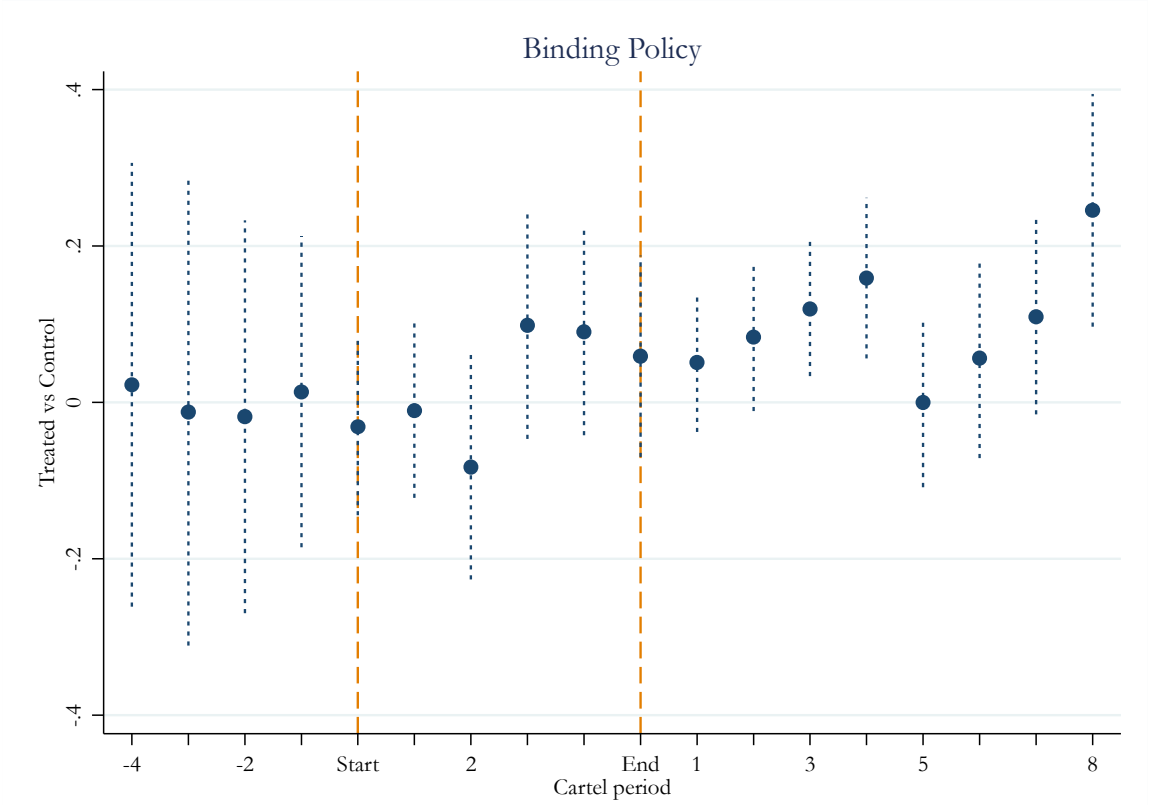


The figure shows the percentage of women on boards for cartelized and non-cartelized firms for each period before, during and after the cartelization period, only for those countries with binding policy (France, Italy, Germany, Belgium and Portugal). The cartel end date refers to the earliest event: cartel breakup or authorities' first notice.

Source: Authors' own elaboration.

These two figures (Figure 10 and 11) show that the percentage of women on boards is significantly higher in cartelized than in non-cartelized firms after the cartel breaks up in the countries applying binding quotas.

Figure 11. Conditional mean differences in the presence of women in cartelized vs non-cartelized firms in countries with binding policy.

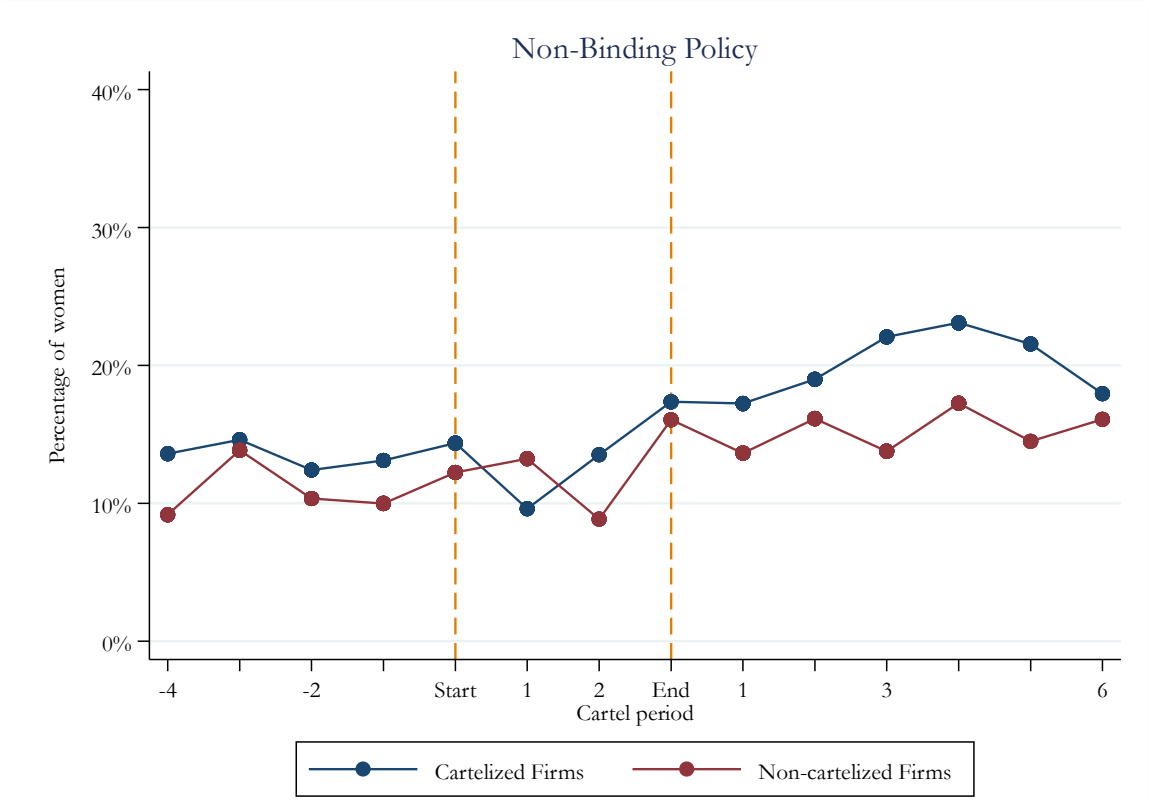


The figure represents the conditional mean differences in the percentage of women of cartelized versus non-cartelized firms, only for those countries with binding policy (France, Italy, Germany, Belgium and Portugal). These differences have been estimated using a regression including country fixed effects and firms' characteristics as controls. The mean conditional differences between the two groups are not statistically significant before the cartel starts nor during the cartel period, while significant mean differences are found after the cartel breakup. The cartel end date refers to the earliest event: cartel breakup or authorities' first notice.

Source: Authors' own elaboration.

However, when analysing countries with non-binding quotas, as represented in the following figures (12 and 13), the presence of women on boards seems also to be higher in cartelized than in non-cartelized firms. Nevertheless, this difference is not statistically significant.

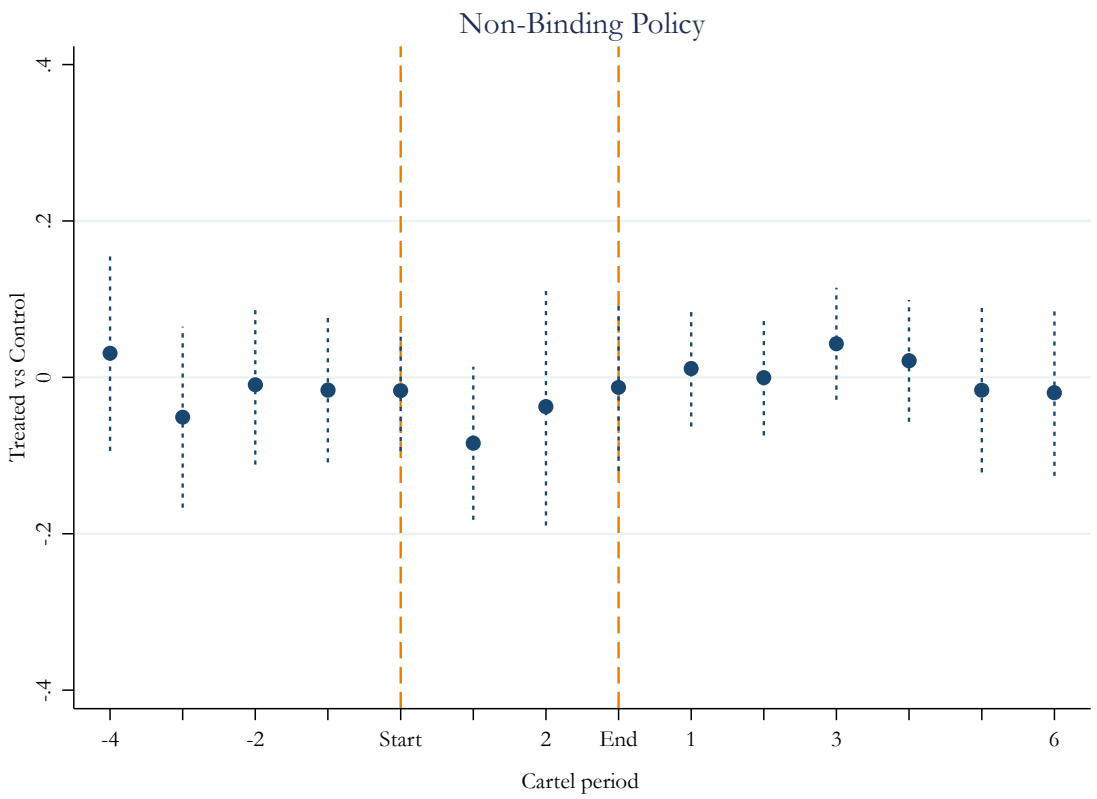
Figure 12. Average presence of women on boards by group of firms and cartel life in countries with non-binding gender quotas



The figure shows the percentage of women on boards for cartelized and non-cartelized firms for each period before, during and after the cartelization period, only for those countries with non-binding policy (Austria, Spain, United Kingdom and Sweden). The cartel end date refers to the earliest event: cartel breakup or authorities' first notice.

Source: Authors' own elaboration.

Figure 13. Conditional mean differences in the presence of women in cartelized vs non-cartelized firms in countries non-binding gender quotas



The figure represents the conditional mean differences in the percentage of women of cartelized versus non-cartelized firms, only for those countries with non-binding policy (Austria, Spain, United Kingdom and Sweden). These differences have been estimated using a regression including country fixed effects and firms' characteristics as controls. The mean conditional differences between the two groups are not statistically significant in any period of the cartel life. The cartel end date refers to the earliest event: cartel breakup or authorities' first notice.

Source: Authors' own elaboration.

Summarizing, this section shows that the presence of women on boards is higher in cartelized than in non-cartelized firms after the cartel breakup. Moreover, this effect is only present in the countries that have implemented binding gender quotas. This effect 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. However, we do not have enough evidence to check whether this is the driver of the compliance by sanctioned firms after cartel break-up.

We will next continue to check whether the presence of women induces cartel breakup, but the data seems not to support that hypothesis. The data shows that the presence of women increases after cartel breakup as board restructuring is balancing gender composition. In the following sections, we explain the methodology followed to further analyze these questions, to identify better gender and anti-cartel policies complementarities.

2.5. Estimates

As we have mentioned before, the percentage of women in boards and cartel activity are two variables that are probably simultaneously determined. In this research paper we present evidence regarding the impact of one on the other using different techniques.

Concretely, we first use a simple logit model to assess the impact of the percentage of women in boards on cartel activity: cartel creation and cartel breakup. As the changes of this percentage is gradual across time, this logit model allows us to assess to what extent having more women on average on corporate boards leads to cartel activity for some firms with respect to their matched firms. However, we have not been able to disentangle the direction of causality. We cannot attribute causality in one or the other direction (gender balance on cartel activity, or cartel activity on gender balance) with this simple logit. We just have a look at the conditional correlation among these variables using the simple logit.

Over the long run, it might also be the case that cartelization affects, as part of the literature suggested, corporate board composition. And, particularly, in countries with binding gender quotas, we may find significant changes to the percentage of women in corporate boards once cartels are uncovered and sanctioned as discussed before. So, we will use a difference-in-difference estimation to assess the impact of cartel creation and breakup on the percentage of women on boards.

However, we find that binding gender quotas is strongly affecting board composition after cartel breakup. The explanation and the previous data shown graphically is more consistent with cartel sanctioning driving changes in corporate board gender composition. This will be expanded on later. 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 in boards. This allows us to suggest causality in the difference-in-difference estimate of the impact of cartel busting on the percentage of women in corporate boards.

2.5.1. Logit Model

We want to assess better whether the increase in the presence of women on boards affects cartel formation or cartel breakup. For this purpose, we run two different logit models for different dependent variables. In all of them, the explanatory variable is always the same: the percentage of women on boards.

However, the dependent variable in each of the two logit models we estimate takes the following values:

1. Cartel period & Cartelized Firms: takes value 1 for cartelized firms during its cartelization period, and 0 before and after cartel. This variable also takes value 0 for non-cartelized firms for all the periods: before, during and after its matched cartelized firm had been cartelized.

2. After cartel & Cartelized Firms: takes value 1 for cartelized firms after its cartelization period, and 0 before and during the cartel. This variable also takes value 0 for non-cartelized firms for all of the periods: before, during and after its matched cartelized firm had been cartelized.

We show the estimations of the logit model with these two dependent variables to compare results, controlling for firm covariate characteristics, country fixed effects and year fixed effects.

2.5.2. Difference-in-Differences Estimator

In our case, 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.

This method allows to control for unobserved differences between treated and control observations and for common shocks through the variables cartelized and period. In particular, the following regression is run on the constructed matched sample:

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

where

where Y_{ijt} is the percentage of women in the boards of directors in firm *i*, at 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; $Cartel\ Period_t$ takes value 1 the years in which the treatment took place and 0 before and after; $Cartelized_i * Period_t$ is the interaction of the previous two dichotomous variables, so it takes value 1 for the cartelized firm during the period in which it was cartelized and 0 before and after; $Period\ After_t$ 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 before and during the cartel; w_{it} represents firms' observable characteristics in each year[22]; α_j represents country fixed effects, constructed as a dummy variable representing each country, which takes value 1 for the corresponding country and 0 otherwise; δ_t represents time fixed effects; 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 two groups are the same in the absence of intervention. The figures included in the previous section show that there is no significant difference in the outcome of interest between the two groups (cartelized and non-cartelized firms) in the period before the cartel starts. So, we can focus the analysis in the question of whether there is a significant change in gender board composition during or after firms engage in cartel activity.

In order to further explore the question of interest, we estimate equation (1) considering alternative specifications with respect to the baseline model. Thus, we include in separate models variables related to the gender quotas implemented in different countries. 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; *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 two variables. These model specifications will allow us to understand whether the effect on the presence of women on

[22] Control variables described in Figure 3.

boards comes only from binding quotas or the corresponding target, or also from the cartel engagement.

2.6. Results

The logit regressions show that an increase in the presence of women does not have an impact on the probability of forming a cartel, finding no significant effect in this case. By contrast, when analyzing the probability of cartel breakup, we find a positive and significant effect from the presence of women on the probability of cartel breakup (see Figure 14). The logit model estimation results show the positive correlation between the presence of women and the probability of cartel breakup. As discussed before, we do not attribute causation to this found correlation.

Figure 14. Logit Model

	Probability (Cartel Formation)	Probability (Cartel Breakup)
Percentage of women	0.75	**4.616*** **
	(1.309)	**(1.096)**
Firms' characteristics	Yes	Yes
Country Effects	Yes	Yes
Year Effects	Yes	Yes
Pseudo-R^2	0.2235	0.3404
N	479	612

Source: Authors' estimates

By contrast, also as discussed before, the difference-in-differences estimator is more prone in our setting to identify a causal effect of cartel busting on the percentage of women in boards of cartel sanctioned firms.

Results show clearly that there is not significant change in the percentage of women in corporate boards during the firm's engagement in cartel activity (Figure 15). However, the difference-in-difference model very clearly and significantly shows that there is a substantial change in the percentage of women in boards of cartelized firms after cartel busting (break up or first public notice of cartel investigation).

Thus, we can conclude 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. 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.

Figure 15. Difference-in-Differences Estimator. Percentage of women in corporate boards

	Model (1)	Model (2)	Model (3)	Model (4)
Cartelized	0.001	-0.004	-0.004	-0.003
	(0.023)	(0.025)	(0.025)	(0.025)
Cartel Period	0.012	0.012	0.013	0.015
	(0.021)	(0.023)	(0.023)	(0.023)
DiD Cartel Period	**-0.008**	**-0.001**	**-0.001**	**-0.002**
	(0.028)	**(0.031)**	**(0.031)**	**(0.031)**
Period after Cartel	-0.024	-0.020	-0.020	-0.015
	(0.023)	(0.025)	(0.025)	(0.025)
DiD after Cartel	**0.064****	**0.068****	**0.068****	**0.067****
	(0.026)	**(0.028)**	**(0.028)**	**(0.028)**
Binding Quota		**0.202*****		
		(0.045)		
Target Quota			0.039	
			(0.076)	
Binding*Target Quota				0.040
				(0.056)
Constant (β_0)	-0.083**	-0.082**	-0.074*	-0.082**
	(0.036)	(0.038)	(0.041)	(0.038)
Firms' characteristics	Yes	Yes	Yes	Yes
Country Effects (α_j)	Yes	Yes	Yes	Yes
Year Effects (δ_t)	Yes	Yes	Yes	Yes
R^2	0.4354	0.4318	0.4320	0.4323
N	622	564	564	564

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Source: Authors' estimates

It is unclear whether this effect comes only from cartelization, or also from implementing gender quotas policies at country level. Separate estimations for countries with binding and non-binding quotas are presented in the following figure (Figure 16), together with the fully saturated model.

Results are slightly weaker, due to the small sample, but we can confirm that the effect comes from the implementation of binding quotas, finding no significant effect in the case of countries with non-binding quotas (see bolded coefficients, which are those referring to β_3 and β_5 from previous equation).

Figure 16. Difference-in-Differences Estimator. Countries with binding or non-binding gender quotas

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Non-binding policy						
Cartelized	0.008	0.003			0.010	0.005
	(0.025)	(0.025)			(0.028)	(0.029)
Cartel Period	0.023	0.024			0.018	0.018
	(0.024)	(0.024)			(0.027)	(0.027)
DiD Cartel Period	**-0.042**	**-0.035**			**-0.042**	**-0.038**
	(0.035)	**(0.034)**			**(0.040)**	**(0.040)**
Period after Cartel	-0.002	-0.000			-0.007	-0.009
	(0.029)	(0.030)			(0.027)	(0.029)
DiD after Cartel	**0.003**	**-0.004**			**0.006**	**0.000**
	(0.029)	**(0.030)**			**(0.034)**	**(0.035)**
Binding policy						
Cartelized			-0.022	-0.037	-0.036	-0.037
			(0.066)	(0.066)	(0.065)	(0.065)
Cartel Period			0.031	0.010	0.015	0.004
			(0.062)	(0.062)	(0.059)	(0.059)
DiD Cartel Period			**0.036**	**0.055**	**0.078**	**0.082**
			(0.071)	**(0.071)**	**(0.074)**	**(0.074)**
Period after Cartel			-0.009	-0.031	0.004	-0.006
			(0.062)	(0.062)	(0.056)	(0.058)
DiD after Cartel			**0.115***	**0.131***	**0.119***	**0.133***
			(0.069)	**(0.069)**	**(0.070)**	**(0.070)**
Binding Quota					**0.216*****	**0.292**
					(0.071)	**(0.302)**
Constant	-0.114	-2.084	0.142**	-5.296**	-0.068*	-4.210***
	(0.036)	(3.481)	(0.081)	(2.357)	(0.039)	(1.409)
Firms' characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Country characteristics	No	Yes	No	Yes	No	Yes
Country Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.4125	0.3907	0.4557	0.4769	0.4477	0.4532
N	270	252	294	294	564	546

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Summarizing, the descriptive statistics and the logit model estimation show the correlation between cartel breakup and gender of corporate boards of cartelized firms. And the difference-in-difference estimations for a sample of European cartelized and non-cartelized firms give us the causal impact of the cartel break up on a significant change of the gender balance in corporate boards of cartel sanctioned firms. Once the cartel has broken, 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), increases. This fact takes place only in countries with binding gender quotas, so we can conclude that only binding quotas are effective in balancing gender in boards prone to restructure after cartel busting.

3. Spanish cartels

The previous section has used a database comprised by European firms participating in international cartels. The empirical strategy implemented has let us find the impact of cartel busting on corporate board restructuring, with a more gender balanced leaning in the countries with binding gender quotas. A single country micro-analysis may help us to find additional evidence to support the previous findings. For this reason, we focus on the case of Spain as we have managed to obtain more detailed information on the appointments and dismissals of members of corporate board of directors and senior management during the last decade.

3.1. Database

We have detailed information on more than 800 firms that have been sanctioned in Spain by the competition authority because of its engagement in cartel activity. From this, we have been able to build a new database with the full financial information, corporate board and senior management designations and dismissals for 182 cartelized firms and 175 matched similar firms that have not been sanctioned for cartel activity.[23]

In this database, we can fine tune the matching method, so we end up with a better comparison non-cartelized firms for each of the cartelized firm.

To study the question of interest, a panel dataset has been collected from the Iberian Balance sheet Analysis System (SABI), which is a tool developed by Bureau Van Dijk (the same provider of the European database AMADEUS).

SABI contains information about the balance sheets of Spanish firms. We had access to the information of the 21,514 largest Spanish firms measured as the Operating Revenues in the year 2019. The biggest firm earned €23 billion in Operating Revenues in 2019 and the smallest earned €14m.

While firms participating in cartels sanctioned by the Spanish Competition Authority may be incorporated in Spain or not, given that we use SABI for getting firm's financial information and to find the match, we end up with Spanish incorporated firms only. Still, those firms may be subsidiaries of international firms (around 30% might be subsidiaries), but since the firms are incorporated under Spanish law they are only subject to gender quotas set by Spanish law, which have been voluntary, that is, non-binding.

So, studying the case of Spain allows us to identify the impact of gender composition on cartel activity in a country with non-binding gender quotas. Therefore, in this section we would like to delve deeper into the analysis detailed in Figure 16.

In the case of Spain, we have been able to obtain detailed information on the exact dates of appointments, dismissals, or termination of any member of the board of director and senior management position between 1998-2018 for all firms considered. The company *INFOEMPRESA* published information online about each firm's corporate board appointments, dismissals, or termination of senior management positions. We web scrapped that information to create the set of cartelized and non-cartelized comparison firms.

For some, we only got the information of the appointment which could mean that the senior management position had not been terminated by the end of 2018 (last year of the appointment and dismissal data). For others, we got only information of the dismissal or termination date, so the appointment of that senior manager was before 1998 (the first year of the appointment and

[23] The analysis only focuses on firms that have been cartelized once during the period sample, so repeated offenders are excluded. If a firm is involved in many cases at the same time or over time, the intensity of treatment is different for these observations. In addition, the effect of interest may not be linear with respect to the number of cases in which the firm has been involved.

dismissal data). Unfortunately, we do not know the number of members in boards for each year. In SABI there is information only for the last sample year: 2019.

For each appointment, dismissal, or termination, *INFOEMPRESA* provided us with the detailed information regarding the senior management position: member of the board, director, chief executive officer, chief financial officer, treasurer, secretary of the board, and so on.

We had to work hard to clean and structure the web-scraped database that contained more than 98,000 observation. The name of the person appointed or dismissed appeared sometimes with some minor variations, different name/surname order, and the web scraped database was classifying those persons with different identification numbers. The name of the companies also appeared with different slight variations.

To identify the gender of the appointee or dismissed person, we matched our database with the database provided by the Spanish Statistical Institute which provides the names and gender of Spanish citizens. We also double checked the matching outcome and cleaned the data to guarantee the correctness of the gender allocation.

We ended up with a database with all the appointments and terminations of senior managers by gender, by firm, and year. We were able then to merge this database with the database containing the cartelized and non-cartelized firm's financial information from SABI.

With respect to the data on cartels, we have information regarding all cartel cases sanctioned by the Spanish Competition Authority.[24] A certain number of the cases were discovered due to investigations started by the Authority's own initiative or complaints and the rest have been detected under the Leniency Program[25]. From the reports, information regarding the date of formation and breakup of the cartel can be obtained.

The date of formation refers to the first moment for which the Authority has evidence of the existence of the cartel. The breakup date is either the date in which the cartel died naturally, or the date in which they were caught and had to stop colluding. In addition, there is information about which firms participated in the case and in which period they were a member of the cartel. There are around 1,000 cartelized firms that have been sanctioned in the 1990-2019 period.

Therefore, it can be distinguished which firms have participated in a collusive agreement (*cartelized*) from those that either have never participated in a cartel or have not been discovered yet (*non-cartelized*). The fact that there may exist cartelized firms that we cannot classify as such is one of the limitations of any data set when working with this type of cartel sanctioning information. As discussed previously in the European cartel cases, the fact that some comparison firms may have engaged in covert cartel activity without being sanctioned makes our task more difficult as the estimates may tend to be downward biased.

Before building the matched sample, outliers belonging to the upper and lower tails of the distribution are dropped from the sample. The reason for doing this is that a good counterfactual may not exist for these observations. As we are working with firms, an outlier in terms of firms' observable characteristics could drive the results of the estimation and having a good counterfactual for the cartelized firms is crucial for the validity of the results. This is a common procedure in the literature when working with firm-level data.

To build the matched sample, the matching has been performed five years before the treatment takes place. For example, if a firm starts being a member of a cartel in 2000, the matching is performed in the year 1995, using the characteristics of both firms (cartelized and non-

[24] More information about the data can be found in Borrell, Jiménez and Ordóñez-de-Haro (2015), or in Ordóñez-de-Haro, Borrell and Jiménez (2018) for the European case.

[25] This policy offers companies involved in a cartel either total immunity from fines or a fine reduction if they self-report the existence of the cartel or if they cooperate with the Authority.

cartelized) in that year. Then, it can be tracked the evolution of the outcomes of *cartelized* and *non-cartelized* firms over time. An exemption is made with those firms that started participating in a cartel agreement in 1995 and 1996. Given that the sample starts in 1992, the matching for these firms was made three and four years before the start of the treatment, respectively[26]. Moreover, given that the matching should be done on pre-treatment characteristics, it has been excluded from the analysis those cartel cases that started before 1995.

The non-parametric nearest neighbor matching method has been used. Imbens and Wooldridge (2009) define the algorithm. Let Y_i denote the outcome of interest, let X_i be the observable characteristics on which we are matching and let C_i be the treatment variable. Given a sample $\{Y_i, X_i, C_i\}_{i=1}^{N}$, let $\ell_1(i)$ be the nearest neighbor to *I*, that is:

$$\ell_1(i) = j, \qquad for\ j \in \{1, \dots, N\}, \qquad if\ C_i \neq C_j\ \ and\ \left\|X_j - X_i\right\| = \min_{k:\, C_k \neq C_i} \|X_k - X_i\|$$

where the metric used is the Mahalanobis metric, which is based on the inverse of the full sample variance-covariance matrix and is the most common in the literature. In addition, the option *exact* in Stata has been specified for one of the characteristics (see below). Following Abadie et al. (2004), this option allows to specify exact, or as exact as possible, matching on one or more variables. In practice, it multiplies the corresponding elements in the weight matrix by 1,000 relative to the weights placed on the other variables; and in this case, the inverse sample standard errors are used for the variables specified in *exact*.

The observable characteristics used for the matching are based on the firms' financial conditions that have been found to predict cartel participation in the literature. Bertrand, Lumineau and Fedorova (2014) find that firms with relatively larger market share are more likely to participate in cartels whereas firms with high liquidity ratio are less likely to participate in cartels. They do also find that relatively older firms tend to participate more in cartels and that firm's size is positively related to the likelihood of participating in a cartel, although this effect varies with industry concentration.

In this case, we match *cartelized* and *non-cartelized* firms on the following observable characteristics: age, indebtedness (or debt ratio), the ratio of long-term debt over total assets, leverage, sector (at two digits level), costs of employees, the ratio of costs of employee over operating revenues, the solvency ratio, and total assets. This last variable was used in the *exact* option, which means that the size of the firm is the most relevant variable when looking for a good control.

The variable total assets accounts for firm's size and is related to profitability, whereas the long-term debt over assets controls for the loans and financial obligations lasting over one year with respect to the firms' assets. In addition, two different measures of the company's leverage are used. On the one hand, the debt ratio (or indebtedness) compares a company's total debt to its total assets. On the other hand, leverage is the level of a company's debt related to is equity capital and is expressed in percentage form. It shows the extent to which its operations are funded by lenders versus shareholders.

Finally, two measures of personnel expenses are considered: costs of employees and the ratio of costs of employee over operating revenues, measured in levels and in percentage, respectively. Symeonidis (2008) finds no evidence of any effect of collusion on wages, although he shows that there exists a negative effect of collusion on labor productivity growth. For this reason, we look for a firm in the control group that has similar costs of employees to the cartelized firm before the treatment to control for firm's efficiency.

[26] There are 2 cartel cases in 1995, which involve four firms; and 1 cartel case in 1996, which involves 3 firms.

3.2. Descriptive statistics

The following figures show the descriptive statistics of the matched database we have created with cartelized and non-cartelized incorporated firms in Spain for the period 1998 to 2018. Out of the total 815 firms sanctioned by the Spanish Competition Authority, we have been able to obtain the data from SABI, appointments and terminations for 182 cartelized firms, and for 175 matched non-cartelized comparison firms.

Figure 17. Number of firms in the Spanish database

	All cartelized sanctioned by the Spanish Competition Authority	Cartelized firms in the matched database	Non-Cartelized firms in the matched database
# companies	815	182	175
Cartel duration (months)	68.6 (69.6)	59.0 (55.9)	-
Cartel duration (years)	5.5 (5.9)	4.7 (4.7)	-

Source: Authors' own elaboration

The following figure also shows that one group and the other group of firms have significant mean differences in terms of operating revenues, total assets, debt ratios, number of employees, average cost per employee and number of board members.

Figure 18. Descriptive statistics of the Spanish database

Covariates	Obs.	Mean	Std. Dev.	Mean	Std. Dev.	Mean Differences *t-test* (Cartelized vs non-cartelized firms)
		Cartelized firms		*Non-cartelized firms*		
Operating revenues	6,734	173,735.1	589,730.7	118,850.3	473,423.3	**54,884.9*** **
Total assets	6,757	130,303.5	383,495.9	94,789.1	251,423.2	**35,514.4** ***
Debt ratio	6,757	65.9	30.2	63.4	20.9	**2.4** ***
Leverage	6,757	247.0	7,359.8	137.3	606.6	**109.6**
# employees	6,446	413.1	1,637.3	233.4	460.7	**179.7** ***
Avg. cost per employee	6,446	39.9	57.5	36.4	19.3	**3.5** ***
# board members 2019	7,854	3.0	3.9	2.3	2.9	**0.6** ***

Source: Authors' own elaboration. Obs.: Observations. Std. Dev.: Standard Deviation. t-test compares treated versus control firms. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Additionally, the Figure 19 shows that cartelized and matched firms also do not significantly differ at the mean covariates of total assets, debt ratio, leverage, number of employees, average cost per employee and number of board members 5 years before the firms engaged in cartel activities, given that these variables were used in the matching process. They only differ in operating revenues. Still, we condition the comparisons controlling on the covariates as we did in the case of European firms, but results do not qualitatively change.

Figure 19. Descriptive statistics of the Spanish database in the matching period (5 years before the cartel starts)

Covariates	Obs.	Mean	Std. Dev.	Mean	Std. Dev.	Mean Differences *t-test* (Cartelized vs non-cartelized firms)
		Cartelized firms		*Non-cartelized firms*		
Operating revenues	279	191,355.4	653,473.7	69,511.7	155,241.1	**121,843.8****
Total assets	279	86,976.5	251,802.3	79,529.2	234,566.1	**7,447.3**
Debt ratio	279	68.4	18.2	68.6	17.9	**-0.2**
Leverage	279	141.8	205.1	156.7	278.8	**-15.0**
# employees	264	306.1	1,209.1	219.6	491.8	**86.5**
Avg. cost per employee	264	32.9	12.8	32.7	11.5	**0.23**
# board members 2019	279	2.9	4.1	2.3	2.9	**0.6**

Source: Authors' own elaboration. Obs.: Observations. Std. Dev.: Standard Deviation. T-test compares mean equality of cartelized versus non-cartelized firms. * p < 0.10, ** p < 0.05, *** p < 0.01.

3.3. Gender composition on boards in cartelized and non-cartelized firms

Following the same analysis carried out previously for European firms, we start by looking at the evolution of the percentage of women appointments (with respect to the total number of appointments) per year, and the percentage of women terminations (with respect to the total number of terminations) per year. Then we study what happens over the cartel life. With the data available, we cannot compute the percentage of women on boards, the exact composition of boards across time, so in the Spanish case we can only analyse the percentage of women in all new appointments or position terminations.

We show the descriptive statistics for the whole sample of cartelized firms on the one hand, and for the subsample of cartelized firms with a counterpart and the corresponding non-cartelized firm.

The following figure clearly shows that the percentage of women's appointments and terminations has been increasing from 1998 to 2018, with a similar trend as in the percentage of women in boards in the previous European database.

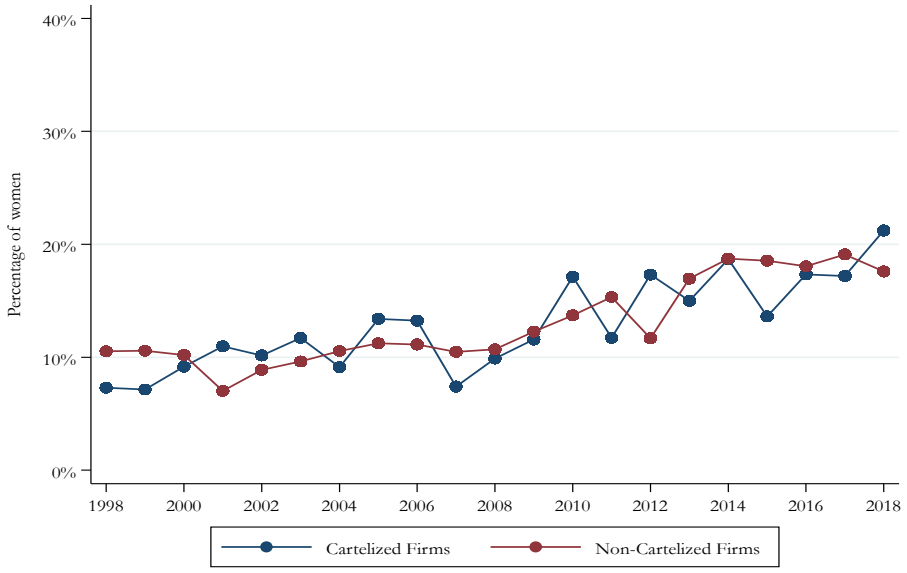
Figure 20. Average percentage of women's appointments and terminations on boards for all cartelized firms

The figure represents the percentage of women appointments (with respect to the total number of appointments) and the percentage of women terminations (with respect to the total number of terminations) per year, which have increased from slightly less than 10% in 1998 to 16-17% in 2018.

Source: Authors' own elaboration.

The following two figures (Figure 21 and 22) show that there is no mean difference in the percentage of women's appointments or terminations in cartelized and non-cartelized matched firm's sub-samples.

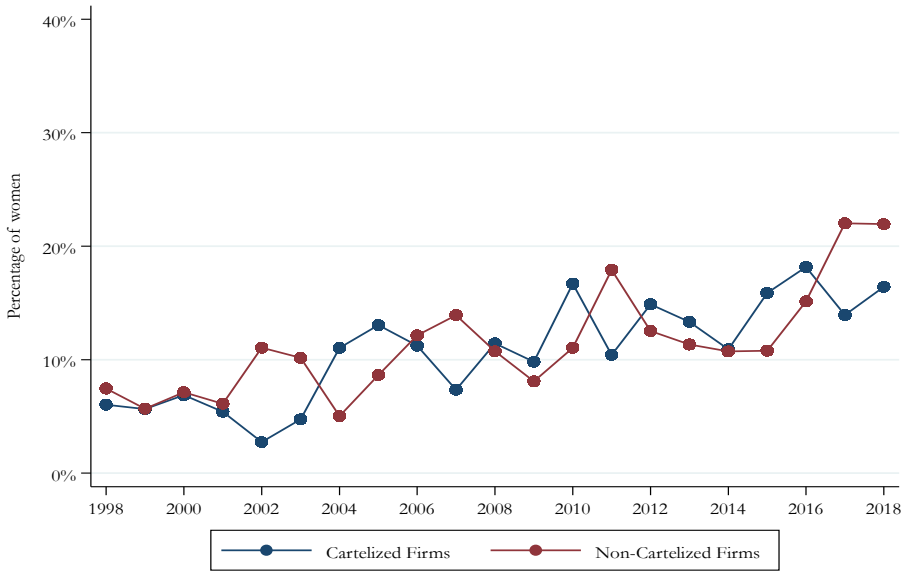
Figure 21. Average percentage of women's appointments on boards for cartelized and non-cartelized firms



The figure represents the percentage of women appointments (with respect to the total number of appointments) per year, for Spanish cartelized and non-cartelized firms.

Source: Authors' own elaboration.

Figure 22. Average percentage of women's terminations on boards for cartelized and non-cartelized firms.



The figure represents the percentage of women terminations (with respect to the total number of terminations) per year, for Spanish cartelized and non-cartelized firms.

Source: Authors' own elaboration.

The Figure 23 shows that there are not significant mean differences in the percentage of appointments and terminations by gender before, during and after the engagement in cartel activity by one firm and its matching non-cartelized firm.

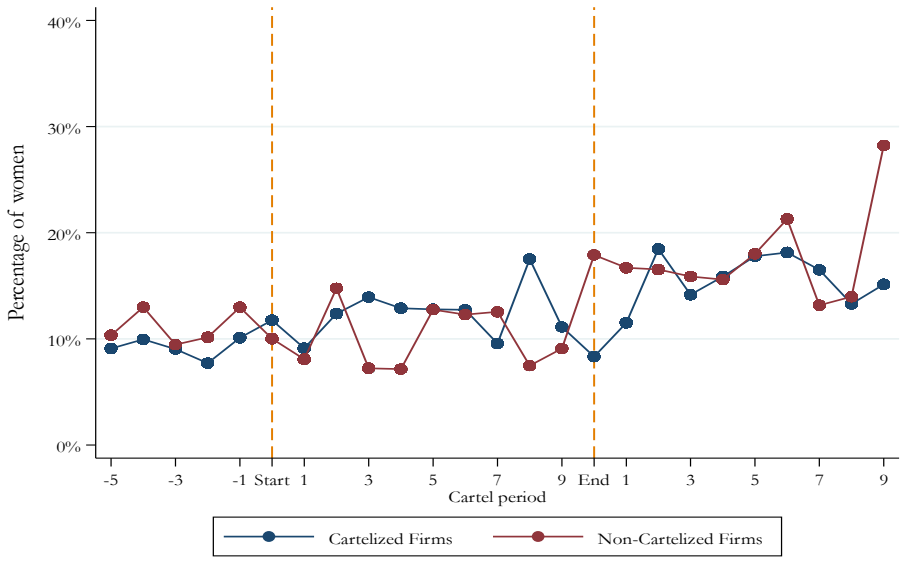
Figure 23. Average percentage of women's appointments and terminations on boards for all cartelized firms.

	All	Cartelized (C)	Non-Cartelized (NC)	Mean Differences *t-test* (Cartelized vs non-cartelized firms)
% women appointments				
Before Cartel	0.12 (0.24)	0.10 (0.21)	0.11 (0.22)	-0.01 (0.01)
During Cartel	0.13 (0.23)	0.12 (0.21)	0.11 (0.20)	0.01 (0.01)
After Cartel	0.17 (0.27)	0.17 (0.26)	0.17 (0.26)	0.00 (0.02)
% women terminations				
Before Cartel	0.10 (0.23)	0.08 (0.20)	0.10 (0.22)	-0.02 (0.01)
During Cartel	0.11 (0.23)	0.10 (0.21)	0.10 (0.22)	0.00 (0.02)
After Cartel	0.15 (026)	0.14 (0.24)	0.14 (0.24)	0.00 (0.02)

Source: Authors' own elaboration. t-test compares mean equality of cartelized versus non-cartelized firms. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The next four figures show these percentages of appointments and terminations by cartelized and non-cartelized firms, which clearly show that there are not significant differences in the subsamples of the Spanish database[27].

Figure 24. Average percentage of women's appointments on boards for cartelized and non-cartelized firms.

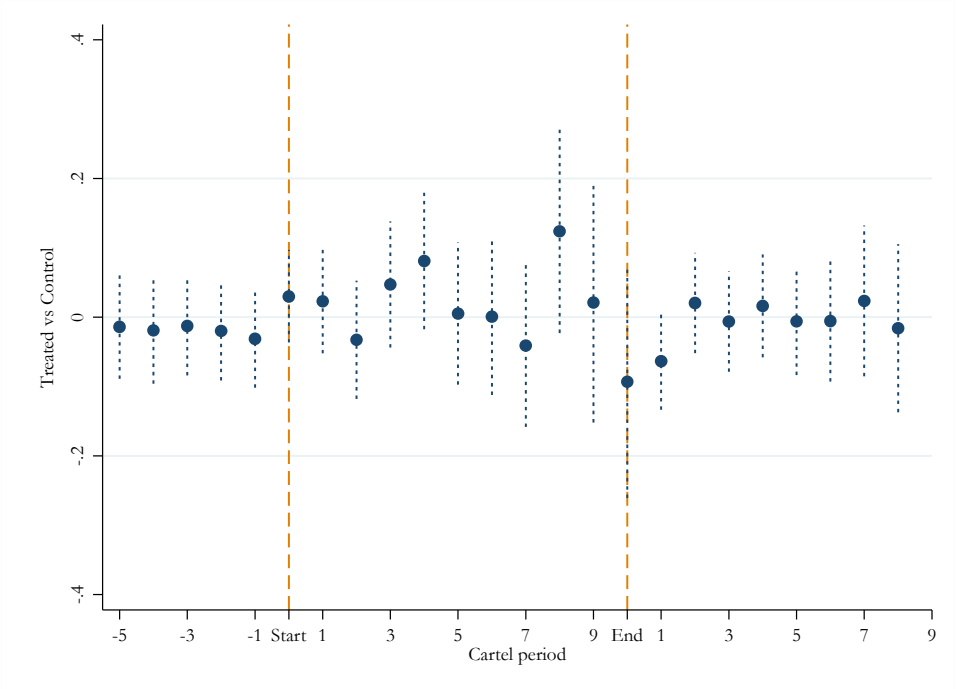


The figure shows the percentage of women appointments to boards (with respect to the total number of appointments) for Spanish cartelized and non-cartelized firms for each period before, during and after the cartelization period. The cartel end date refers to the earliest event: cartel breakup or authorities' first notice.

Source: Authors' own elaboration.

[27] 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.

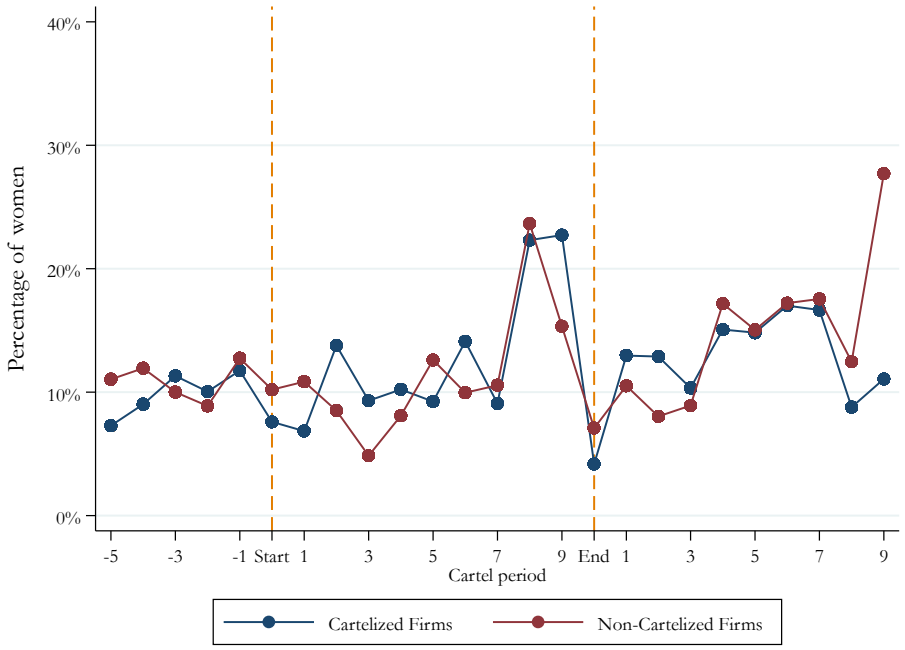
Figure 25. Differences in the percentage of women's appointments on boards in cartelized vs non-cartelized firms.



The figure represents the conditional mean differences in the percentage of women appointments to boards (with respect to the total number of appointments) of Spanish cartelized firms versus non-cartelized firms. These differences have been estimated using a regression including country fixed effects and firms' characteristics as controls. The mean conditional differences between the two groups are not statistically significant in any period over the cartel life. The cartel end date refers to the earliest event: cartel breakup or authorities' first notice.

Source: Authors' own elaboration.

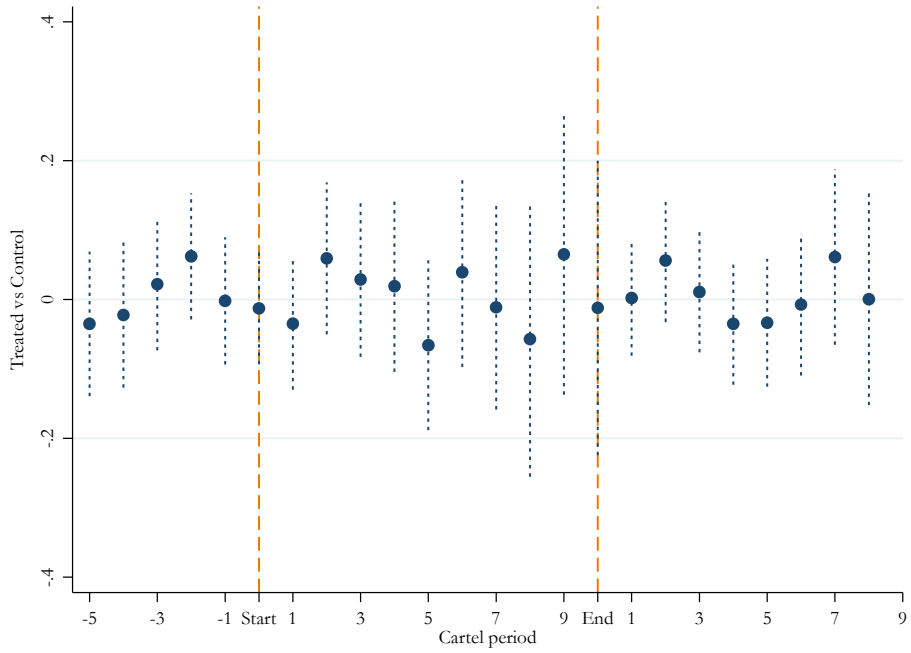
Figure 26. Average percentage of women's terminations on boards for cartelized and non-cartelized firms.



The figure shows the percentage of women terminations (with respect to the total number of terminations) for Spanish cartelized and non-cartelized firms for each period before, during and after the cartelization period. The cartel end date refers to the earliest event: cartel breakup or authorities' first notice.

Source: Authors' own elaboration.

Figure 27. Differences in the percentage of women's terminations on boards in cartelized vs non-cartelized firms.



The figure represents the conditional mean differences in the percentage of women terminations (with respect to the total number of terminations) of Spanish cartelized firms versus non-cartelized firms. These differences have been estimated using a regression including country fixed effects and firms' characteristics as controls. The mean conditional differences between the two groups are not statistically significant in any period over the cartel life. The cartel end date refers to the earliest event: cartel breakup or authorities' first notice.

Source: Authors' own elaboration.

3.4. Estimates

Again, as in the case of the European database we detailed at section 2, we estimate two different logit models for different dependent variables. In all of them, the explanatory variable is always the same: the percentage of women appointments or terminations on boards. Using this simple logit, we look at the correlations in the data between cartel activity and women board appointments.

As we explained before, the dependent variable in each of the two logit models we estimate take the following values: *i)* binary variable for Cartel period & Cartelized Firms; *ii)* binary variable for After cartel & Cartelized Firms. We show the estimations of the logit model with these two dependent variables to compare results, controlling for firm covariate characteristics, country fixed effects and year fixed effects.

Again, as with the European database, we also estimate a difference-in-differences model to assess the causal impact of cartelization on the percentage of appointed women on corporate boards. This method allows to control for unobserved differences between treated and control observations and for common shocks through the variables cartelized and period. The partly random component of the timing of cartel busting allows us to identify the causal impact of such cartel busting on the percentage of women appointed as board members.

3.5. Results

Figure 28 includes the results of the logit regressions. They show that an increase in the presence of women in appointment or in dismissals (terminations) neither have an impact on the probability forming a cartel, nor in the cartel breakup probability, finding no significant effect in the case of the Spanish database. Results, not shown for simplifying the story but available from the authors, do not change if separate regressions are estimated for appointments and terminations.

Figure 28. Logit Model

	Probability (Cartel Formation)	Probability (Cartel Breakup)
% women appointments	0.133	0.014
	(0.301)	(0.296)
% women terminations	-0.118	-0.249
	(0.299)	(0.317)
Firms' characteristics	Yes	Yes
Year Effects	Yes	Yes
Pseudo-R^2	0.0647	0.3624
N	1772	1985

Source: Authors' estimations

Again, in the case of the Spanish database, the difference-in-difference estimations show that there is not significant effect of cartel formation or breakup on women appointments or terminations (Figure 29).

Figure 29. Difference-in-Differences Estimator.

	% women appointments	% women terminations	# women appointments/ # women terminations	% women appointments/ % women terminations
Cartelized	-0.007	-0.011	0.074	-0.036
	(0.012)	(0.015)	(0.326)	(0.071)
Cartel Period	-0.023	-0.024	-0.010	-0.082
	(0.015)	(0.018)	(0.370)	(0.081)
DiD Cartel Period	**0.023**	**0.009**	**-0.381**	**0.148**
	(0.018)	**(0.023)**	**(0.479)**	**(0.104)**
Period after Cartel	-0.016	-0.055**	-0.064	-0.114
	(0.020)	(0.024)	(0.445)	(0.092)
DiD after Cartel	**0.010**	**0.010**	**-0.280**	**0.040**
	(0.018)	**(0.022)**	**(0.434)**	**(0.093)**
Constant	0.097	0.098	1.087	0.387
	(0.025)	(0.029)	(0.615)	(0.130)
Firms' characteristics	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
R^2	0.0346	0.0353	0.0566	0.1523
N	3630	2321	716	523

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Source: Authors' estimations

Previous results show that women appointments or terminations do not significantly increase during the cartel period. Unlike the case of the European firms, women appointments or terminations do not increase significantly after cartel breakup in cartelized firms compared to non-cartelized firms. This result seems to be due to the lack of a binding gender quota in Spain. These results support the findings of the equation (1), included at Figure 16.

4. Concluding remarks

Cartels are one of the most harmful competition restraints for consumers and the economy in general. The literature on cartel policy enforcement has focused recently on the role of board members, senior managers, and directors in cartel activity.. Our research focusses on understanding the effect of the presence of women on boards in relation to cartel activity. There is a growing literature that show that, in general, there seems to be gender differences particularly in the response of women/men when they face risk situations.

Our research paper contributes by explaining how the presence of women on boards and cartel activity is related. Our starting hypothesis was that women in the company's board of directors, senior management positions or director posts may have a significant effect in reducing the firm's misbehavior, and correspondingly having women as board members may reduce cartel engagement.

The evidence on European and Spanish firms sanctioned due to cartel engagement and comparison firms not sanctioned do not support this hypothesis. We found no differences in the presence of women in boards among those type of cartelized and non-cartelized firms. So, we did not find any significant effect from women's participation on boards on cartel engagement.

By contrast, we do find a statistically significant impact of cartel busting on corporate board restructuring. And, in countries with binding gender quotas, the post cartel breakup restructuring results in greater gender balance in senior management positions.

So, the main take-away of this research paper is that binding gender policies and cartel policies interact, and influence gender board composition of firms sanctioned by anti-cartel authorities. There is sound evidence that causality goes in the direction that firms sanctioned by competition authorities as members of cartels are seizing the opportunity to restructure their boards and improve their reputation by at the same time complying with the new binding gender quotas.

Binding gender quotas seem to be driving a statistically significant differential increase in the percentage of women on corporate boards after cartel busting in cartelized sanctioned firms in Europe with respect to non-cartelized matched firms.

However, this is not the case with non-binding gender policies. The Spanish case, with non-binding gender policies, shows that gender and cartel policies do not have a clear-cut effect on the number of women on boards and in senior management positions of sanctioned firms.

It seems that evidence provides a catchy lesson: cartel sanctioning and prosecution is an effective tool for corporate restructuring, which may lead to greater gender balance in corporate boards if gender quotas are binding. Future research in this topic may offer more light on this interesting salient issue in the data that we have been able to identify.

In particular, we think that future research should be directed to some of the following questions : (1) case studies of cartelized firms that restructured the board of directors after cartel breakup might offer more nuanced and detailed explanations of the interplay between cartel policy enforcement and the compliance with gender policies; (2) as more countries adopt gender binding policies, new research may be directed to study how cartel policy may make corporate board restructuring more effective; (3) research may also be directed to study the differences among listed and non-listed companies, and include smaller companies in the analysis; (4) finally, data on the gender balance not only directors boards, but also management boards and senior managers, should also be studied as lower level of management appear to be engaged in cartel conduct.

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Annex 1. About the authors

Joan-Ramon Borrell holds a PhD in Economics and is Associated Tenured Professor at the University of Barcelona. His main research fields are competition policy, regulation, and public policy evaluation. He has participated in competitive calls for research grants from the European Commission, the Catalan Government, the Spanish Government, the OECD, ACUP-RecerCaixa and Merck Foundation, among others. He has published several papers on those topics.

http://www.ub.edu/gim/membre/joan-ramon-borrell/

Carmen García holds a PhD in Economics from the European University Institute and is Associate Part-time Professor at the University of Las Palmas de Gran Canaria (ULPGC). Her main research fields are competition policy, evaluation of public policies and applied microeconometrics.

https://sites.google.com/view/carmengarciagalindo/home

Juan Luis Jiménez holds a PhD in Economics and is Assistant Professor at the University of Las Palmas de Gran Canaria (ULPGC), Spain. His main research fields are competition policy, regulation and public economics. He has participated in projects for OECD, European Commission or the Chilean Government, among others. He has published several papers for those topics.

https://scholar.google.es/citations?user=Mbm79PcAAAAJ&hl=es

José Manuel Ordóñez de Haro holds a PhD in Economics and is Associate Professor at the University of Malaga, Spain. His main research fields are industrial economics, competition policy, regulation, and public economics. He has participated in numerous research projects funded by regional, national, and international institutions. He has published several papers for those topics.

https://theeconomics.uma.es/en/jose-manuel-ordonez-de-haro__trashed/

Annex 2. Index of figures and tables