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RESEARCH ARTICLE

Women directors and firm innovation: The role of women directors' representative function

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Abstract

We argue that the link between women directors in co-determined supervisory boards and firm innovation depends on two contextual factors: (1) Women directors' power, as measured by their share among shareholder representatives, and (2) on whether women are represented in *both* representative functions, that is, shareholder *and* employee representatives. In our empirical analysis based on German panel data, we find the positive link between women directors and firm innovation to be driven by women shareholder representatives, and we find the joint presence of women among shareholder and employee representatives to be positively linked to firm innovation.

JEL CLASSIFICATION

G34, J16, O32

1 | INTRODUCTION

Innovation leads to a competitive advantage of firms (e.g., Briest et al., 2020; Li et al., 2018; Subramaniam & Youndt, 2005) and has been shown to be an important driver of economic growth (e.g., Hasan & Tucci, 2010). Hence, it comes as no surprise that an increasing number of studies explores the determinants of firm innovation at different levels: Country, industry, and firm (e.g., Foucart & Li, 2021; Hoxha & Kleinknecht, 2020; Speldekamp et al., 2020; Wu et al., 2021; Xie et al., 2020).

In our paper, we focus on a potentially important firm level determinant of innovation: board composition. More specifically, we focus on a board's gender composition and how it interacts with board members' representative function in co-determined supervisory boards, that is, in supervisory boards that include both, shareholder and employee representatives. In so doing, we seek to enhance our

understanding of the *contextual factors* that affect the link between women directors and firm innovation. One first contextual factor relating to directors' representative function refers to *director power*. Specifically, and referring to shareholder primacy theory (Parmar et al., 2010; Smith & Rønnegard, 2016), we argue that a director's power is related to the director's representative function, with shareholder representatives being generally more powerful than employee representatives. The second contextual factor relating to directors' representative function refers to women directors potentially assuming a *bridging role* between shareholder and employee interests. Specifically, we argue that the link between women shareholder representatives and firm innovation will be stronger if there are women directors in *both* representative functions: among shareholder representatives *and* employee representatives.

Our contribution to the literature is twofold: First, we contribute to the literature by enhancing our understanding of potential

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contextual factors that affect the link between women directors and firm innovation, concentrating on women directors' power and their potential bridging role. Second, we contribute to the literature that focuses on potential interactions between different diversity dimensions. By including directors' representative function as a second diversity dimension besides directors' gender, we follow the call by Harrison et al. (2002) to regard further, preferably “deeper-level” diversity dimensions in addition to “surface-level” demographic ones, and study potential interactions.

While our study is based on a specific institutional context, that is, German co-determined supervisory boards (see Section 2 for the details), we are confident that our insights can be extended to other countries and contexts. First, a two-tier board structure is not only common in many other European countries besides Germany, for example, in Austria, France, or the Netherlands (European Trade Union Institute [ETUI], 2020; Ferreira & Kirchmaier, 2013), but the tasks of the supervisory board (i.e., to monitor and advise the management board) are also similar to the ones of outside directors in monistic board systems (Lin et al., 2018). Second, while several European countries provide employee representation on corporate boards, it is the German system of co-determination which has served as a role model for the discussion on whether to also stipulate employee board representation in the United States, for instance, in the context of the *Accountable Capitalism Act* introduced by U.S.-Senator Elizabeth Warren in 2018 (Gleason et al., 2021, p. 1047). Third, our theoretical argumentation focuses on one diversity dimension (gender) interacting with another one (representative function), but is not restricted to the two specific diversity dimensions under consideration. In another context—for example, in a monistic board structure such as in the United States—the second diversity dimension might, for instance, refer to inside versus outside directors. Hence, our analysis and results are also informative for other institutional contexts and have implications beyond the specific context studied in our paper.

2 | INSTITUTIONAL CONTEXT

Germany's corporate governance system is characterized by a two-tier board structure with an executive board on the one hand and a nonexecutive supervisory board on the other. While the executive board (including, among others, the CEO) is responsible for the day-to-day business operations of the firm, the supervisory board monitors and advises the executive board. The two boards are strictly separated from one another such that members of one board of one company may not be members of the other board of the same company at the same time (Kim et al., 2018).

Even though not engaged in day-to-day business, the supervisory board may influence a firm's innovation strategy via several channels: First and foremost, the supervisory board appoints (and dismisses) the members of the executive board. The executive board shapes a company's corporate vision (Wu et al., 2021) and innovation culture (Schein, 1992) and the employees' willingness to contribute to innovation processes and outcomes (Amabile, 1998). Hence, in

deciding on whom (not) to appoint to the executive board, the supervisory board affects a firm's innovation strategy. Second, the supervisory board sets the (collective and individual) targets for the members of the executive board, it determines the degree of target accomplishment and it links target accomplishment to executive remuneration. By setting appropriate targets, supervisory boards may thus also promote innovation. Last but not least, the supervisory board may affect firm innovation directly when advising the executive board in innovation-related matters or by (dis-)approving decisions of fundamental importance that require its approval (Jäger et al., 2021).

In Germany, supervisory boards are composed of shareholder representatives and—depending on firm size—also employee representatives. Co-determined supervisory boards are legally binding for companies with at least 500 domestic employees. If a firm has at least 500 but not more than 2000 domestic employees, employee representatives make up one third of the supervisory board members (One Third Participation Act). A firm with more than 2000 domestic employees has a parity co-determined supervisory board with half of its members representing employees (Parity Co-Determination Act). While the shareholder representatives are elected by the shareholders at the annual shareholder meetings, the employee representatives are elected by the company's workforce in elections organized by the works councils as employees' shop-floor representation institution. Depending on firm size, the union may also nominate external candidates to represent the interests of employees in supervisory boards (see, e.g., Jäger et al., 2021; Kim et al., 2018; Lin et al., 2018).

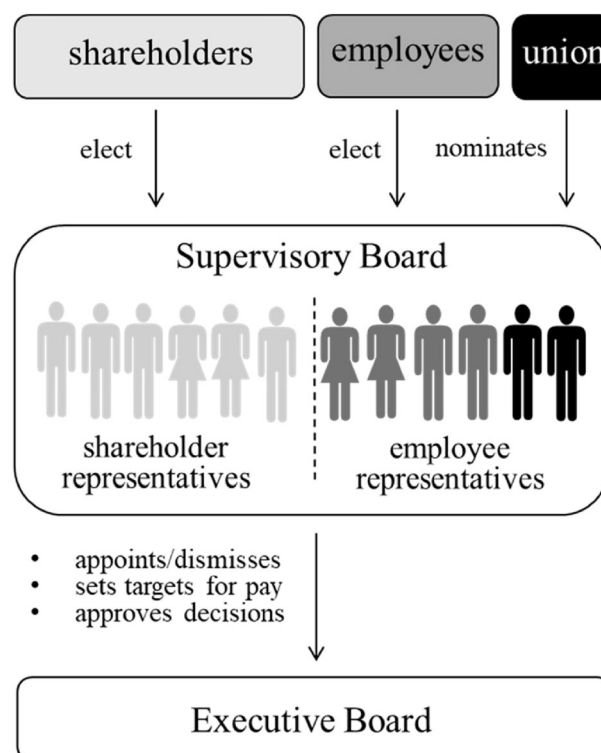


FIGURE 1 Institutional context. Source: Own compilation

TABLE 1 Overview of previous empirical studies on women on boards and innovation

Author(s), year	Gender diversity measure (explanatory variable)	Innovation measure (dependent variable)	Data base (n, country, years)	Main result
Griffin et al. (2021)	Women – percent	Citation-weighted number of patents applied for by a firm over a 3-year window	12,244 firms from 45 countries (2001–2014)	Positive link
Saggese et al. (2021)	Women – percent, women – critical mass	R&D intensity	149 high-tech Italian firms (2012–2015)	Women-percent: no link; critical mass: positive link
Hernández-Lara and Gonzales-Bustos (2020)	Women – percent	R&D expenditure; number of patents	86 Spanish firms belonging to innovative sector (2003–2017)	Positive link
Almor et al. (2019)	Women – percent Women – dummy	R&D intensity	8480 North American company-year pairs and 10,401 global company-year pairs in 44 countries (1999–2014)	Negative link
Li (2019)	Women – percent	Number of patents in technology domains in which a firm has not patented in the preceding four-year window	895 US public firms (2000–2008)	No link
Töpfer (2018)	Women – percent, women – dummy, women – critical mass	R&D intensity, patents/firm age	15,871 firm-year observations from Chinese firms in Shanghai and Shenzhen stock exchanges (2006–2015)	Critical mass: negative link to R&D intensity, women percent: positive link to patents/firm age
Chen et al. (2018)	Women – percent	R&D expenditures; patent count & citations	1224 US firms from 6644 firm-year observations (1998–2006)	Positive link
Mukarram et al. (2018)	Women – percent	R&D expenditures	71 Indian technology firms (2008–2013)	Positive link in non-family owned firms, negative link in family owned firms
Rossi et al. (2017)	Women – percent	R&D expenditures	41 Italian companies (2005–2013)	Positive link
Chen et al. (2016)	Women – percent	R&D expenditures	3714 US firms (1998–2013)	Negative link
Ruiz-Jiménez et al. (2016)	Board gender diversity (Blau index)	Innovation performance (self-assessed by survey respondents)	205 Spanish technology based firms (2010)	No link
Galia et al. (2015)	Women – percent	Environmental innovation (dummy variables, self-assessed by survey respondents)	142 French Firms (2008)	Positive link
Galia and Zenou (2012)	Women – percent	Product innovation, process innovation, organizational innovation, marketing innovation (dummy variables; self-assessed by survey respondents)	176 French firms (2008)	Positive link with marketing innovation, no link with organizational and process innovation, negative link with product innovation
Østergaard et al. (2011)	Board gender diversity (Shannon–Weaver entropy index)	Introduction of a new product or service (dummy variable)	1648 Danish firms (2003–2005)	Positive link
Torchia et al. (2011)	Women – critical mass	Organizational innovation (self-assessed by survey respondents)	317 Norwegian firms (2005–2006)	At least three women: positive link
Miller and Triana (2009)	Board gender diversity (Blau index); women-percent	R&D intensity	326 US firms (2002–2005)	Positive link

Source: Own compilations.

Figure 1 exemplifies the institutional context of our study for the case of a firm with more than 2000 but less than 10,000 employees. The supervisory board of such a firm consists of 12 members: Six shareholder representatives elected by the shareholders and six employee representatives, four of which are elected by the company's workforce and two of which are nominated by the union.

Though shareholder and employee representatives are co-equal members of the board, shareholder representatives are more powerful: In case of the One Third Participation Act, shareholder representatives hold the majority of board seats (two thirds); in case of the Parity Co-Determination Act, they do hold the same number of seats, but they hold the majority of votes, because the chairperson (who is a shareholder representative) has double voting rights when shareholder and employee representatives are deadlocked (Jürgens et al., 2000).

3 | LITERATURE AND THEORY

Starting with Miller and Triana (2009), the literature has repeatedly studied the link between women on boards and firm innovation (see Table 1 for an overview in reverse chronological order). The vast majority of existing works points to a positive link, for example, as a result of women directors being more strongly focused on long-term performance-enhancing strategies (Eckel & Grossman, 2008; Post et al., 2022) and being more likely to pursue a transformational leadership style (Antonakis et al., 2003; Bendig, 2022), thus fostering creative thinking (Wu et al., 2021). Griffin et al. (2021) explore potential mechanisms of the link between board gender diversity and innovation and find that gender diverse boards focus more strongly on long-term goals, create a culture that promotes innovation and more diverse inventors. All of this is conducive to innovation.

While only very few studies have found a negative link between women directors and firm innovation (Almor et al., 2019; Chen et al., 2016), several study results are apt to question the existence of a *universally* positive link between women directors and firm performance (e.g., Galia & Zenou, 2012; Li, 2019; Mukarram et al., 2018; Saggese et al., 2021; Töpfer, 2018) and rather hint at a potential context dependency of the link between women directors and firm innovation.

With our study, we contribute to the existing literature by trying to enhance our understanding of a potential context-dependency of the link between women on boards and firm innovation that has not been analyzed so far. Specifically, we focus on two potential contextual factors that might affect the link between women directors and firm innovation: Women directors' power as well as their potential bridging role in a board with more than one functional group.

Following shareholder primacy theory, the interests of shareholders have primacy over the interests of other stakeholders (Parmar et al., 2010; Smith & Rönnegard, 2016). If shareholder primacy is a dominant norm among the board of directors, this has consequences for the impact that other stakeholders represented on the board (i.e., employee representatives) may have. This does not only refer to

shareholder representatives' numerically stronger voting power, but also to the extent to which directors' contributions are recognized and valued.

Consequently, there is good reason to believe that women are more likely to have an influence as shareholder representatives than they have as employee representatives. Especially when it comes to strategic decisions that are likely to affect shareholder value, the interests of shareholders will be given primacy, resulting in women shareholder representatives having a stronger impact on firm innovation than women directors representing employees. That is, if board gender diversity is apt to foster "more failure-tolerant and long-term executive compensation, a more innovative corporate culture, and more diverse inventors" as has been found by Griffin et al. (2021, p. 148), then this is more likely to happen when the women in the boardroom have more of a say, that is, when they represent the interests of shareholders. Hence, we expect the link between women directors and firm innovation to be stronger when women directors are shareholder representatives and less strong when they represent the interests of employees.

Hypothesis 1. The share of women directors among shareholder representatives in co-determined supervisory boards is positively linked to firm innovation.

Focusing on firm innovation as an outcome promises particularly exciting insights, because innovation is a topic where the interests of both groups of representatives may not always coincide. Since shareholder representatives can be assumed to focus on shareholder value maximization, they will arguably have a stronger interest in firm innovation than employee representatives who might fear adverse effects from rationalizations, for example, in terms of job losses. Also, because product innovations often require a reorganization of workflows, innovation might be less liked by employees (Kraft et al., 2011). As a result, employee representatives might be more reluctant to support firm innovation as compared to shareholder representatives, thus reinforcing our theoretical prediction of the positive link between women directors and innovation being driven by women shareholder representatives.

Further, the potential divergence between shareholder and employee interests might make it necessary to mediate between the two representative functions. Women directors might fulfill this mediating role (Joecks et al., 2019), and they might accomplish their bridging function more easily when there are women directors represented in each of the two representative functions. While women shareholder representatives will, of course, intensively engage with the other (i.e., male) shareholder representatives (e.g., as a result from regularly meeting them in the separate preparatory meetings), they will also link to the other women in the boardroom (i.e., the women employee representatives) and thus provide a "bridge" between the two representative functions. While, in general, the men among shareholder representatives might also link to the men among employee representatives, it is more likely that women directors perform this bridging role because women directors typically represent a minority

in the boardroom, and are likely to also share other attributes, in particular in terms of a lower board tenure.

The bridging function is of particular importance as German supervisory board decisions are typically consensual or even unanimous (FitzRoy & Kraft, 2005, p. 237; Gold, 2011, p. 50; Steger, 2011, p. 122). When women are represented in both representative groups, consensus-building might be enhanced by women forming coalitions across the two representative functions and by mediating between the interests of shareholder and employee representatives. Especially, when it comes to important and far-reaching strategic decisions, this type of consensus-building and actively involving also the employees' side is crucial, as it is a prerequisite for successful strategy implementation. Hence:

Hypothesis 2. The joint presence of both women shareholder and employee representatives in co-determined supervisory boards is positively linked to firm innovation.

4 | DATA AND METHODS

4.1 | Sample and data

Our initial sample consists of all 105 companies listed on one of the German stock exchange indices DAX30, MDAX50, SDAX, and TecDAX30 on December 31st, 2015 that do have a co-determined supervisory board. We collected data on a 16-year-period, including the years from 2000 to 2015. As not all firms that were listed on one of the indices at the cut-off-date were continuously listed in the indices over the whole observation period, our panel is imbalanced.

4.2 | Measures

To capture firm innovation, we use *patent propensity* as an outcome-related innovation measure (Balsmeier et al., 2014; Bernile et al., 2018; Dorner & Harhoff, 2018) that at the same time is closely linked to a firm's *innovation strategy* and thus likely to be affected by the supervisory board. By focusing on patents as a more outcome-related measure of firm innovation, we follow the recent claim by Griffin et al. (2021) who argue that studies on the subject should rather focus on outcome-related instead of input-related variables of firm innovation, such as, for example, R&D expenditures.

Patent propensity is a measure of innovation efficiency and refers to the number of patent filings of a firm in a given year divided by R&D expenditures and multiplied by 1000. The measure thus contains the number of patent filings of a firm in a given year per 1000 Euros of R&D expenditures (see Belderbos et al., 2010; Caputo et al., 2016 for a similar procedure). Similar to Bendig (2022), we use patent filing dates instead of patent issue dates as the former more closely reflect the time of the invention. Because patent filings are costly, we expect firms to only undergo the process when they expect to receive a considerable economic return in the future. Information on patent filings

is provided by IPlytics, a data platform that collects data on patent filings on the basis of the data provided by the European Patent Office. Average *patent propensity* in our data is 0.30; that is, in our sample of firm-year observations, R&D expenditures of 1000 Euros result, on average, in 0.3 patents. Accounting for a possible time lag, we lag our measure of *patent propensity* by 1 year.

Our explanatory variables refer to the gender composition of supervisory boards. The respective data was hand-collected from annual reports and provided by Weckes (2016). In a first regression model, we use the overall share of women on the board (*women – percent*) as explanatory variable to explore whether women directors and firm innovation are positively linked in our data set. For the test of Hypothesis 1, we use the share of women directors on the shareholders' side (*women shareholder side – percent*) as explanatory variable and control for the share of women directors on the employees' side (*women employee side – percent*). For the test of Hypothesis 2, we use the interaction of two dummy variables: The variable *women employee side – dummy* takes the value of 1 if at least one employee representative is a woman, and the variable *women shareholder side – dummy* takes the value of 1 if at least one shareholder representative is a woman. The interaction term of the two dummy variables captures the joint presence of (at least one) woman director among both: shareholder and employee representatives.

The average share of women on boards (*women – percent*) is 12.2%. The highest share of women on a board is 50%. The average share of women shareholders (*women shareholder side – percent*) is 8% with a maximum of 50%. With respect to the dummy variables, we find more boards with at least one woman on the employees' side (67%) than we find boards with at least one woman on the shareholders' side (46%).

In accordance with the literature (Balsmeier et al., 2014; Bernile et al., 2018; Griffin et al., 2021), we control for a set of board and firm variables. Information on firm level controls is taken from Datastream, and information on board-level controls is provided by Weckes (2016). At the board level, we include *board size* (measured by the number of board members), *one-third co-determination* as an indicator for the type of co-determination (with parity co-determination representing the reference category), an indicator of multiple directorships (*outside directorships*), and *board tenure* as further controls. *Outside directorships* is calculated as the average number of supervisory board memberships a board member holds in one of the listed companies in our data set—besides the one on the board under consideration. Average *board size* is 14.59. Average *outside directorships* amount to 1.28. Average *board tenure* is 6.62 years. As firm level controls, we include *market value* as a proxy for firm size, return on equity (ROE) to measure firm performance, and *leverage ratio* measured as long-term debt divided by total capital. Average *market value* is 11.48 million Euros, average ROE is 11.34%, and average *leverage ratio* is 29.19%.

4.3 | Estimation strategy

When analyzing the link between board composition and firm innovation potential reversed causality might be a concern. To account for

potential reversed causality, we run our analyses with a time lag of 1 year as we cannot exclude that more innovative firms are more likely to appoint women to their boards or that women self-select onto the boards of more innovative firms (see Bendig, 2022; Dittmann et al., 2010; and Farrell & Hersch, 2005, for a similar procedure). To further account for reversed causality, we include a two-year lead as well as a one-year lead of *women – percent*, *women shareholder side – percent*, and *women employee side – percent* to test for strict exogeneity (see, e.g., Engle et al., 1983; Hsieh et al., 2022; Jeong & Harrison, 2017). We find the corresponding explanatory variables for women directors to be exogenous in all models.

To estimate the effect of female board representation on firm innovation, we use count data models with industry and year fixed effects. Since the dependent variable *patent propensity* does not contain negative values and does include several zero observations, we use the Poisson estimator (for a similar procedure, see, e.g., Balsmeier et al., 2014; Hall & Ziedonis, 2001).

5 | EMPIRICAL ANALYSIS AND RESULTS

5.1 | Summary statistics and correlations

Table 2 reports the summary statistics for all variables included in the analyses and shows the Pearson correlation matrix. *Patent propensity* ($t + 1$) is significantly positively related to *women – percent* ($r = .112^{**}$) and *women shareholder side – percent* ($r = .167^{**}$).

We tested for potential multicollinearity in all of our following multivariate estimations by calculating variance inflation factors (VIF). As all VIF values were below 2.31, we can exclude multicollinearity problems (O'Brien, 2007).

5.2 | Results

Table 3 presents the results of the Poisson regression analyses on *patent propensity*. As Model 1 shows, the percentage of women on supervisory boards (*women – percent*) is significantly positively related to firm innovation as measured by *patent propensity*. Hence and in accordance with the vast majority of previous studies (see Table 1 for the details), we do find support for a positive link between women directors and firm innovation.

In Table 3 Model 2, we find a positive link between the share of women shareholder representatives (*women shareholder side – percent*) and *patent propensity*, while there is no link between the share of women employee representatives (*women employee side – percent*) and *patent propensity*. Thus, we find the link between women directors and *patent propensity* from Model 1 to be driven by women shareholder representatives—as postulated in Hypothesis 1.

Table 3 Model 2 also points to a significant positive link between *patent propensity* and the simultaneous presence of women in both representative functions. Hence, we also find support for Hypothesis 2.

TABLE 2 Bivariate correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Patent propensity ($t + 1$)	1								
(2) Women – percent	.112**	1							
(3) Women shareholder side – percent	.167**	.752***	1						
(4) Women employee side – percent	.030	.829***	.283***	1					
(5) Board size	.021	.007	.022	–.051	1				
(6) Outside directorships	–.025	–.128***	–.045	–.172***	.332***	1			
(7) Board tenure	–.127**	–.265***	–.311***	–.150***	.156***	.202***	1		
(8) Market value (in million euro)	–.016	.133***	.096*	.082*	.555***	.497***	.170***	1	
(9) ROE	–.004	–.030	–.070	–.0004	–.055	–.002	.042	.092**	1
(10) Leverage ratio	.215***	.075*	.061	.066	.430***	.211***	.049	.253***	–.170***

Source: Own compilations.

* $p < .10$. ** $p < .05$. *** $p < .01$.

TABLE 3 Poisson regression results on patent propensity

	(1) Patent propensity (t + 1)	(2) Patent propensity (t + 1)	(3) Patents propensity (t + 1)
Women – percent	2.612*** (0.589)		
Women shareholder side – percent		0.81*** (0.009)	
Women employee side – percent		–0.10 (0.12)	
Women shareholder side – dummy (reference group: no woman)			0.44 (1.48)
Women employee side – dummy (reference group: no woman)			0.15 (1.27)
Women shareholder side – dummy # Women employee side – dummy			1.50** (0.75)
Board size	0.15 (0.12)	–0.01 (0.20)	–0.03 (0.10)
One third co-determination (reference: parity co-determination)	–2.37*** (0.40)	–1.81*** (0.49)	–1.91*** (0.50)
Outside directorships	1.31 (2.34)	1.31 (2.39)	1.18 (2.62)
Board tenure	0.09*** (0.03)	0.08*** (0.03)	0.08*** (0.03)
Market value	–0.27 (0.43)	–0.27 (0.42)	–0.32 (0.45)
ROE	0.02** (0.008)	0.04** (0.006)	0.05** (0.002)
Leverage ratio	.034 (0.03)	.031 (0.03)	0.08 (0.08)
Year and industry FE	Yes	Yes	Yes
Log pseudo-likelihood	–1752.1	–1856.2	–1888.8
N (obs)	745	745	745
N (firms)	74	74	74

Note: Standard errors in parentheses.

* $p < .10$. ** $p < .05$. *** $p < .01$.

5.3 | Robustness checks

As a first robustness check, we replicate the analyses in Table 3 excluding services and utilities, thus addressing the concern that *patent propensity* might be less relevant in the corresponding industries. All of our results are robust (see Table A1 in the Appendix).

As a further robustness check, we use the *number of patents* as an alternative dependent variable and replicate the analyses from Table 3 for this measure (see Table A2 in the Appendix). We find the overall share of women to be significantly positively linked to the *number of patents*. The effect is again driven by the women on the shareholders' side. In Model 3, Table A2 and contrary to our main estimation, we do not find a link between the interaction term that captures the presence of women directors in both representative functions and the *number of patents*.

6 | DISCUSSION AND CONCLUSIONS

6.1 | Theoretical implications

Our study supports the view that women directors might foster innovation, and it additionally provides evidence for the link between women directors and firm innovation to depend on important

contextual factors: First, the likelihood that women directors make a difference for firm innovation seems to be contingent on them holding a comparatively more powerful position. This is an important finding because it highlights that adding more women to the boardroom will not per se positively affect firm innovation, but it will only do so if women directors have the power to affect boardroom decisions. Among others, our first result thus ties in with the recent work by Bozhinov et al. (2021) who find the link between women directors on supervisory boards and the appointment of women to the executive board to be driven by women shareholder representatives.

Second, we find the link between women directors and firm innovation to be further strengthened when women are represented in *both* representative functions: shareholder *and* employee representatives. Again, this finding is interesting for several reasons. First, it is interesting because it seems to contradict what has been known as the “Queen Bee” phenomenon (Goldberg, 1968) according to which minority women do not support other minority women (Arvate et al., 2018; Bagues & Esteve-Volart, 2010; Derks et al., 2016; Merluzzi, 2017) or what is postulated by the “value threat approach” (Duguid et al., 2012). According to the latter, one would expect that “out-groupers” (such as women shareholder representatives in male-dominated supervisory boards) would rather not identify and align with other out-groupers (i.e., women employee representatives) (Duguid et al., 2012; Goldberg, 1968). Rather, women shareholder

representatives might not so much identify with women employee representatives than they might identify with the other (predominantly male) shareholder representatives—in an (unconscious) attempt to thus improve their own self-perceived status (Chatman & O'Reilly, 2004; Duguid et al., 2012; Ely, 1995). As a result, women shareholder representatives as out-groupers might not be willing to align with other out-groupers, that is, women employee representatives. Our study, however, is not so much about women supporting or not supporting other women, but rather about how women directors' power to affect boardroom decisions. One way to do so might be via effective coalition building, cooperation and collaboration—all of which have been shown to be part of a “feminine model of leadership” (Klenke, 1993, p. 330) and a transformational leadership style (Wu et al., 2021). As decisions in German supervisory boards are typically taken consensually, coalition building in co-determined supervisory boards refers to coalitions that include *both* representative groups. When there are also women directors among employee representatives, women shareholder representatives might more easily link to the employees' side and its female members to thus promote consensual decision making.

On a more general ground, our second result further hints at the importance of *cross-cutting* diversity dimensions in enhancing group effectiveness, where cross-cutting diversity dimensions refer to two (or more) diversity dimensions that are not perfectly aligned with one another in a sense, that, for example, all shareholder representatives would be men and all employee representatives would be women. As has been shown in other contexts and with respect to other diversity dimensions (e.g., Crucke & Knockaert, 2016; Iseke et al., 2015), cross-cutting diversity dimensions might in fact foster group effectiveness because potential fault lines between subgroups might be mitigated. In that sense, the performance of co-determined supervisory boards might also be enhanced when members in both representative functions can successfully link to one another because of another shared characteristic, for example, directors' ethnicity or education.

6.2 | Practical implications

Our findings have important practical implications. Above all, we find that women directors are not negatively linked to firm innovation. Hence, even though the literature shows women to be generally more risk-averse than men (Charness & Gneezy, 2012) and even though innovation activities are inherently risky (Bernile et al., 2018), we do not find evidence that would suggest that women directors tend to hamper firm innovation. With this finding, we challenge prevalent gender stereotypes, supporting the view that gender differences in the general population might not necessarily mirror gender differences in the boardroom (Yang et al., 2019). And even if women directors were characterized by a higher risk aversion than their male counterparts (for supporting evidence, see García & Herrero, 2021; Zalata et al., 2019), there is no reason to fear adverse effects on firm innovation from an increased female representation in the boardroom, for example, as a result of having to fulfill gender quotas. Rather, and

as gender quotas often target the share of women among *shareholder representatives* (see Mensi-Klarbach & Seierstad, 2020), complying to these quotas will most likely foster rather than hamper firm innovation.

6.3 | Limitations and future research

Our study also has limitations that indicate fruitful next steps for further research. First, future studies might want to investigate potential mechanisms that mediate the link between board composition and firm innovation. To that aim, additional qualitative interviews might help to deepen our understanding of the board director-innovation link and shed further light into the black box.

Second, we have focused on co-determined supervisory boards in a two-tier board structure. Future studies might extend our analyses to other institutional contexts with different functional groups in the boardroom and analyze whether it makes a difference in which functional group women are represented, and whether it makes a difference if they are represented in more than one functional group. We can only speculate about how our results might translate to other institutional contexts. For instance, we would expect that in a one-tier board system, outside directors who represent the interests of the shareholders are more powerful than outside directors who represent the interests of other stakeholders, resulting in women directors representing the interests of shareholders more strongly affecting innovation than other women directors. Whether and to what extent women directors in a one-tier board system could mediate between potentially diverging interests when it comes to corporate innovation strategies is an open question that should be addressed in future studies.

Third, while we included information on women directors' representative function as a second diversity dimension, we have no information on the educational background of the board directors. This, however, might be interesting to consider in future research, as Hsieh et al. (2022) showed directors with a STEM background to be positively linked to firm innovation. Future studies might also want to take into account a potential interaction between board members' gender and, for example, biographic information to check the robustness of our results and thus further contribute to an enhanced understanding of the mechanisms that link board gender diversity and firm innovation.

Last, our data are nonexperimental, thus inhibiting causal inferences. While our longitudinal design, panel data techniques, and further attempts to control for unobserved and time-invariant firm heterogeneity represent important first steps in the direction of detecting a potential causal link between boardroom gender composition and firm innovation, we hope to inspire further analyses that move further in the direction of detecting causality.

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CONFLICT OF INTEREST

There is no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Hans Böckler Foundation but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the Hans Böckler Foundation.

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APPENDIX A

TABLE A1 Poisson regression results on patent propensity: Reduced sample

	(1) Patent propensity (t + 1)	(2) Patent propensity (t + 1)	(3) Patents propensity (t + 1)
Women – percent	2.943*** (0.619)		
Women shareholder side – percent		0.81*** (0.009)	
Women employee side – percent		–0.13 (0.28)	
Women shareholder side – dummy (reference: no woman)			0.34 (1.28)
Women employee side – dummy (reference: no woman)			0.25 (1.27)
Women shareholder side – dummy # Women employee side – dummy			1.71** (0.69)
Board and firm controls	Yes	Yes	Yes
Year and industry FE	Yes	Yes	Yes
Log pseudo-likelihood	–1852.8	–2048.3	–2094.2
N (obs)	691	691	691
N (firms)	69	69	69

Note: Standard errors in parentheses.

* $p < .10$. ** $p < .05$. *** $p < .01$.

TABLE A2 Poisson regression results for the number of patents as the dependent variable

	(1) Patents ($t + 1$)	(2) Patents ($t + 1$)	(3) Patents ($t + 1$)
Women – percent	2.423*** (0.812)		
Women shareholder side – percent		0.033*** (0.007)	
Women employee side – percent		0.005 (0.003)	
Women shareholder side – dummy (<i>reference group: no woman</i>)			0.69*** (0.22)
Women employee side – dummy (<i>reference group: no woman</i>)			0.68*** (0.22)
Women shareholder side – dummy # Women employee side – dummy			–0.37 (0.24)
Board and firm controls	Yes	Yes	Yes
Year and industry FE	Yes	Yes	Yes
Log pseudo-likelihood	–18,853.8	–18,8142.7	–18,3152.7
<i>N</i> (obs)	745	745	745
<i>N</i> (firms)	74	74	74

Note: Standard errors in parentheses.

* $p < .10$. ** $p < .05$. *** $p < .01$.