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The role of political ties and political uncertainty in corporate innovation

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ABSTRACT

We examine the relationship between firms' political connections and corporate innovation in a European context. We also consider the moderating effect of political connections on the relationship between political uncertainty and firms' innovation. We use two different metrics of innovation: R&D (an input measure), and patent counts (an output measure). We find that firms with former politicians on their board of directors invest less in R&D than their counterpart firms. However, the presence of this type of director on the board is positively associated with the number of a firm's patent applications. It seems that, although political ties reduce the amount of resources devoted to R&D activities, they increase the effectiveness of intellectual rights protection. Results also show that political uncertainty decreases R&D investment but exacerbates the need for legal protection of innovation through patents. According to our results, political connections attenuate the effect of political uncertainty on firm innovation such that the negative (positive) effect of uncertainty on R&D intensity (patents) weakens when the firm is politically connected.

Introduction

Given the relevant role that innovation plays in promoting economic growth and sustainable competitive advantage, international authorities have repeatedly expressed widespread concern surrounding the amount of investment in innovation, which is below the desired level and is currently even lower than in previous decades (Cornell University, 2017; European Commission, 2019). In turn, there is a long-running history of research into firm-level issues that affect corporate innovation (Bocken and Geradts, 2020; Bocquet et al., 2019; Snihur and Wiklund, 2019; Weber and Heidenreich, 2018). Although certain corporate governance issues, principally ownership structure, have attracted attention, little is known about how other corporate governance mechanisms, namely the board of directors, can affect corporate innovation (Almor et al., 2020; Pearce and Patel, 2018).

The political connections of boards of directors can prove useful since politically connected directors bring support and valuable knowledge about public policies to the firm (Duchin and Sosyura, 2012; Faccio et al., 2016; Goldman et al., 2013). Nevertheless, political ties may also serve as an effective barrier to prevent others firms entering a given sector, thereby lowering industry

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competition (Sun et al., 2016; Wu, 2011). In addition, the way in which firms' political connections are related to corporate innovation remains a relatively unexplored field, and one which calls for further research (Zhou et al., 2017).

These divergent theoretical arguments are reflected in a still scant number of empirical studies that examine the link between political ties and innovation and that consider different institutional contexts. Ovtchinnikov et al. (2020) evidence a positive effect of political activism on US firms' patent citation. Similarly, Kotabe et al. (2017) conjecture a complementary effect of political ties and the introduction of incrementally or radically new products in China. However, Kim (2018) finds a substitute effect between corporate lobbying and R&D spending and patent creations in a sample of US firms. Moreover, Zhou et al. (2017) find that state ownership enables a firm to obtain crucial R&D resources although it makes the firm less efficient in transforming R&D input into new products.

In addition, political uncertainty negatively affects innovation given the long timing and potential impact on risk linked with this corporate decision (Gulen and Ion, 2016; Julio and Yook, 2012). We look at how political uncertainty may change the way firms deal with innovation due to possible changes in government policy or politicians' behaviour. Ovtchinnikov et al. (2020) argue that political connections allow firms to acquire information about the lawmakers' political cost, which reduces political uncertainty and might lead to more innovation. Consequently, during periods of political uncertainty, politically connected firms may have a different understanding of possible future policy changes than their non-connected counterparts (Kim, 2018; Ni, 2018; Su et al., 2019) and move accordingly through the challenges posed by governmental regulations (Fernández-Méndez et al., 2018).

In this paper we analyse the influence of political ties and political uncertainty on innovation. We also examine whether connected firms can use the benefits of these ties to innovate more than non-connected firms during times of political uncertainty. We use a unique dataset of Spanish firms between 2003 and 2014, considering both input (R&D) and output (patents) measures of the corporate innovation process. Our results reveal an interesting effect of political connections on corporate innovation. We find that firms with former politicians on their board of directors invest less in R&D than their counterpart firms. Contrary, the presence of former politicians on the board proves to be positive and significantly associated with the number of a firm's patent applications. This could mean that political connections improve the efficiency of corporate innovation in that these firms achieve more output (patents). We also find that political uncertainty has a twofold relationship with innovation: while greater uncertainty results in less R&D intensity it also exacerbates the need for legal protection for innovation through patents. Another set of results concerns the interaction between political uncertainty and connections. We discover that political connections attenuate the effect of political uncertainty on firm innovation such that the negative (positive) effect of uncertainty on R&D expenditures (patents) weakens when the firm is politically connected.

The Spanish case provides a paradigmatic setting for exploring the effect of political connections on corporate innovation for several reasons. Former politicians have been recruited for the boards of many Spanish firms as a result of the large number of privatizations in Spain -as in many other European countries-in recent decades. Thus, political connections are quite common in Spanish listed firms, thereby allowing for comparisons with other European countries in a similar situation (Guerra Pérez et al., 2015; Pascual-Fuster and Crespí-Cladera, 2018). In addition, as in other European countries, the Spanish government plays an active role in business, being a major customer for firms in certain regulated industries. At the same time, Spanish firms have a highly concentrated ownership structure, which reinforces the relevance of internal corporate control mechanisms, such as the board of directors and the role played by the social capital of politicians as directors. Moreover, the economic environment in Spain is characterized by weak investor protection and poor enforcement of ownership rights (Djankov et al., 2008; La Porta et al., 1998). Taken together, all of these factors make this setting an opportunity for the analysis of political connections as a strategic corporate decision.

This paper makes several contributions to the literature. First, our study sheds some light on how former politicians on the board might affect corporate innovation decisions. Whereas a number of studies have addressed other consequences of political connections, such as firm value or corporate access to funds, to the best of our knowledge how having politicians on the board might affect firms' innovation decisions has not yet been studied. Second, previous research has analysed the effect of politicians on corporate decisions when the controlling shareholder is the State. In such instances, the role of politicians differs from that of a director in a firm controlled by another type of shareholder since it is almost impossible to separate the role of politicians as owners and directors. Moreover, politicians' objectives differ in the two scenarios.

Third, we provide evidence on the link between political ties and the innovation process in the European context, bearing in mind that prior literature has focused on US and Chinese firms. Although all of these environments share the undeniable political connections of firms, in continental European framework political connections are mainly established by having politically connected directors on the board (Faccio and Lang, 2002; Guerra Pérez et al., 2015). However, political practices are established mainly by lobbying in the US (Woll, 2006). The European setting also differ from China context, where the government has large and stable capital stakes in listed firms, and where politicians use the role as owner to promote their political careers. In this context, firms do not usually actively pursue political connections but are "born" with connections, which are essentially maintained through state-ownership as well as through directors and managers who are at the same time members of the Communist Party, the People's Congress or who are bureaucrats appointed by the government (Cull et al., 2015; Chen et al., 2017; Tihanyi et al., 2019). Thus, the main motive for political ties in China and other East Asian countries is not concerned with corporate objectives but relates to government interest in promoting certain public-policy actions, such as providing support for strategic industries or even certain ethnic groups, generating more tax revenue, increasing local employment rates, or promoting social welfare programmes (Adhikari et al., 2006). In contrast, in continental Europe the presence of political connections is explained by corporate rather than by public policy reasons. Thus, our results may be generalized to other continental European countries, such as Italy or France, that display similar institutional characteristics and a similar level of innovation.

Four, although previous literature has focused on different links between internal firm factors and the political environment, few studies have analysed the overall level of political uncertainty in the economy and how political connections moderate the relationship

between uncertainty and corporate innovation (Jens, 2017). Finally, we provide a more in-depth analysis through so-called hybrid models. These models are based on the idea that there are two levels of variance for a variable: within-firm and between-firm variance. The first component reflects changes in the firm's political connections over time: a high value of within-firm variance suggests that the value of political ties evolves over the period. Between-firm variance is indicative of the differences between connected and non-connected firms. By differentiating within-firm and between-firm variance, hybrid methods combine the strengths of random- and fixed-effects models, which have remained hidden in other types of estimations.

The next section of the paper reviews the literature and sets out the hypotheses, while section 3 describes the main aspects of the methodology. We report univariate analyses, discuss multivariate results, and present several robustness checks in section 4. Finally, section 5 concludes.

Theory and hypotheses

Boards of directors are widely recognized as playing three main roles: managerial monitoring, strategic advice, and provision of critical resources. Stevenson and Radin (2009) highlight the ties among members of the board as a key factor in the dynamics of board decision-making. Political ties are the connections of board of director members when some of them are former politicians. The personal networks of former politicians, and even the centrality of the firm in the network of political connections, can promote corporate innovation by facilitating access and control over resources and knowledge (Shu et al., 2012; Tsai et al., 2019).

According to Lester et al. (2008), the relevance of politicians as directors stems from their human and social capital. A board of directors' political connections may prove to be particularly useful for fulfilling the third role since politically connected directors bring support and valuable information about public policies to the firm. In this sense, prior literature has shown that politically connected firms obtain valuable resources from governments such as preferential treatment by increasing access to bank financing, lower tax rates, preference in the awarding of government contracts, lenient regulatory oversight, and advice on legislative and bureaucratic procedures (Guo et al., 2014; Sharma et al., 2020).

Additionally, political uncertainty can affect investment in innovation. Possible or actual changes in a country's government or national leadership can result in threats and opportunities for firms (Gulen and Ion, 2016; Julio and Yook, 2012). These events have an impact on firms' decisions, specifically on investment related ones. Even when policies are not dramatically altered by these events, the firms' managers may be uncertain as to the government's commitment to enforcing existing regulation. Consequently, these changes may affect not only the behaviour of firms.

Political connections and corporate innovation

Innovation activities create substantial firm value but are difficult to manage due to the high level of uncertainty and information asymmetry, which results in underinvestment in innovation. Corporate innovation can include a number of different features. When studying the influence of political connections on firm innovation in emerging markets, Krammer and Jiménez (2020) differentiate between radical and incremental innovation, based on the degree of newness. More interestingly, these authors find that political connections have an opposite effect depending on the type of innovation (new products or services *vs.* the improvement in existing products). Similarly, Cheng et al. (2019) attempt to reconcile the seemingly contradictory results of the research into the relationship between political connections and corporate innovation by positing that such a relationship depends on firm-level characteristics. Following this dual approach, we posit that the relationship between firms' political connections and corporate innovation may be conditional upon the dimensions of the innovation.

Investing in R&D can be considered an input-based feature of innovation with some specific characteristics. Given these characteristics, political ties can result in less resources being allocated to R&D for a number of reasons. First, firms with strong political connections might pursue non-value-adding strategies (Liedong and Rajwani, 2018; Rajwani and Liedong, 2015). Chen et al. (2017) argue that political connections might prove to be either "helping hands" or "grabbing hands". Politically connected firms might pay more attention to lobbying and influencing politicians' decisions than to investing in innovation activities. Accordingly, firms' political connections might discourage managers from spending resources in R&D activities.

Additionally, by enhancing alternative sources of funds, political connections can to a certain degree lead to firms being isolated from stock market scrutiny. The literature has empirically supported the lower number of financial constraints imposed on politically connected firms (Boubakri et al., 2012a, b; Cull et al., 2015; Shen and Lin, 2016; Song et al., 2015). In turn, politically connected firms rely on stock markets to a lesser extent, since connections help them to secure access to other sources of external capital. As external monitors, stock markets can reduce asymmetric information, lower the cost of capital and, consequently, decrease managerial myopia and enable innovation activities. Consequently, politically connected firms rely less on external finance, and managers may have an incentive to divert resources away from R&D activities and towards their own private benefits. Coates IV (2012) and Sun et al. (2016) show that political connections may raise a principal-principal agency conflict, which can be exacerbated by the board's political capital. Under these circumstances, connections might result in managers using company resources to help connected politicians, despite possible non-beneficial effects for the firm (Bertrand et al., 2018). From a public policy perspective, this view has been confirmed by Schoenherr (2019), who shows that politicians' social networks lead to inefficiencies in contract allocation to private firms.

Another channel through which political connections may reduce R&D intensity involves the smaller number of incentives that managers have to effectively refine internal routines, which leads to organizational inertia in these firms (Hou et al., 2017; Wu, 2011). As a consequence, political ties generate over-embeddedness that might mean a reduced flow of new ideas into the company,

restricting its openness to exploit fresh strategies. Political connections may thus act as a barrier to entry that can curb industry competitiveness and reduce innovation activities (Kim, 2018). In this line, there may be a substitute effect between political capital and innovation investments since, when a company loses political ties, it loses market power, and its competitive position deteriorates. Firms try to make up for this loss by investing more in innovation in order to stay competitive.

Taken together, the above arguments lead to our first hypothesis, which can be stated as follows:

H1. Political connections have a negative effect on R&D investment.

Complementary to the focus on R&D investments (i.e., an input-based approach of corporate innovation), we now address patents as an output-based feature of corporate innovation. Although R&D intensity and patents are measures of corporate innovation, the interaction between them is by no means insignificant (Baraldi et al., 2014; van Ophem et al., 2002). In this case, in addition to the above-developed factors, patents display certain peculiar characteristics, such that the relationship with political connections may deviate from that of investment in R&D.

Political connections can bring three types of benefits that are relevant to patent activity: valuable advice related to public policy processes; networks with existing political decision makers; and influence over political decisions. Through these formal and informal ties, firms' decision makers can have fluid communication with policy makers on current or future public policies that could improve the legal protection of corporate innovation. Political ties bring knowledge and expertise in legislative and bureaucratic procedures, market information, industry development plans, foreign trade, energy policy, or patent legislation, which are influential determinants when applying the corporate discoveries made through investment in innovation (Ovtchinnikov et al., 2020). Accordingly, politically connected firms gain access to relevant information on innovation related to technological developments, competition and so on, which may prove useful when developing the products or technologies that governments might require or prefer (Tsai and Xu, 2018).

In addition, in contexts with weak intellectual property protection, political ties positively affect corporate innovation by discouraging imitation and unfair competition (Zhao, 2006). Given that patents permit firms to protect and profit from innovative activities, political connections allow firms to stop unlawful imitation by competitors. Consequently, the connections with the political arena are likely to strengthen the firms' incentives for patenting activity.

Politically connected firms may also enjoy greater legitimacy, making clients more willing to accept the new products or services launched as a result of corporate innovations (Guo et al., 2014; Wu, 2011). These intuitions are in line with previous research. Brogaard et al. (2015) find an indirect positive relationship between US firms' political campaign contributions and corporate innovative activity, as measured by the scale and novelty of firms' patents. For the Chinese market, Shi and Zhu (2014), Jiang et al. (2018) and Tsai et al. (2019) prove that firms with stronger political connections innovate more when innovation output is measured by patent applications.

All of these factors taken together suggest there could be a complementary effect between firms' political connections and corporate innovation outcomes in terms of patents. In turn, we state our second hypothesis as follows:

H2. Political connections have a positive effect on patents.

Political uncertainty and corporate innovation

Given the long timing, content, and potential impact on corporate investment decisions, corporate innovation could be affected by uncertainty. Political uncertainty may be important for corporate innovation because it includes a large amount of irreversible investment in intangible assets (Arif Khan et al., 2020; Wang et al., 2017). In these cases politicians make policy and regulatory decisions that frequently alter the economic setting in which innovative firms operate (Bhattacharya et al., 2017). Even when policies do not change, managers may be uncertain as to the government's commitment to enforcing existing statutes. Possible policy shifts, such as in government subsidies to private R&D and changes to intellectual property rights law, can influence firms' future cash flows and innovation decisions. It comes as no surprise that the 2017 edition of the Global Innovation Index states that unexpected changes in national regulations negatively affect innovation success (Cornell University, 2017). The "political uncertainty hypothesis" thus argues that this kind of uncertainty adversely affects corporate innovation bearing in mind how sensitive innovative activities are, coupled with the fact that they are not entirely reversible.

There is abundant evidence that political uncertainty induces firms to hold more cash and to delay investment due to possible changes in government policy or in politicians' behaviour (Amore and Minichilli, 2018; Demir and Ersan, 2017; Jens, 2017). In line with the above arguments, Stokey (2016) finds that firms hold off on their investments during periods of major uncertainty and that, once the uncertainty is resolved, investment increases to make up for lost time. Political uncertainty is also negatively associated with other corporate investments such as mergers and acquisitions (Bonaime et al., 2018; Nguyen and Phan, 2017), especially in cross-border markets (Cao et al., 2018), and with the investment propensity of venture capital (Tian and Ye, 2018).

Consistent with the previous arguments, we state our third hypothesis as follows:

H3. Political uncertainty has a negative relationship with R&D investment.

Gholipour (2019) and Bhattacharya et al. (2017) find that economic policy uncertainty translates into a decrease in the number of patent applications. Nevertheless, their results are not fully consistent since they only hold in the short term. On the contrary, some research suggests that firms react to political uncertainty by investing in patents as growth options (Pertuze Salas et al., 2019). As shown by these authors, whereas political instability can discourage irreversible innovation investments, patents imply a strategic option to grow and block potential competitors until the uncertainty blurs. Similarly, Tajaddini and Gholipour (2020) show that higher

levels of political uncertainty are positively associated with higher innovation outputs such as patent applications and patent grants in 19 developed countries. Analogous evidence has been reported by He et al. (2020), who find a positive correlation between economic policy uncertainty and the number of patent applications in China.

Consistent with the previous arguments, we state our fourth hypothesis as follows:

H4. Political uncertainty has a positive relationship with patents.

Although greater uncertainty over government policy outcomes might affect firms' willingness to make long-term investments, the question arises as to whether the sensitivity of corporate innovation is affected by political connections. Political ties allow firms to acquire information from lawmakers, which reduces political uncertainty and might impact innovation. During times of political uncertainty, politically connected firms may have a better understanding of future policy changes than their non-connected counterparts (Su et al., 2019).

More specifically, politically connected firms are better informed by lawmakers about future perspectives and the circumstances under which innovation will be successful. Indeed, Kim (2018) shows that firms seek political connections not only to mitigate political uncertainty, but also to enhance their growth opportunities and to increase their innovation activities. Therefore, political connections may offset the direct effect of political uncertainty on innovation (Akey and Lewellen, 2017). In this setting, Ovtchinnikov et al. (2020) argue that lower political uncertainty decreases the value of the option to wait and increases investment in innovation.

Consequently, we posit that political connections attenuate the effect of political uncertainty on firm innovation. The two-fold relationship between political uncertainty and either R&D expenditures or innovation output (i.e., patents) means that political connections could also have a two-fold impact. On the one hand, during periods of political uncertainty, connected firms might allocate more resources to R&D activities than non-connected ones given the less uncertain environment they face. On the other hand, politically connected firms are not so in need of legally preserving their growth options as their non-connected counterparts, which could mean a moderating effect on the relationship between political uncertainty and patents. Based on the above arguments, we formulate our fifth hypothesis:

H5. Political connections attenuate the relationship between political uncertainty and corporate innovation.

The theoretical framework and hypotheses of this research are shown in Fig. 1.

Research design

Data and variables

Our sample starts in 2003, when a law designed to increase the transparency of financial reporting in Spanish capital markets was passed. The sample comprises 113 non-financial firms listed on the Spanish Stock Exchange over the period 2003–2014 and contains 1047 firm-year observations. This sample accounts for 98.2% of Spanish market capitalization in 2014.

Corporate innovation measure

Among a number of possible variables, the literature has considered two dimensions or proxies to measure corporate innovation activities: R&D investment and patenting activity (Faleye et al., 2014). We thus use R&D intensity to measure innovation input, and the number of patent applications filed by a firm in a given year to measure innovation output (Acharya and Xu, 2017; Hirshleifer et al., 2012). According to Faleye et al. (2014), the first variable is a good indicator because the timing of R&D expenditure is close to when innovation activity starts and reflects the input of this process. We scale R&D expenditure by total assets (Balsmeier et al., 2017; Hirshleifer et al., 2012; Kor, 2006). Although some studies use the number of employees as scaling variable, the number of employees is a measure of firm size that is relevant in labour-intensive industries (Brossard et al., 2013) whereas our sample is characterized by the importance of non-industrial firms. The R&D-to-assets ratio is a more structural measure of a firm's innovation activities, reflecting

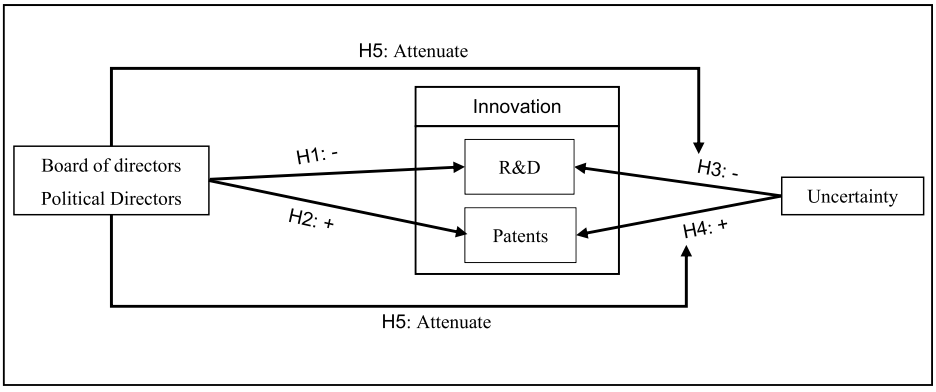

Fig. 1. Theoretical Model on the effect of political ties and uncertainty on corporate innovation.

the firm's long-term innovation policy. Thus, we define *R&D* as the ratio of R&D expenditures over total assets. Information on R&D expenditure is taken from firms' financial reports.

Patenting activity is another measure of corporate innovation since patent applications capture innovation outputs. As did Balsmeier et al. (2017), Cornaggia et al. (2015), Fang et al. (2014), and because the distribution of patent counts is right-skewed, we use the logarithm of patent counts. We collect firm-year patent count data from several databases. In particular, we looked for patents in the ESPACENET, which is the European Patent Office database. The PATENTSCOPE database also provides access to international Patent Cooperation Treaty (PCT) applications. Thus, we define *Patents* as the number of patent applications filed by a firm in a given year.

Firms' political connections and political uncertainty

Studies into the relationship between political connections and corporate behaviour must cope with the limited transparency inherent in such links. Our dataset comes from Guerra Pérez et al. (2015), who draw on earlier literature and consider the presence of politicians on the firm's board of directors as a proxy of political connections (Boubakri et al., 2012a,b; Chaney et al., 2010; Cheng and Leung, 2016; Duchin and Sosyura, 2012; Pascual-Fuster and Crespí-Cladera, 2018; Shi et al., 2018). Since our study covers the period 2003–2014, we extend the aforementioned database to embrace fresh data covering 2013 and 2014. Therefore, we define *Connected* as a dummy variable that equals 1 if at least one member of the firm's board of directors has held a political position at a European, national, regional or local level in the past, and zero otherwise.

Consistent with prior research focusing on the corporate effects of political uncertainty (Gulen and Ion, 2016; Matousek et al., 2020; Meinen and Roehe, 2017; Pástor and Veronesi, 2013; Pham, 2019), we use the economic policy uncertainty index (BBD index) created by Baker et al. (2016) and refined for Spain by Ghirelli et al. (2019) as a proxy for this political uncertainty. This index is a measure of uncertainty related to future economic policy and regulatory outcomes. Specifically, the index is built as a weighted mean of three components. The first and most heavily weighted component includes media references to policy uncertainty. The second factor measures uncertainty about future changes in tax code provisions. The third component is based on the disagreement between the consumer price index and government spending to proxy uncertainty about fiscal and monetary policy. Thus, we define *Uncertainty* as the quarterly average of the BBD index in year t.

Control variables

We control for several firm characteristics that might affect corporate innovation. As Balsmeier et al. (2017) and Lu and Wang (2018) suggest, a negative relationship between board size and innovation activities is plausible. Although larger boards could imply more resources in terms of human capital (knowledge, expertise, social capital and so on), they can also be associated to more conservative decisions or to less propensity to take risk, less director incentive to monitor and advise management as well as more problems when exchanging information among directors (Lu and Wang, 2018; Zona et al., 2013). We thus use *Board_size* (logarithm of the number of directors) to isolate the effect of political directors from changes in the number of board members.

Larger firms have more knowledge, information advantages, economies of scale and resources that can be allocated to innovation activities (Atanassov, 2013; Balsmeier et al., 2017). Thus, we expect a positive effect of firm size on both dimensions of innovation and introduce *Firm_Size*, measured as the logarithm of total assets. By exacerbating managerial risk aversion and by reducing resources for risky projects, financial leverage might discourage corporate innovation (Faleye et al., 2014; Yuan and Wen, 2018). Thus, we include financial leverage as a control variable (*Leverage*), measured as the ratio of total debt over total assets, and we assume a negative relationship with corporate innovation. Growth options could also enhance innovation as a way to exploit such opportunities. We capture growth opportunities through a proxy of *Tobin's q,* measured as the ratio of the firm's asset market value to its book value (Tsai et al., 2019), and we expect a positive relationship with corporate innovation.

We also consider cash holding (*Cash*) as the ratio of cash to total assets and expect a positive relationship with corporate innovation (Shaikh et al., 2018; Yuan and Wen, 2018). Finally, we also control for a firm's age (measured as the logarithm of one plus the firm's age in a given year). Since younger firms are more innovative and mature firms have fewer financial constraints on innovation we expect a U-shaped relationship between corporate innovation and firm age.

The control variables have been winsorized at the 1st and 99th percentiles in order to reduce the impact of potential outliers and are considered with a one year-lag in all the models. We also control for time and industry effects with two sets of dummy variables: time variables and industry variables based on the sector classification of the Spanish Stock Exchange.

Model specification and estimation

After a preliminary descriptive analysis, we run four different analyses. First, we estimate a system of two simultaneous equations through three-stage least squares (3SLS). In the first equation, corporate innovation (either R&D investments or patent applications) depends on political connections and a number of control variables. In the second equation, political connections are run against corporate innovation and the control variables. The underlying rationale is to control for possible reverse causality in the sense of politicians self-selecting in more innovative firms (because of prestige, influence, power, or other factors). To reinforce the control for reverse causality, the right-hand side variables are one-year lagged. The system of simultaneous equations is as follows:

$$\text{Corporate Innovation}_{it} = \beta_0 + \beta_1 \text{ Political connections}_{it-1} + \gamma \cdot Z_{\ it-1} + \theta_t + +\alpha_j + \varepsilon_{it} \quad [1]$$

$$\text{Political connections}_{it} = \beta_0 + \beta_1 \text{ Corporate Innovation}_{it-1} + \gamma \cdot Z_{\ it-1} + \theta_t + +\alpha_j + \varepsilon_{it} \quad [2]$$

Nevertheless, the three-stage least squares method does not exploit the combination of time series and cross-sectional data. Thus,

we run a new analysis with the panel data method. This procedure has the advantage of considering firm-fixed effects, i.e., firm specific characteristics that remain invariant over time. The equation to be estimated is equation [1]. The panel dataset is estimated either by random effects or by fixed effects conditional on the Hausman test.

Third, we run a more in-depth analysis through the so-called hybrid models. These models are based on the idea that there are two levels of variance for a variable: within-firm and between-firm variance. The first component reflects changes in the firm over time: a high value of within-firm variance suggests that the value of the variable evolves during the sample time span. Between-firm variance is indicative of the differences across firms. By differentiating within-firm and between-firm variance, hybrid methods combine the strengths of random- and fixed-effects models.[1]

As do Certo et al. (2017), we take the group mean of our independent variables. These variables are supposed to remain constant for each firm over time. We then calculate the group mean centred scores as the difference between the value of each variable and the group mean. We include the group mean and the centred scores of the variables in a random-effects Model so that we can compare the between-firm effects with the within-firm effects (Schunck, 2013).

Finally, we perform some additional analyses using propensity score matching in order to address any concern regarding unobserved heterogeneity. This concern implies a problem of endogeneity in the sense that the presence of former politicians on the board of directors is not random in itself, such that politically connected and non-connected firms might differ in several characteristics, with these differences possibly transferring to corporate innovation.

This procedure requires the observations to be assigned to different groups randomly. Since controlled experiments are not easily carried out in most business studies, implementing matching techniques means that the set of control firms is narrowed down to a more comparable subsample in order to correct the non-random treatment effect by matching to the appropriate counterfactual firm based on the nearest neighbour. To select the matched sample, following Koh and Reeb (2015), we use the lagged Tobin's q, firm age, leverage, and year as control characteristics. We consider politically connected firms as our treatment group. We then use the estimated propensity score to match each firm in our treatment group with a firm in our control group that has the closest propensity score. We thus build a control sample of non-connected firms without observable differences in these characteristics compared to connected firms.

Results

In this section, we report the results of the study. First, we present a descriptive and univariate analysis in order to determine whether the mean values of company innovation in politically connected firms differ from those in non-connected firms. Second, we conduct a multivariate analysis, controlling for other variables that may affect corporate innovation decisions.

Univariate analysis

Panel A of Table 1 provides some descriptive statistics of the main variables considered in this study, and Panel B compares the characteristics of politically connected *vs.* non-connected firms. Data shows that the average value for *R&D* is 0.77%. Firms in our sample file an average of 4.05 patent applications. This result is consistent with González Álvarez and Nieto Antolín (2007), who find a mean of 4.79 patents for a sample of Spanish manufacturing firms. Moreover, in line with Faleye et al. (2014), we also find that the median is 0 for each measure of corporate innovation, suggesting that the typical firm in our sample does not engage in R&D activities or patentable innovation.

Our measure of political connections, which we refer to as *Connected*, indicates the percentage of Spanish listed firms with former politicians on the board of directors. Row 3 of Panel A in Table 1 reports descriptive statistics for this variable. As can be seen, 52.76% of sample firms are politically connected, highlighting the relevant role played by political ties in this institutional context. The second measure, which we refer to as *Politicians*, counts the number of former politicians serving as directors over total board size. In this case, when considering only connected firms, the mean value is 15.68%. These values are in line with the previous papers of Bona-Sánchez et al. (2014) and Guerra Pérez et al. (2015) for a similar sample. The index of political uncertainty has an average value of 106.34 and the median value is 93.76.

As regards other variables of interest, the average firm in our sample has almost eleven board members. The mean leverage of these firms is 62.30%. On average, the Tobin's q is about 1.53, and the cash-holding ratio is about 6.45%. Finally, the mean firm is 48.36 years old.

In order to shed some initial light on whether political connections affect firms' corporate innovation, in Panel B of Table 1 we report the means differences of the innovation variables for the subsamples of connected *vs.* non-connected firms. The results reveal significant differences in R&D intensity and patents when we compare the two groups of firms. Data show that politically connected firms invest less in R&D than non-connected firms (0.59% *vs.* 0.98%), with the difference being statistically significant. In contrast, and in terms of innovation outputs, connected firms have significantly more patent counts compared to non-connected firms (5.55 *vs.* 2.37). In other words, politically connected firms invest less in R&D (an input metric of innovation), although the number of patent applications (an output metric of innovation) is significantly higher. This preliminary evidence is in line with our hypotheses H1 and H2 and suggests that the relation between political connections and corporate innovation seems to be more complex than initially

[1] For a more in-depth explanation of hybrid models, see Certo et al. (2017), Shaver (2019), and Schunck and Perales (2017).

Table 1
Descriptive and univariate analysisPanel
A reports descriptive statistics for all the variables used in the estimations. Panel B displays the innovation activities and other characteristics of connected and non-connected firms. The sample comprises 1
047 firm–year observations over the period 2003–2014. *R&D* is the ratio of R&D investment over total assets; *Patents* is the number of patent applications filed by a firm in a given year; *Connected* takes the value 1 if at least one member of the firm's board of directors has held a political position; Politicians is the ratio of former politicians serving as directors over the total number of directors; *Uncertainty* is political uncertainty and is measured by the quarterly average of the BBD index; *Board_size* is the number of board members; *Firm_size* is the logarithm of total assets; *Leverage* is the ratio of total debt over total assets; *Tobin's q* is the ratio of a firm's market value over the book value of its assets; *Cash* is the cash to total assets ratio; and *Age* is the firm's age in years.[a] Statistics calculated for connected firms. *, **, *** indicate significant at 10, 5, 1%, respectively.

Panel A. Descriptive statistics

	Mean	St. Dev.	Q1	Median	Q3
R&D	0.0077	0.0269	0.0000	0.0000	0.0024
Patents	4.0517	14.8821	0.0000	0.0000	1.0000
Connected	0.5276	0.4995	0.0000	1.0000	1.0000
Politicians[a]	0.1568	0.1076	0.1000	0.1250	0.1818
Uncertainty	106.3460	30.8601	82.4002	93.7664	128.3538
Board_size	10.8000	3.5407	8.0000	10.0000	13.0000
Firm_size	13.8956	1.9019	12.4229	13.6623	15.1335
Leverage	0.6230	0.1939	0.4985	0.6353	0.7637
Tobin's q	1.5315	1.3400	0.9786	1.1847	1.5774
Cash	0.0645	0.0747	0.0143	0.0405	0.0820
Age	48.3586	29.0938	25.5000	41.0000	69.0000

Panel B. Non-connected firms versus connected firms

	Non-connected			**Connected**			
	Mean	**St. Dev**	**Median**	**Mean**	**St. Dev**	**Median**	**Diff.**
R&D_Intensity	0.0098	0.0331	0.0000	0.0059	0.0196	0.0000	2.482***
Patents	2.3741	10.5689	0.0000	5.5539	17.7576	0.0000	−3.652***
Uncertainty	105.7269	30.8249	93.7664	106.9003	30.9062	93.7664	−0.646
Board_size	9.7537	3.2478	9.0000	11.7369	3.5321	11.0000	−9.916***
Firm_size	13.0880	1.5758	13.0122	14.6187	1.8788	14.7001	−14.939***
Leverage	0.6054	0.2027	0.6007	0.6387	0.1843	0.6576	−2.925***
Tobin's q	1.5771	1.6276	1.1646	1.4907	1.0152	1.1925	1.097
Cash	0.0562	0.0719	0.0309	0.0719	0.0764	0.0502	−3.581***
Age	45.3832	28.2056	38.0000	51.0229	29.6370	43.5000	−3.310***

anticipated and thus demands further analysis. In any case, these are merely bivariate statistics and require additional scrutiny, such as multivariate analysis in which we control for other determinants of corporate innovation.

Panel B of Table 1 also compares other characteristics between connected and non-connected firms. Politically connected firms tend to be bigger, have larger boards, and be older than their non-connected counterparts. Moreover, connected firms hold more cash and also exhibit higher financial leverage.

Table 2 presents the Pearson correlation matrix among our variables. The absence of high correlations between the explanatory and control variables suggests that multicollinearity is not an issue. We confirmed that this is the case by calculating variance inflation factors (VIF). All VIF, including mean VIF, are well below a commonly used rule of thumb of five (available upon request), suggesting that multicollinearity is unlikely to be a problem in our study (Studenmund, 1997). Moreover, the data show significant correlations between the variables of corporate innovation and those of political connections. Specifically, there is a significant negative correlation between political connection and R&D intensity. These correlations suggest that firms with political connection reduce their investment in this type of innovation activity. In contrast, we see a significant positive correlation between political connection and patents. The data reveals the different role played by former politicians in the firm's board when the input and output measure of innovation are considered.

As regards the control variables, cash ratio presents a positive and significant correlation with both dimensions of corporate innovation. However, board size and firm size are significantly and positively associated with patents, while displaying a significant but negative correlation with R&D intensity. Finally, Tobin's q is positively associated with R&D intensity, whereas age is correlated with corporate innovation output.

Baseline results

The results of estimating the system of simultaneous equations through 3SLS are reported in models 1 and 2 of Table 3: in Model 1, we study R&D investments and in Model 2 we study patents. In both models, the dependent variable of equation (1) is corporate innovation and that of equation (2) is the presence of former politicians on the board. Each equation includes the main explanatory variables (political connections in equation (1) and dimensions of corporate innovation in equation (2)) together with the control variables. These control variables included in equation (1) are those previously defined, whereas the ones in equation (2) are those

Table 2
Correlation matrix
R&D is the ratio of R&D investment over total assets; *Patents* is the number of patent applications filed by a firm in a given year; *Connected* takes the value 1 if at least one member of the firm's board of directors has held a political position; Politicians is the ratio of former politicians serving as directors over the total number of directors; *Uncertainty* is political uncertainty and is measured by the quarterly average of the BBD index; *Board_size* is the number of board members; *Firm_size* is the logarithm of total assets; *Leverage* is the ratio of total debt over total assets; *Tobin's q* is the ratio of a firm's market value over the book value of its assets; *Cash* is the cash to total assets ratio; and *Age* is the firm's age in years. *, **, *** indicate significant at 10, 5, 1%, respectively.

	R&D	Patents	Connected	Politicians	Uncertainty	Board_size	Firm_Size	Leverage	Tobin's q	Age
Patents	0.1399***									
Connected	−0.0727**	0.1067***								
Politicians	−0.0707**	0.0893***	0.7081***							
Uncertainty	0.0302	0.0831***	0.0190	0.0084						
Board_size	−0.077***	0.1240***	0.2798***	0.1469***	−0.0339					
Firm_size	−0.1513***	0.2615***	0.4020***	0.3553***	0.0434	0.6505***				
Leverage	−0.0075	0.0274	0.0857***	0.0932***	0.1651***	0.1574***	0.2917***			
Tobin's q	0.0736**	−0.0221	−0.0322	−0.0525*	−0.1265***	−0.0885***	−0.1557***	−0.0633**		
Cash	0.0492*	0.0612**	0.1047***	0.0543*	0.0685**	−0.0310	0.0026	0.0154	0.2616***	
Age	−0.0039	0.0727**	0.0968***	0.0897**	0.0585**	0.2087***	0.2373***	0.1745***	−0.0163	−0.0345

Table 3
Connected firms and political uncertainty on corporate innovationModels
1 and 2 are estimated using 3SLS; Model 3 is estimated using the fixed-effects panel model regression, and Model 4 is estimated using the negative binomial panel model with random-effects. *R&D* is the ratio of R&D investment over total assets; *Patents* is the number of patent applications filed by a firm in a given year; *Connected* takes the value 1 if at least one member of the firm's board of directors has held a political position; *Uncertainty* is political uncertainty and is measured by the quarterly average of the BBD index; *Board_size* is the number of board members; *Firm_size* is the logarithm of total assets; *Leverage* is the ratio of total debt over total assets; *Cash* is the cash to total assets ratio; *Tobin's q* is the ratio of a firm's market value over the book value of its assets; and *Age* is the logarithm of one plus the firm's age in years. In equation (2) of Models 1 and 2 (*i.e.*, when the dependent variable is the political connection) we add as control variables, *Presi_dual, IBEX35* and *Own_Board*. Presi_Dual is a dummy variable that equals 1 if the chair of the board has an executive role, and 0 otherwise; IBEX35 equals 1 if the firm is included in the IBEX35 index; and Own_Board is the fraction of shares owned by directors. All the explanatory variables are included with a one-year lag. We also control for time and industry effects with two sets of dummy variables: time variables and industry variables. *, **, *** indicate significant at 10, 5, 1%, respectively.

	Model 1		Model 2		Model 3	Model 4
Estimation method	3SLS		3SLS		Panel regression	Negative binomial panel
Dependent variable	R&D (Eq. (1))	Connected (Eq. (2))	Patents (Eq. (1))	Connected (Eq. (2))	R&D	Patents
$R\&D_{t-1}$		−0.5604				
		(-1.09)				
$Patents_{t-1}$				0.0032		
				(0.18)		
Connected $_{t-1}$	−0.0046**		0.1218*		−0.0049**	0.3123*
	(-2.25)		(1.73)		(-2.29)	(1.74)
Uncertainty $_{t-1}$	0.0002	−0.0012	0.0019**	−0.0006	−0.0003*	0.0122**
	(0.59)	(-0.14)	(2.02)	(-0.13)	(-1.81)	(2.47)
Board_size $_{t-1}$	0.0002		−0.0319***		0.0001	−0.0236
	(0.42)		(-2.60)		(0.36)	(-0.69)
Firm_size $_{t-1}$	−0.0017	0.0916***	0.2669***	0.1097***	−0.0021	0.1936*
	(-1.03)	(7.66)	(9.93)	(4.66)	(-1.18)	(1.91)
Leverage $_{t-1}$	0.0116**	−0.1847**	−0.7624***	−0.0488	0.0124**	−1.1052**
	(2.11)	(-2.28)	(-3.88)	(-0.61)	(2.15)	(-2.51)
Tobin's q $_{t-1}$	0.0007	−0.0065	−0.0174	−0.0294***	0.0007	−0.0459
	(0.79)	(-0.58)	(-0.63)	(-3.22)	(0.72)	(-0.57)
Cash $_{t-1}$	−0.0203*	0.6353***	−0.9120**	0.5407***	−0.0196*	−1.7838*
	(-1.83)	(3.30)	(-2.01)	(3.43)	(-1.66)	(-1.63)
Age $_{t-1}$	−0.1465***	0.0108	−0.5203	−0.3459***	−0.1448***	−4.4414***
	(-4.50)	(0.53)	(-1.45)	(-3.26)	(-4.19)	(-3.18)
Age $_{t-1}2$	0.0311***		0.0754		0.0305***	0.6183***
	(3.83)		(1.47)		(3.54)	(2.90)
Presi_dual		0.1539***		0.0890***		
		(4.88)		(2.59)		
IBEX35		0.1057**		0.1382***		
		(2.21)		(3.06)		
Sales growth		−0.0232		0.0025		
		(-0.45)		(0.08)		
Own_Board		−0.2294***		−0.1979***		
		(-3.58)		(-2.84)		
Intercept	0.0562	−0.5791	−1.6523**	1.0590	0.1165***	4.6114*
	(1.03)	(-0.52)	(-2.51)	(1.16)	(2.82)	(1.75)
No. of observations	1041	1041	1041	1041	1041	1041
Wald chi2/F test	1258.08***	301.86***	224.47***	3605.97***	2.76***	102.09***
Breusch and Pagan test					702.33***	759.56***
Hausman test					20.95**	10.54
Sargan Hansen statistic					17.19**	

which prior research has usually considered as determinants of political connections.

Firm size is expected to be positively related to the likelihood of establishing a political connection (Agrawal and Knoeber, 2001; Boubakri et al., 2008; Faccio, 2006; Faccio et al., 2006). Leverage is justified by some research which shows that connected firms use higher levels of debt (Boubakri et al., 2012a,b; Khwaja and Mian, 2005). In the same vein, Chen et al. (2011) and Cooper et al. (2010) show that politically connected firms are characterized by higher profitability and greater investment opportunities. For this reason, we include the effect of growth opportunities through *Tobin's q*. Chen et al. (2011) also argue that the duality of CEO and chairman positively affects the likelihood of having a politically connected board, as the concentration of power facilitates negotiation with politicians and reduces the risks derived from sharing information about the real benefits of political connections. Thus, we control for the effect of the board president's bargaining power by including the variable *Presi_dual*, a dummy variable that equals 1 if the president of the board has an executive role, and zero otherwise.

Since Guerra Pérez et al. (2015) show that ownership concentration negatively affects political connections, we include *Own_board*, measured as the percentage of ownership in the hands of directors. In addition, firms with political connections are more likely to get preferential access to debt, thereby reducing the need for cash (Johnson and Mitton, 2003; Khwaja and Mian, 2005). In turn, we

include *Cash* as a control variable measured as the percentage of cash holding over total assets. This variable is expected to negatively affect the likelihood of having a politically connected board. The literature suggests that politically connected firms can benefit from government officials' support, especially when it comes to imposing tariffs on competitors, reducing regulatory requirements or awarding valuable government contracts (Bunkanwanicha and Wiwattanakantang, 2009; Goldman et al., 2009). Consequently, we introduce the variable *Sales growth*, measured as the percentage change in sales, and we expect a positive effect on the likelihood of having a politically connected board. Finally, following Boubakri et al. (2012) we introduce two measures related to firm reputation: the age of the firm and the presence of the company in the main market index (operationalized as a dummy variable that equals 1 if the firm is included in the IBEX-35 index). We expect a positive relation of both variables with the likelihood of having a politically connected board.

As can be seen in Table 3, political connections have an asymmetric and significant effect: negatively related to expenditures in R&D ($\beta = -0.0046$, $p < 0.05$, equation (1) in Model 1) but positively related to the firm's patents ($\beta = 0.1218$, $p < 0.1$, equation (1) in Model 2). In contrast, neither of the two measures of innovation has a significant influence on political connections (equation (2) in Models 1 and 2). Taken together, these results lend support to the idea concerning the lack of reverse causality between corporate innovation and political connections.

In order to exploit the advantages of combining time series and cross sectional data, we run new estimates using the panel data method (Models 3 and 4 in Table 3). The Breusch-Pagan Lagrange multiplier proves that panel models outperform OLS regression. The choice between random effects and fixed effects regression is thus based on the Hausman test (fixed effects models for R&D investment and random effects models for patents). The results of Model 3 show that both political connections ($\beta = -0.0049$, $p < 0.05$) and political uncertainty ($\beta = -0.0003$, $p < 0.1$) are negatively related to R&D investment. Model 4, which is estimated as a negative binomial Model given the characteristics of the *Patent* variable, shows a positive relationship between political connections and patents ($\beta = 0.3123$, $p < 0.1$). In this Model, political uncertainty presents a positive and significant coefficient ($\beta = 0.0122$, $p < 0.05$).

In terms of the economic magnitude of the relationships, the R&D intensity of a politically connected firm is 0.49% lower than that of a non-connected firm (Model 3), whereas their patent output is 36.65% higher.[2] These results evidence the economic relevance of having politicians as directors, since they reduce the investment in corporate innovation but increase the output of this decision. In addition, a one standard deviation increase in uncertainty (30.8601) is associated with a 0.92% decline in R&D intensity, but an 37.64% increase in patent output. These results confirms that political uncertainty affects corporate innovation policy.

As far as the control variables are concerned, the most consistent results are the negative relationship of cash with both measures of firm innovation and a U-shaped association between R&D and firm age. This latter result could reflect the fact that the youngest firms need to innovate in order to enter the market, and that the oldest ones need to innovate in order to renew their knowledge so as to maintain their competitive advantage. In Model 4, we see a positive relationship between firm size and corporate innovation output, which means that large firms are more likely to protect their innovation results through the use of patents. Finally, the estimated models show a dual effect of leverage on corporate innovation: positive for the input dimension and negative for the output.

Table 4 (Models 5–10) reports the results of the hybrid models. The estimates of Model 5 show that political connections have a negative and significant between- ($\beta_b = -0.0809$, $p < 0.05$) and within-firm effect ($\beta_w = -0.0049$, $p < 0.05$). These results corroborate previously reported findings and confirm our hypothesis H1. They suggest that politically connected firms invest less on R&D both when compared to non-connected firms and when taking into account the switch from being non-connected to having a former politician on the board of directors. In addition, political uncertainty has a negative and significant association with R&D investment ($\beta = -0.0003$, $p < 0.1$), which supports hypothesis H3.

As regards innovation output, Model 6 shows that the between-firm effect of political connections on patents is not significant, whereas there is a positive and significant within-firm effect ($\beta_w = 0.3685$, $p < 0.1$). These results lend partial support to hypothesis H2 insofar as, although there are no significant differences between connected and non-connected firms, by setting up political connections a given firm has more patents. The estimates of Model 6 also show a positive effect of political uncertainty on patents ($\beta = 0.0041$, $p < 0.01$). This result is in line with our hypothesis H4 since it means that greater political uncertainty implies a greater propensity towards patents.

Models 7 to 10 (Table 4) aim to test hypothesis H5 concerning the moderating effect of political connections on the relationship between political uncertainty and corporate innovation. In Model 7, whereas the coefficients of between-firm and within-firm political ties and that of uncertainty are negative, the interacted variable has a positive coefficient. In turn, political connections attenuate the negative direct relationship between uncertainty and R&D investments. In Model 8, we see that political uncertainty is positively related to patent applications. For a better understanding of this interplay, we present a graphical analysis in Figs. 2 and 3.

Fig. 2 illustrates the combined effect of political connections and political uncertainty on R&D investment.[3] In most of the points, both lines are under the horizontal axis, which means that political uncertainty has a negative effect on R&D intensity. Nevertheless, the slope of the politically connected firm line is positive, whereas that of non-connected firms is negative. This means that the presence of politicians on the board moderates the influence of uncertainty: whereas uncertainty is negatively related with investment in R&D for unconnected firms, the relation in politically connected firms is more complex. For low levels of uncertainty, politically connected firms invest less in R&D than their unconnected counterparts. However, after a certain threshold, the relationship changes and even results in connected firms investing more in R&D for high levels of political uncertainty (when the index of political

[2] These numbers are calculated based on the coefficients in the exponentiated form, which can be interpreted as relative risk ratios (akin to odds ratios).

[3] We only report the between-effect, given the lack of significance of the within-firm effect.

Table 4
Connected firms and political uncertainty on corporate innovation. Hybrid Models
R&D is the ratio of R&D investment over total assets; *Patents* is the number of patent applications filed by a firm in a given year; *Connected* takes the value 1 if at least one member of the firm's board of directors has held a political position; *Politicians* is the ratio of former politicians serving as directors over the total number of directors; *Uncertainty* is political uncertainty and is measured by the quarterly average of the BBD index; *Board_size* is the number of board members; *Firm_size* is the logarithm of total assets; *Leverage* is the ratio of total debt over total assets; *Tobin's q* is the ratio of a firm's market value over the book value of its assets; *Cash* is the cash to total assets ratio; and *Age* is the logarithm of one plus the firm's age in years. All the explanatory variables are included with a one-year lag. We also control for time and industry effects with two sets of dummy variables: time variables and industry variables. Models 5, 7, and 9 are estimated as panel models. Models 6, 8, and 10 are estimated as negative binomial panel models. *, **, *** indicate significant at 10, 5, 1%, respectively.

Dependent variable	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
	R&D	Patents	R&D	Patents	R&D	Patents
B_Connected	−0.0809**	−0.1428	−0.3034**	−4.9038*		
	(-2.28)	(-0.25)	(-2.22)	(-1.83)		
W_Connected	−0.0049**	0.3685*	−0.0064	0.8048**		
	(-2.29)	(1.93)	(-1.46)	(2.12)		
Uncertainty	−0.0003*	0.0041***	−0.0003*	0.0067**	−0.0003**	0.0054***
	(-1.81)	(2.66)	(-1.84)	(2.42)	(-2.04)	(2.72)
*B_Connected*Uncertainty*			0.0024**	0.0404*		
			(2.17)	(1.84)		
*W_Connected*Uncertainty*			0.0000	−0.0041		
			(0.39)	(-1.31)		
B_Politicians					−2.2128**	−7.1173***
					(-2.29)	(-2.61)
W_Politicians					−0.0076	12.4008***
					(-0.38)	(3.16)
*B_Politicians*Uncertainty*					0.0191**	0.0034
					(2.20)	(0.20)
*W_Politicians*Uncertainty*					0.0000	−0.0962***
					(0.28)	(-2.61)
Board_size $_{t-1}$	0.0001	−0.0262	0.0002	−0.0214	0.0000	−0.0153
	(0.36)	(-0.79)	(0.38)	(-0.65)	(0.09)	(-0.53)
Firm_size $_{t-1}$	−0.0021	0.2630***	−0.0021	0.2871***	−0.0024	0.2083**
	(-1.18)	(2.71)	(-1.21)	(2.93)	(-1.35)	(2.18)
Leverage $_{t-1}$	0.0124**	−0.7955*	0.0124**	−0.7477*	0.0116**	−0.4035
	(2.15)	(-1.79)	(2.16)	(-1.93)	(2.00)	(-1.07)
Tobin's q $_{t-1}$	0.0007	−0.0381	0.0007	0.0045	0.0007	−0.0417
	(0.72)	(-0.49)	(0.71)	(0.06)	(0.71)	(-0.69)
Cash $_{t-1}$	−0.0196*	−1.5530	−0.0194*	−1.7874*	−0.0228**	−0.8348
	(-1.66)	(-1.44)	(-1.64)	(-1.69)	(-1.92)	(-0.84)
Age $_{t-1}$	−0.1448***	−4.0445***	−0.1440***	−3.5707***	−0.1486***	0.2466
	(-4.19)	(-3.05)	(-4.16)	(-2.78)	(-4.28)	(0.24)
Age $_{t-1}2$	0.0305***	0.5748***	0.0304***	0.5217***	0.0320***	−0.0465
	(3.54)	(2.84)	(3.53)	(2.67)	(3.71)	(-0.31)
Intercept	0.1925***	4.6203*	0.1932***	3.2972	0.1910***	−1.5976
	(4.15)	(1.83)	(4.16)	(1.29)	(4.24)	(-0.90)
No. of observations	1054	1054	1054	1054	1054	1054
Wald chi2/F test	1132.29***	89.42***	1131.41***	99.19***	1119.77***	119.28***

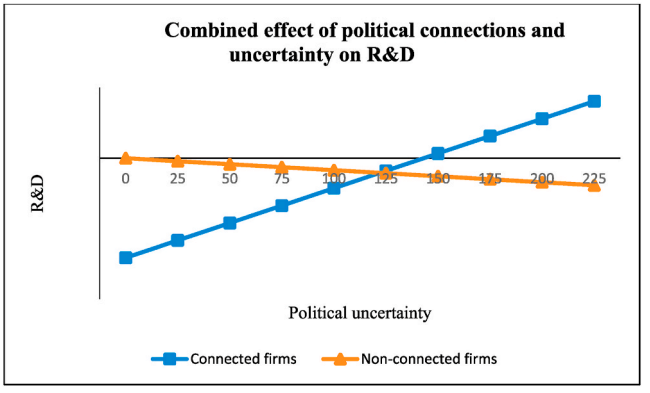

Fig. 2. Combined effect of political connections and uncertainty on R&D.

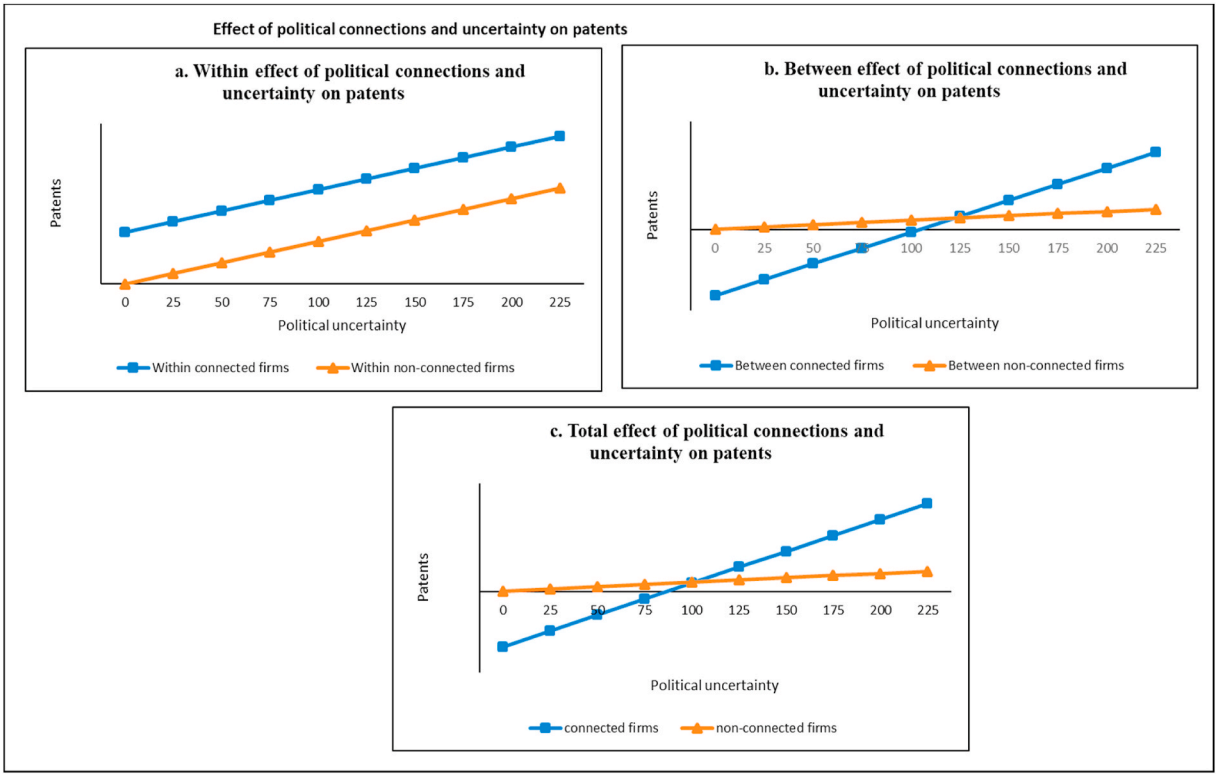

Fig. 3. Effect of political connections and uncertainty on patents.

uncertainty is above 122).[4] In other words, the association of uncertainty and R&D investment is conditional on the existence of political ties, such that political uncertainty increases R&D expenses when the firm is politically connected. In turn, political connections are valuable for high levels of uncertainty. It seems that political uncertainty and connections have complementary effects: contrary to non-connected firms, the negative effect of uncertainty on firms with politicians not only diminishes as uncertainty increases but may also prove to be positive.

Fig. 3 illustrates the within-, between-firm and total effect of political connections and uncertainty on innovation output (patents). Hybrid Models have the advantage of separating the within- and between-firm effects, which would have remained hidden in other types of estimations. These effects are notably different for patents and for R&D investment. As shown in Fig. 3a (within-firm effect), uncertainty has a positive effect on patent applications, with this effect being stronger for politically connected firms, irrespective of the level of uncertainty. Fig. 3b (which displays the between-firm effect) also shows a positive slope for both lines, meaning that greater uncertainty translates into more patents. However, contrary to the within effect, Fig. 3b shows a switch in the effect of political uncertainty: for low levels of uncertainty, the impact is higher on the patents of unconnected firms but, after a given point, the impact is higher for politically connected firms.

In Fig. 3c, we display the combination of both effects. It can be seen that the between-effect is more influential than the within-firm effect, such that the number of patents increases when political uncertainty increases. The effect of uncertainty on the number of patents is always positive for unconnected firms, which could be seen as an indicator that, when firms do not have these political connections, uncertainty leads them to seek more legal protection in the form of patents. For connected firms, the positive effect of political uncertainty only holds for high enough levels of such uncertainty (when the index is over 85).

Taken together, the results from Models 5–8 and Figs. 2 and 3 confirm that the relationship between political uncertainty and corporate innovation is more complex than what the usual statistical Models suggest. By differentiating two components of variance, our analysis of hybrid Models shows that the link between uncertainty and innovation (both in terms of R&D investment and patents) is moderated by political connections. This finding corroborates our hypothesis H5 in the sense that the firm's political connections attenuate the influences of political uncertainty on both dimensions of corporate innovation. Therefore, the negative effect of political uncertainty on R&D intensity is lower when the firm has politicians, although the positive effect on patents is also lower when a firm has this type of director on its board.

[4] To assess the feasibility of achieving this point, one should take into account that the mean value of the uncertainty index is 106.5 and the third quartile is 132.4.

Robustness analysis

In this subsection, we perform a set of robustness tests to ensure the reliability of our findings. We re-estimate the Models and include new control variables, new measures of the dependent variables, and we use new methods. Overall, these additional tests, which are reported in Tables 5 and 6, reinforce our evidence that political connections have a dual effect on corporate innovation (conditional on the innovation dimension, i.e., whether it is an input or an output innovation measure).

In Models 9 and 10, we re-estimate the previous hybrid Models and consider an alternative measure of political ties, which we refer to as *Politicians*. This variable is the number of former politicians serving as directors over total board size. Findings are consistent with those previously reported. The percentage of politicians has a negative and significant between-firm effect on both dimensions of corporate innovation. In isolation, these findings would mean that firms with more former politicians invest less in R&D and apply for fewer patents. This is in line with our H1 but challenges our H2. Nevertheless, when the within-firm effect is considered, an increase in the percentage of politicians inside a firm over time has a positive influence on patents (see Model 10 in Table 4) which makes up for the negative sign of the between-firm coefficient. This result reveals that if a firm were to increase its political connections, it would be more likely to protect its corporate innovation output, as hypothesized in H2.

Political uncertainty is also seen to have a negative and significant association with R&D intensity, but a positive one with patents (Models 9 and 10), supporting hypotheses H3 and H4. In addition, the coefficient of the interaction term of between-firm connections and political uncertainty is significant and positive in the case of Model 9 (R&D intensity), although the coefficient of the interaction term of within-firm connection and political uncertainty is significant and negative in the case of Model 10 (patents). These results bear out the attenuation role that political connections play in the relationship between political uncertainty and innovation (H5).

Models 11 and 12 in Table 5 deal with the influence of political connections and political uncertainty on R&D expenditures, whereas Models 13 to 15 focus on patents. In Model 11, we control for some external factors that may affect investment in innovation by including a new control variable (*R&D_GDP*), defined as gross domestic expenditures on R&D as a percentage of GDP. In Model 12, we use an alternative dependent variable and scale R&D expenditures by firms' sales. The estimates in both columns support our baseline results since the proportion of politically connected directors is negatively related to R&D intensity. Interestingly, the interaction of between-firms' political connections with political uncertainty has a positive coefficient, which means that when faced with increased political uncertainty an increase in a firm's political connections decreases or attenuates the reduction of R&D investment.

In Model 13, we include two variables that could positively affect the number of patents: the world ranking of Spain in the defence of property rights and the citations that each patent makes to prior patents. The defence of property rights is measured with the variable *RankProper_Rights,* defined as one minus the position which Spain holds each year in the ranking published by the World Economic Forum (Global Competitiveness Reports). The number of citations of each patent is measured with the variable *Backward_citations*, calculated as the logarithm of the number of citations each patent makes to prior patents. The references to previous patents reflects the importance of prior knowledge in the sense that the higher the number of citations, the more the firm takes advantage of technologies developed by third parties, which enhances the firm's innovative capacity (Appio et al., 2019). We search the backward citations of the patents of each firm in the LENS Patent database.

Although in most previous Models of innovation output the quantity of innovation is measured through the number of a firm's patents, "there is a large number of patents of limited value and a small number of highly valuable ones" (Dechezleprêtre et al., 2017, p. 796). For this reason, some authors advocate controlling for the quality of corporate innovation with the number of citations received by the patents (Atanassov and Liu, 2020; He and Tian, 2013; Helmers et al., 2017). Accordingly, this is the method we employ. In Model 14, we include the logarithm of the number of citations received for each firm-year as the dependent variable.

We also construct another indicator of patent quality; patent family size (Bai and Tian, 2020; Harhoff et al., 2003; Rong et al., 2017). This variable encompasses "the set of patents (or applications) filed in several countries which are related to each other by one or several common priority filings" (OECD, 2009), and is measured as the logarithm of the number of jurisdictions in which patent protection was sought for the same invention. This variable has been hand-developed from the LENS database.

The results of Models 13–15 show a positive association between backward citations and corporate innovation output, whereas the coefficient of the *RankProper_Rights* is not significant. More interestingly, within-firms political connections have a positive and significant coefficient that outperforms the negative within-firms coefficient.

Political uncertainty is negatively associated with the different metrics of innovation output in all the Models 13–15. Furthermore, the interaction of political uncertainty and connections also provides confirmatory evidence: whereas the interaction with between-firm connections has a positive coefficient, the interaction with within-firm connections has a negative coefficient that makes up for the positive one. In turn, all these estimates support the notion that political ties attenuate (in the sense of lessening) the positive effect of uncertainty on patents.

Another issue we address is that politically connected firms might differ from unconnected ones on dimensions that are correlated with the corporate innovation decision. To mitigate this concern, we perform some additional analyses using the propensity score matching technique. We create a matched sample by matching each politically connected firm in the sample to an unconnected one with similar observable characteristics that are known to influence a firm's propensity to innovate (lagged Tobin's *q*, firm age, leverage, and year). We consider a matched sample of 751 firm-year observations equally distributed between connected and non-connected firms. We then estimate the final Model using this matching sample for the four measures of corporate innovation: R&D intensity, patent counts, patent citations, and patent families. Table 6 (Models 16 to 19) shows the results of those Models.

In Model 16, the coefficient of the between-firm *Politicians* effect is negatively associated with R&D intensity, which suggests that an increase in the proportion of politically connected directors compared to other firms reduces investment in R&D. The results also

Table 5
Robustness analysis I.
R&D (sales) is the ratio of R&D investment over total assets (sales); *Patents* is the number of patent applications filed by a firm in a given year; Cites received is the number of citations received by the patents; patent families are the number of jurisdictions in which patent protection was sought for the same invention; *Politicians* is the ratio of former politicians serving as directors over the total number of directors; *Uncertainty* is political uncertainty and is measured by the quarterly average of the BBD index; *Board_size* is the number of board members; *Firm_size* is the logarithm of total assets; *Leverage* is the ratio of total debt over total assets; *Tobin's q* is the ratio of a firm's market value over the book value of its assets; *Cash* is the cash to total assets ratio; and *Age* is the logarithm of one plus the firm's age in years; R&D_GDP is the proportion of gross domestic expenditures in R&D over GDP; *RankProper_Rights* is based on Spain's position in the ranking of property rights protection. *Backward_citations*, is the (log of) the number of citations that each patent makes to prior patents. All the explanatory variables are included with a one-year lag. We also control for time and industry effects with two sets of dummy variables: time variables and industry variables. Models 11 and 12 are estimated as panel models. Models 13, 14 and 15 are estimated as negative binomial panel models. *, **, *** indicate significant at 10, 5, 1%, respectively.

Dependent variable	Model 11	Model 12	Model 13	Model 14	Model 15
	R&D	R&D (sales)	Patents	Cites received	Patent families
B_Politicians	−0.8583***	−1.2634**	−13.7870***	−9.0495**	−11.1271***
	(-2.60)	(-2.17)	(-3.09)	(-1.95)	(-2.94)
W_Politicians	0.0117	0.0130	17.8559***	21.9498***	19.0555***
	(0.89)	(0.56)	(3.16)	(2.75)	(3.07)
Uncertainty	0.0000	0.0000	0.0138**	0.0199**	0.0151***
	(0.38)	(0.48)	(2.44)	(2.30)	(2.70)
*B_Politicians*Uncertainty*	0.0070**	0.0101*	0.02096	0.0592**	0.0454*
	(2.26)	(1.84)	(0.95)	(1.95)	(1.91)
*W_Politicians*Uncertainty*	−0.0001	−0.0000	−0.1217**	−0.1418*	−0.1224**
	(-0.84)	(-0.31)	(-2.21)	(-1.82)	(-1.95)
Board_size $_{t-1}$	0.0001	0.0003	−0.0643*	−0.0605	−0.1096***
	(0.53)	(0.54)	(-1.77)	(-1.38)	(-3.43)
Firm_size $_{t-1}$	−0.0023**	−0.0028	0.1525	0.4412***	0.3360***
	(-2.00)	(-1.41)	(1.24)	(3.97)	(3.67)
Leverage $_{t-1}$	0.0012	0.0073	−0.3654	0.1046	−0.8025***
	(0.31)	(1.10)	(-0.86)	(0.16)	(-2.65)
Tobin's q $_{t-1}$	0.0003	0.0006	0.0599	0.2122*	0.1464*
	(0.42)	(0.56)	(0.59)	(1.92)	(1.81)
Cash $_{t-1}$	−0.0176**	−0.0342**	0.0981	−1.8237	−1.1125
	(-2.27)	(-2.50)	(0.10)	(-1.10)	(-0.97)
Age $_{t-1}$	−0.10376***	−0.1897***	−2.1738	−5.6293***	−3.5027***
	(-6.89)	(-7.16)	(-1.18)	(-3.30)	(-2.97)
Age $_{t-1}$*2*	0.0200***	0.0353***	0.3478	0.7528***	0.5259***
	(6.38)	(6.37)	(1.24)	(3.01)	(3.04)
R&D_GDP	−0.0091*	−0.0201**			
	(-1.73)	(-2.15)			
RankProper_Rights			0.6499	−2.1522	0.0237
			(0.35)	(-0.62)	(0.02)
Backward_citations			0.0034*	0.0073***	0.0126***
			(1.75)	(3.88)	(6.43)
Intercept	0.1608***	0.2714***	1.9331	3.0353	−0.4138
	(5.92)	(5.69)	(0.59)	(1.14)	(-0.22)
No. of observations	1054	1054	1054	1054	1054
Wald chi2/F test	2066.11***	1607.85***	138.58***	116.80***	385.79***

confirm that, given an increase in political uncertainty, the reduction of R&D intensity is lower when firms increase the presence of former politicians in their boards. In contrast, the coefficient of the within-firm *Politicians* effect is positive and significant in all three measures of corporate innovation output (Models 17 to 19), which suggests that more politicians on the board increase the quantity and quality of innovation output (patents, citations and families). These coefficients are large enough to make up for the potential negative coefficient of between-firm *Politicians*. The positive and significant coefficient of the uncertainty variable implies that the firm's decision to protect its innovation results through the use of patents increases when political uncertainty is greater. Moreover, the coefficients of the interacted variables (Models 17–19) mean that this positive relationship is attenuated when firms have former politicians as directors. Overall, our findings concur with those of previous Models.

Further analyses

One clear result that stems from our previous analyses is the greater efficiency of corporate innovation enhanced by political connections. Firms with political ties in their board achieve more patents with less investment. In this section, we explore this result in greater depth and provide additional analyses regarding the impact of political connections on the efficiency of innovation. In line with Lodh et al. (2014), we use two measures of efficiency: *Eff_asset* and *Eff_sales*. These are the ratio of the number of patents to R&D investment scaled by assets and sales, respectively. Table 7 reports the results of the Models. We run six specifications. The first two sets of results (Models 20 and 21) are ordinary least squares (OLS) regressions, where the dependent variable is the innovation efficiency

Table 6
Robustness analysis II. Matching sample.
R&D (sales) is the ratio of R&D investment over total assets (sales); *Patents* is the number of patent applications filed by a firm in a given year; Cites received is the number of citations received by the patents; patent families are the number of jurisdictions in which patent protection was sought for the same invention; *Politicians* is the ratio of former politicians serving as directors over the total number of directors; *Uncertainty* is political uncertainty and is measured by the quarterly average of the BBD index; *Board_size* is the number of board members; *Firm_size* is the logarithm of total assets; *Leverage* is the ratio of total debt over total assets; *Tobin's q* is the ratio of a firm's market value over the book value of its assets; *Cash* is the cash to total assets ratio; and *Age* is the logarithm of one plus the firm's age in years; R&D_GDP is the proportion of gross domestic expenditures in R&D over GDP; *RankProper_Rights* is based on Spain's position in the ranking of property rights protection. *Backward_citations*, is the (log of) the number of citations that each patent makes to prior patents. All the explanatory variables are included with a one-year lag. We also control for time and industry effects with two sets of dummy variables: time variables and industry variables. Model 16 is estimated as a panel Models. Models 17–19 are estimated as negative binomial panel models. *, **, *** indicate significant at 10, 5, 1%, respectively.

Dependent variable	Model 16	Model 17	Model 18	Model 19
	R&D	Patents	Cites received	Patent families
B_Politicians	−0.8110*	−4.9032	3.2803	−8.8203***
	(-1.71)	(-1.38)	(0.69)	(-3.05)
W_Politicians	0.0112	16.1223***	12.4311*	14.6355**
	(0.67)	(2.95)	(1.75)	(2.13)
Uncertainty	0.0000	0.0223***	0.0900**	0.0208***
	(-0.05)	(3.36)	(2.02)	(4.34)
*B_Politicians*Uncertainty*	0.0076*	−0.0355	−0.0586*	0.0254
	(1.63)	(-1.30)	(-1.72)	(1.14)
*W_Politicians*Uncertainty*	−0.0001	−0.1257**	−0.1198*	−0.1214**
	(-0.85)	(-2.53)	(-1.85)	(-1.96)
Board_size $_{t-1}$	0.0000	−0.0808*	−0.2366***	−0.1029**
	(0.09)	(-1.64)	(-3.25)	(-2.52)
Firm_size $_{t-1}$	−0.0037***	0.3860***	0.5728***	0.5093***
	(-2.71)	(2.57)	(3.48)	(4.28)
Leverage $_{t-1}$	0.0048	−0.4410	0.7956	0.0399
	(1.08)	(-1.04)	(1.00)	(0.14)
Tobin's q $_{t-1}$	−0.0010	0.0282	0.1156	−0.0253
	(-1.53)	(0.23)	(0.87)	(-0.19)
Cash $_{t-1}$	−0.0120	−0.4864	−0.9198	−2.0640
	(-1.28)	(-0.36)	(-0.44)	(-1.55)
Age $_{t-1}$	−0.0734***	0.5428	−0.7626	−3.1428**
	(-2.53)	(0.28)	(-0.25)	(-2.21)
Age $_{t-1}2$	0.0154***	−0.1660	0.0638	0.4431**
	(2.53)	(-0.55)	(0.15)	(2.09)
R&D_GDP	−0.0059			
	(-0.78)			
RankProper_Rights		3.0115	1.8664	2.2004
		(1.22)	(0.79)	(1.39)
Backward_citations		0.0151**	0.0196**	0.0258***
		(1.97)	(2.15)	(3.67)
Intercept	0.1300***	−5.6529*	−6.6521	−3.9347
	(2.96)	(-1.78)	(-1.28)	(-1.73)
No. of observations	751	751	751	751
Wald chi2/F test	1558.56***	119.01***	67.25***	2031.88***

relative to assets and sales, respectively. Since these variables are censored, in Models 22 and 23, we apply Tobit methods. Finally, in Models 24 and 25 we replicate Models 22 and 23, respectively, but considering the matching sample.

Overall, the results confirm the expected positive effect of political connections on the innovation efficiency of innovation and the moderating role in the relationship between political uncertainty and efficiency. The *Connected* coefficient is positive and statistically significant across all specifications, which suggests that the innovation activities of politically connected firms are more efficient. Although we find no significant relationship with political uncertainty, the negative coefficient of the interacted variable *Connected*Uncertainty* implies that the influence of political connections is also affected by the level of political uncertainty.

Conclusions

There is worldwide concern among many governments and international institutions over the somewhat subdued current levels of investment in innovation. Bearing this in mind, political ties might foster corporate innovation process in order to achieve the required optimal level. On the other hand, political ties may serve as a barrier to entry, thereby curtailing industry competition. In such a context, politically connected firms may devote more attention to lobbying and influencing decision-makers than to investing in innovation.

In this paper, we examine the effect of corporate political connections and political uncertainty on firms' innovation as well as such connections' moderating role in the relationship between political uncertainty and innovation in a European context. We consider the

Table 7
Corporate innovation efficiency and political connections
Eff_asset (Eff_sales) is the ratio of the number of patents to R&D expenditures scaled by total assets (sales); *Connected* takes the value 1 if at least one member of the firm's board of directors has held a political position; *Uncertainty* is political uncertainty and is measured by the quarterly average of the BBD index; *Board_size* is the number of board members; *Firm_size* is the logarithm of total assets; *Age* is the logarithm of one plus the firm's age in years; and ROA is the return on assets. All the explanatory variables are included with a one-year lag. We also control for time and industry effects with two sets of dummy variables: time variables and industry variables. Models 20 and 21 are OLS regressions, Models 22 and 23 are Tobit regressions, and Models 24 and 25 are Tobit regressions estimated on the matching sample. *, **, *** indicate significant at 10, 5, 1%, respectively.

Dependent variable	Model 20	Model 21	Model 22	Model 23	Model 24	Model 25
	Eff_asset	Eff_sales	Eff_asset	Eff_sales	Eff_asset	Eff_sales
Connected	2.2182*	2.2109*	5.2245*	5.0481*	6.2839*	6.1984**
	(1.81)	(1.91)	(1.81)	(1.86)	(1.84)	(1.93)
Uncertainty	0.0061	0.0056	0.0176	0.0162	0.0381	0.0366
	(0.36)	(0.35)	(0.39)	(0.38)	(0.76)	(0.78)
*Connected*Uncertainty*	−0.0206*	−0.0203*	−0.0496**	−0.0477**	−0.0545*	−0.0542*
	(-1.84)	(-1.94)	(-1.97)	(-2.02)	(-1.79)	(-1.89)
Board_size $_{t-1}$	−0.1231	−0.1125	−0.3364*	−0.3132*	−0.8040***	−0.7460***
	(-1.55)	(-1.51)	(-1.90)	(-1.88)	(-3.62)	(-3.56)
Firm_size $_{t-1}$	−5.9611***	−5.1863***	−10.9577***	−9.8403***	−11.7013***	−10.6996***
	(-5.27)	(-4.92)	(-4.45)	(-4.29)	(-3.45)	(-3.38)
Firm_size $^{2}_{t-1}$	0.2377***	0.2079***	0.4388***	0.3954***	0.4837***	0.4428***
	(5.89)	(5.51)	(5.16)	(4.98)	(4.08)	(4.00)
Age $_{t-1}$	−0.1596	−0.0524	−0.6784	−0.5137	−0.1523	−0.0699
	(-0.61)	(-0.22)	(-1.06)	(-0.87)	(-0.18)	(-0.09)
ROA $_{t-1}$	0.4536	0.8629	0.7730	1.3713	−1.4317	−0.3744
	(0.22)	(0.46)	(0.14)	(0.27)	8–0.19)	(-0.05)
Intercept	39.9052***	34.3040***	68.8864***	61.1905***	72.1336***	65.4490***
	(4.98)	(4.63)	(3.83)	(3.68)	(2.92)	(2.85)
No. of observations	396	396	396	396	275	275
Wald chi2/F test	4.70***	4.35***	4.86***	4.63***	3.41***	3.29***

presence of politicians on the firm's board of directors as a measure of political connections. Although previous research has explored the effect on innovation of certain corporate governance mechanisms, such as ownership structure, what impact the political ties of boards of directors might have is an issue that demands further inquiry We use two different metrics of innovation: R&D intensity (an input measure) and patent applications (an output measure).

We study a sample of non-financial firms listed on the Spanish Stock Exchange over the period 2003–2014. We combine a number of statistical methods to address this data structure: 3SLS, panel data regression, negative binomial panel models, Tobit regressions, propensity score matching, and hybrid models. Whereas propensity score matching techniques address any concern over unobserved heterogeneity, hybrid models allow the longitudinal dimension of the data to be exploited by differentiating two levels of variance: within- and between firms. We find that political connections do have a significant impact on corporate innovation. Broadly speaking, politically connected firms invest less in R&D but have more patents than their non-connected counterparts. This could mean that political connections improve the efficiency of corporate innovation in the sense that these firms achieve more output (patents).

We also find that political uncertainty has a twofold relationship with innovation: while greater uncertainty results in less R&D expenditures, it is positively associated with patenting activity. In any case, the negative influence of uncertainty on R&D investment is not uniform across firms: at low levels of uncertainty connected firms invest less in R&D, although the situation reverses at high levels of political uncertainty, with politically connected firms investing more in R&D than non-connected firms. It shows that in contexts of great uncertainty, firms adopt a different strategy conditional upon political ties: connected firms rely more on corporate innovation than non-connected firms. As far as patents are concerned, our results show a different impact of uncertainty, since it intensifies the need for legal protection for innovation through patents. Another set of results relates to the interaction of political uncertainty and connections. We find that political connections attenuate the effect of political uncertainty on firm innovation, such that the negative (positive) effect of uncertainty on R&D expenditures (patents) weakens when the firm is politically connected.

Our research provides some implications with regard to improving company management. Our results suggest that the board of directors is not only a managerial oversight mechanism but also a strategic guide mechanism as well as a way of bringing critical resources to the firm. Having former politicians on the board can provide the firm with valuable guidance and knowledge on public policies and so improve the efficiency of corporate innovation.

In turn, our results show that directors who have a political background do indeed play a role by achieving higher levels of patents with lower R&D expenditures, and by alleviating the impact of political uncertainty. From this standpoint, the personal networks of former politicians who are members of the board of directors can improve corporate innovation efficiency, given the resources and knowledge they bring. Although this idea applies to different institutional settings, our results are particularly relevant in the continental European context.

In the European framework, our results have particularly valuable implications in the current period which is seeing major political upheavals such as the Brexit, the rise of populisms, and the dramatic consequences of the Covid-19 pandemic. By bringing the expertise and networks of former politicians, the board of directors can promote sustainable competitive advantages through more efficient

corporate innovation. Similarly, governments should pay special attention to firms that lack these political connections in order to prevent them from losing competitiveness and in an effort to support their long term sustainability.

There are a number of possible future extensions for our research. Future studies might examine whether this more effective investment in innovation of politically connected firms translates into enhanced economic or financial performance; in other words, the extent to which the value of the firm reflects the expertise and knowledge brought in by directors with a political background. Another direction for future work is to explore whether politically connected firms are more efficient in the use of financial resources to fund investment in innovation. Given the financial constraints that usually affect investment in innovation, identifying which circumstances could loosen financial constraints might be a way to boost corporate investment in innovation in order to reach socially optimal levels. Future studies might also consider additional measures of innovation performance. We use patents, although not all firms decide to protect the results of their innovation activities with patents. Some companies may prefer to use other mechanisms to protect their innovation output, an issue which might be addressed in future research.

Declaration of competing interest

None.

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