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Women in Leadership Positions and Firm Innovation: Are There Differences Between Countries?

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Abstract

The presence of women on corporate boards has attracted significant attention in recent years due to ongoing political discourse concerning initiatives such as gender quotas in managerial and boardroom positions. *But how does the proportion of women on corporate boards influence firm innovation?* This paper examines this question with reference to the direct and indirect effects of female supervisory board representation. The paper draws on a sample of 60 French firms and is framed in upper echelons theory. In analyzing the proportion of women directors, the paper aims to understand better the relationship between firm innovation and board seats occupied by women. The results suggest that firm innovation is not related to female board representation, which contrasts with empirical evidence that has found a positive relationship for 105 German firms. This deviation from established findings highlights the complexity inherent in understanding the impact of gender diversity on firm-level outcomes and underscores the need for context-specific examinations in this domain.

Keywords: corporate boards; female representation; firm innovation; gender diversity; strategic leadership

1. Introduction

In the wake of globalization and the interconnectedness of areas that affect our everyday lives, new challenges are constantly emerging. Firms operate in an increasingly complex VUCA world characterized by rapid unforeseen shocks, technological changes, and digital disruption. This is making the business environment more dynamic, unpredictable, and interconnected. So, how can firms ensure success and continued growth in these times of constant change?

Firm innovation has been understood for decades as an approach to achieve a positive impact on the natural life cycle of a company through entrepreneurial activities driving firm competitiveness, productivity, and hence, firm value (Griffin et al., 2021, p. 124). In times of economic and societal development, the concerns of various stakeholders have led to an additional challenge for firms, which requires their decision-makers to assume corporate responsibility for diversity. This demand has been popularized in recent years by the political discussion on women's quotas in management or boardrooms (Alshirah et al., 2022, p. 2; Grosvold et al., 2016, pp. 1158–1159). In 2003, Norway was the first country to implement a board gender quota in publicly listed Norwegian firms, requiring a minimum of 40 percent of each gender (Grosvold et al., 2007, p. 349). Since this was associated with an increase in the innovation output of Norwegian firms, researchers suggested that the impact of board gender diversity on corporate innovation is likely causal (Griffin et al., 2021, p. 125).

However, firms face a paradoxical situation, as diversity is seen as both a source of creativity and innovation and of misunderstanding and conflict (Bassett-Jones, 2005, p. 169). Accordingly, researchers still do not agree about the extent to which diversity stimulates firm innovation. Against this background, the question arises of how the perspectives on

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diversity's impacts can be reconciled. Given the magnitude of political interventions and the expectations placed on female directors, it is critical to gain a better understanding of the state of literature to inform policy and shape expectations about the impact of gender-diverse boards on corporate outcomes, such as firm innovation. Therefore, it seems timely that firm innovation is analyzed with respect to female board participation.

The purpose of this paper is, therefore, to provide a comprehensive discussion of the literature on the relationship between female directors and firm innovation by addressing the following research question: *How does the proportion of women on corporate boards influence firm innovation?* In this context, the paper refers to corporate boards as the highest leadership level in organizational structures. More specifically, the study focuses on supervisory boards, as they exert great influence on the executive board which shape a firm's corporate vision (Wu et al., 2021, p. 2) and are key determinants of organizational culture and innovation orientation (Schein, 1985, pp. 316–317) Although not involved in day-to-day business, the supervisory board affects the firm's innovation strategy in several ways: First, the supervisory board monitors the executive board and appoints and dismisses its members (Kim et al., 2018, p. 1257). Second, the supervisory board sets targets for the executive board members and determines their remuneration. Third, the supervisory board also advises the executive board, for instance, on innovation-related topics, and must approve fundamental strategy decisions before implementation (Jäger et al., 2021, p. 675).

The study is framed in Hambrick and Mason (1984) upper echelons theory, which suggests that leaders' characteristics partially shape corporate decision-making and, thus, organizational outcomes, such as innovation activity. Referring to gender differences in cognition, the paper hypothesizes that female transformational leadership style is an underlying mechanism through which women on boards positively affect innovation.

The hypothesis is tested based on an ordinary least squares (OLS) regression, using a sample of 60 French firms listed on one of the French exchange stock markets. To obtain data on the proportion of women directors, the analysis relies on data by Refinitiv Eikon (2023). As a proxy for innovation, the number of patents issued in 2022 is used with data provided by World Intellectual Property Organization (2023) and European Patent Office (2023). In contrast to previous studies, the results do not show a statistically significant link between female directors and firm innovation, so the research design must be reconsidered. The analysis is, therefore, compared to a panel data study by Joecks et al. (2023), using a sample of 105 publicly listed German firms and finding that female directors positively influence a firm's innovation performance.

The remainder of the paper is organized as follows: *Section 2* discusses drivers of firm innovation orientated on the main argumentation lines presented in the literature. The paper emphasizes direct and indirect effects, addresses the diversity-innovation paradox, and outlines contextual factors affecting firm innovation performance. *Section 3* develops the theoretical framework supporting the relationship between women directors and firm innovation, from which a corresponding hypothesis is derived. *Section 4* thus provides an empirical analysis and compares results to existing empirical evidence. *Section 5* presents the main conclusions, draws theoretical and practical implications for women's inclusion in leadership, and identifies limitations and future lines of research on the upper echelons.

2. Literature Discussion: Drivers of Firm Innovation

2.1. Influence of Women on Corporate Boards on Firm Innovation

2.1.1. Direct Effects of Female Board Representation on Firm Innovation

Corporate innovation capacities and capabilities require a profound knowledge base, systematic knowledge integration, and a suitable leadership style, which means that diversified human capital plays a non-negligible role in firm innovation (OECD/Eurostat, 2019, p. 147). Research from psychology (e.g., Silverman, 2003 and management (e.g., Croson and Gneezy, 2009) found evidence of gender differences in preferences regarding the attitude toward risk, time horizon, and personal values. These gender-specific preferences directly affect information processing, decision-making, managerial behavioral tendencies, and, thus, leadership styles. This, in turn, has implications for corporate decisions and implies that gender-based approaches to innovation exist and that the direct effects of gender diversity on a firm's innovation performance can be identified.

In principle, gender diversity, i.e., a greater presence of women on firm level, expands the knowledge base and leads to greater *knowledge differentiation* and organizational decisions of higher quality. This is because more heterogeneous groups with differing points of view consider a more comprehensive set of alternatives (Dai et al., 2019, p. 509; Dezsö and Ross, 2012, p. 1075) and capitalize on atypical ways of exploring and exploiting innovation opportunities (Guerrero, 2022, p. 38). Heterogeneity in knowledge base thus not only leads to diverse perspective and debates over tasks but also stimulates more diverse approaches to solutions (Dai et al., 2019, p. 509). Women contribute to diversity through their life experiences by having additional insights on key strategic issues, notably in relation to female employees, consumers, and trading partners (Dezsö & Ross, 2012, p. 1075). Men and women also have different socialization experiences, for instance, in their professional careers and social networks, so gender, among other demographic backgrounds, explains differences in intellectual capital, such as human and social capital (Dai et al., 2019, p. 509). Increased female presence accordingly is likely to enhance the diversity of human and social resources, helping identify business opportunities and develop innovative ideas (Guerrero, 2022, p. 35). This is supported by the resource dependency theory cultivating that firms should attract board members with complementing resources that bring additional human and social capital to the

company (Siciliano, 1996, p. 1313), and by Becker (1962, p. 49) human capital theory, emphasizing that an individual's education, skills, and experience enhance organizational capabilities. Given the more differentiated knowledge, gender diversity provides potential during the exploration and exploitation of entrepreneurial opportunities, stimulating firm innovation (Guerrero, 2022, p. 38). This applies notably to tasks requiring a high level of information processing, such as board decisions (Van Knippenberg et al., 2004, p. 1012).

Experimental studies have not found significant differences in innovativeness and creativity between women and men entrepreneurs. However, women and men differ in their cognitive information processing styles and approach to *knowledge integration*, contributing to opportunity identification and recognition (DeTienne & Chandler, 2007, p. 379). In this context, Chung and Monroe (1998, p. 268) refer to the psychological phenomenon of confirmation bias, which indicates the tendency to accept information that confirms rather than refutes their current thinking. Accordingly, men tend to encode fewer details and are more likely to ignore non-confirming information (Meyers-Levy & Maheswaran, 1991, p. 63). In contrast, women are more attentive to subtle cues and more sensitive and tolerant of information that is contrary to established mental schemas and paradigms, allowing for processing information more comprehensively (Chung & Monroe, 1998, p. 266). According to Dai et al. (2019, p. 509), women can recognize ideas dispersed among team members more easily, connect them and identify similarities. Men's information processing style is therefore referred to as "item-specific processing", whereas the female is described as "relational processing" (Putrevu, 2001, pp. 7–8). This also explains the higher monitoring capacity of women, which increases the accountability of board members and their attendance at board meetings (Adams & Ferreira, 2009, p. 292). Furthermore, women promote consensual decision-making and assume a mediating role in the event of disagreements (Joecks et al., 2019, p. 24). According to agency theory (Jensen & Meckling, 1976, p. 308), this helps resolve conflicts of interest between agents (e.g., executives) and principals (e.g., shareholders), by integrating the knowledge of both parties (Brahma et al., 2020, p. 5707). As a result, the increase in women's presence promotes openness toward unfamiliar information, which may at first disrupt current practices and procedures but improve knowledge integration in the long term. Since a firm's ability to improve its innovation performance depends on its capacity to manage knowledge successfully, it can capitalize on both female and male information processing styles by forming gender-diversified teams (Dai et al., 2019, p. 510). This means that item-specific information processing, typically attributed to men, is complemented by female attention to non-confirming information. More female presence, therefore, enables a firm to appropriately consider the signals and information by transferring them to others for item-specific processing. The more interconnected knowledge base provides a broader range of information for this focused investigation, and further exploration of details in gender-mixed teams can prevent information crucial to the development of ideas from being overlooked, and thus, missing important impulses to innovation processes (Dai et al., 2019, p. 510).

In addition, differences in male and female cognition not only result in complementary information processing styles, but also shape their *leadership styles*. Being more sensitive to relational information processing, women tend to manage in less hierarchical but more democratic and participatory ways (Dai et al., 2019, p. 510). Female leaders thus encourage the exchange of information and emphasize participation, characterizing their interactive style (Johansen, 2007, p. 271). Subsequent studies also concluded that women tend to exhibit a transformational style with emphasis on communication, collaboration, and cooperation, whereas men tend to correlate more with a transactional style with top-down procedures, task-oriented command, and control (Wu et al., 2021, p. 2). In contrast to the male supervisory approach, female supportive style therefore promotes a sense of self-determination, increases intrinsic motivation, and encourages personal initiative beyond self-interest (Dezsö & Ross, 2012, p. 1077). These findings are supported by the self-determination theory by Deci and Ryan (1987, p. 1024), revealing that intrinsic motivation is positively linked to better conceptual learning and creativity. Female empowering leadership promotes autonomy, engages others' self-concepts, and "encourages 'outside-the-box' thinking" (Wu et al., 2021, p. 2), contributing to the generation of ideas (Dezsö & Ross, 2012, p. 1077). As the working climate is a crucial factor governing firm innovation success, female collaborative management is more effective in solving communication difficulties and conflicts that can easily arise in mixed-gender teams (Dai et al., 2019, p. 512). A more significant number of women can thus contribute to better integration of perspectives and legitimize an open, interactive, and inclusive leadership. Coupled with female relational information processing, firms create an environment where employees can freely express themselves and share task-related information and ideas (Dai et al., 2019, p. 511). Gender diversity, especially when a woman joins an all-male team, improves individual and group performance, leading directly to better firm performance (Dezsö & Ross, 2012, p. 1075). However, innovation success requires negotiations among multiple stakeholders to accumulate information and build cooperation. To effectively manage the innovation process, leaders should not attempt to dominate or control but instead collaborate and integrate knowledge. In addition to relational information processing, the cooperative managerial style enables women to fulfill these tasks (Dai et al., 2019, p. 509). Moreover, a complementary effect of varying female and male leadership tendencies can be beneficial so that the command-and-control approach, typically attributed to men, complements the participatory approach of women entrepreneurs. Firms focusing on gender diversity, i.e., women's cooperation with their male counterparts, thus create synergies in improving innovation performance (Dai et al., 2019, p. 520).

2.1.2. Indirect Effects of Female Board Representation on Firm Innovation

Furthermore, indirect effects play a considerable role in the influence of gender diversity on firm innovation performance, as gender diversity impacts the functional diversity of teams and the corporate culture due to greater female employee presence.

Functional team diversity refers to teams with a variety of expertise or specialization. Organizational diversity studies argue that differing functional backgrounds amplify the knowledge base and promote a diverse domain-specific pool of task-related skills and abilities. This is useful in dealing with non-routine issues, such as innovation activities, and hence, induces the innovation process (Van Knippenberg & Schippers, 2007, p. 518). Consistent with these findings, the study of Simons and Rowland (2011, p. 174) reveals that the functional diversity of both project teams and top managers positively affects the outcomes of the innovation process. Focusing mainly on functional diversity at the group level, their study supports the potential for its moderating role between gender diversity and firm innovation. A subsequent study by Dai et al. (2019, pp. 519–520) confirmed this relationship by conducting simple slope tests with two subsamples of firms with high and low gender diversity. Although the slope for both subsamples is positive, it is steeper for high than low gender diversity. Hence, the observed difference provides evidence not only for the effect of gender diversity on functional diversity but also for the moderating role of functional diversity on the relationship between gender diversity and innovation outcomes. This is compatible with the argument that women may help coordinate and integrate perspectives from different functional backgrounds. Hence, the study results indicate that gender diversity enables the innovation potential of other diversity types, such as functional diversity (Dai et al., 2019, p. 508).

Further, increased gender diversity in companies has an impact on *corporate culture*, representing "a system of shared values [...] and norms that define appropriate attitudes and behaviors for organizational members" (O'Reilly & Chatman, 1996, p. 160). A more equal female representation at the top of a firm's hierarchical structure signalizes not only to a firm's employees but also to stakeholders external to the firm that women are treated equally in the firm (Connelly et al., 2011, p. 40). Hence, gender diversity tends to reduce the impact of societal role expectations on women, partially relieving female employees of the pressure these expectations impose on them (Dai et al., 2019, p. 512). This applies especially to gender-diverse firms in male-dominated industries and patriarchal societies, where the increase in female corporate representation helps improve women entrepreneurs' situation (Godwin et al., 2006, p. 626). By reducing the pressure on female employees, women are encouraged to interact more frequently with male employees and to communicate their perspectives, potentially differing from those of their male colleagues. This reinforces the positive influence of the relational information processing style, attributed to women, on synthesizing knowledge (Dai et al., 2019, p. 512). As gender is an observable characteristic, gender diversity can be easily identified on a superficial level. This means that also surface-level diversity can induce the expectation that differing points of view are existent and therefore encourages to openly express divergent perspectives among the male majority, even if superficial gender diversity is, in fact, not necessarily associated with informational diversity (Phillips et al., 2009, p. 347). Consequently, even the presence of women with congruent information may contribute to a broader elaboration of alternatives, impacting corporate culture and improving decision-making (Dezsö & Ross, 2012, p. 1075). A more far-reaching effect is that the greater female presence at the board level promotes an open-minded corporate culture, which is expected to accept differing ideas, not necessarily only those of women. It follows that companies with a high level of gender diversity can encourage the expression of divergent opinions by every member (Dai et al., 2019, p. 512). In addition to informational and social diversity benefits, greater female participation at the top management level or boardrooms motivates women in middle management (Dezsö & Ross, 2012, p. 1073). This is because, despite the barriers to female advancement that may exist in society, a gender-diverse boardroom signalizes that the firm is committed to implementing equal opportunity. A firm positions itself as a women-friendly firm, increasing women's organizational commitment, notably in lower-level managerial positions (Dezsö & Ross, 2012, p. 1076). It can be concluded that gender diversity enhances the firm's ability to activate functional backgrounds and stimulates the innovation potential of female employees. The latter is because board gender diversity fosters an innovative corporate culture and increases diversity among inventors and entrepreneurs, which is conducive to firm innovation (Griffin et al., 2021, p. 125).

2.1.3. The Diversity-Innovation Paradox

The stated arguments result in the diversity-innovation paradox. Research on applied social psychology has noted a discrepancy between the societal quest for diversity and peoples' individual preference to be surrounded by like-minded others (Hackett & Hogg, 2014, p. 415). Accordingly, diversity, including gender diversity, is also an ambiguous strategic approach in the corporate context. On the one hand, diversity can be considered a source of creativity and innovation, whereas on the other side a source of suspicion, misunderstanding, and conflict (Bassett-Jones, 2005, p. 169). Firms that foster innovation and seek a competitive advantage, therefore, face a paradoxical situation.

On the one side, advocates of the social identity theory argue that heterogeneity among teams harms cohesiveness, reduces communication, and leads to the forming of separate groups (for example, Ibarra, 1993, p. 61; Tajfel, 1974, pp. 69–70; Kanter, 1977, p. 49). This means that diversity, also induced by gender diversity, can potentially negatively impact group cohesion and its performance (Christian et al., 2006, p. 460; Milliken and Martins, 1996, pp. 407–408).

Moreover, the potential of varying points of view of diversified teams leads to increased conflicts (Knight et al., 1999, p. 447) and, therefore, to a slower decision-making process (Hambrick et al., 1996, p. 679). Diversity as a source of suspicion, misunderstanding, and conflict can thus result in poor quality, lack of customer focus and market orientation, and loss of competitiveness (Bassett-Jones, 2005, p. 169).

Contrary, proponents of diversity argue that social cohesion makes teams vulnerable to groupthink so that team homogeneity can restrict the generation and assessment of alternative approaches (for example, Iles and Hayers, 1997, p. 98; Cox and Blake, 1991, p. 51), which leads to inferior decision-making and can be harmful to innovation activities (Hambrick & Mason, 1984, p. 202). Hence, diversity improves creative problem-solving capability when effectively managed, as diverse perspectives generate a greater variety of alternatives (Bassett-Jones, 2005, p. 172). This is why affective discomfort induced by potential conflict does not necessarily lead to inferior performance (Phillips et al., 2009, pp. 337–338). Indeed, some level of dissent amounts to a comprehensive elaboration and critical assessment of alternative opinions (Van Knippenberg et al., 2004, p. 1011), improving decision-making in gender-diverse teams and top management teams' strategic capacity to act (Brahma et al., 2020, p. 5707). Moreover, women's cognitive ability and inclusive leadership style proactively promote a collaborative climate, preventing emotional conflicts and their escalation (Dai et al., 2019, p. 511). A well-managed approach towards diversity thus impedes group thinking as it enhances creativity as a precondition for innovation, leading to increased commitment and job satisfaction (Bassett-Jones, 2005, p. 171). In this context, Griffin et al. (2021) investigated how board gender diversity influences firm innovation activities, using a database of firm-level patents of 12,244 firms and board characteristics across 45 countries. It follows that board gender diversity enables more exploratory and novel innovation and is associated with higher innovative efficiency. However, they also identified a time lag so that an improvement in innovation performance only follows an increase in gender diversity on corporate boards after two or more years (Griffin et al., 2021, p. 125). Despite potential conflicts, the benefits of gender diversity outweigh the costs as a result of the non-routine nature of challenges confronting corporate boards (Dezsö & Ross, 2012, p. 1075).

However, diversity is only apt to foster firm innovation when effectively managed (Bassett-Jones, 2005, p. 173). This emphasizes the need for diversity management. Research by Østergaard et al. (2011, pp. 13–14) identified gender diversity as one of the variables with the most significant influence on a firm's likelihood to innovate and advocate for a moderate degree of diversity, where women as a minority group have a critical mass to contribute to the innovation process. The likelihood of introducing innovation is thus 68 percent higher in groups composed of 60 to 70 percent of the same gender compared to the group dominated by one gender (Østergaard et al., 2011, p. 12). Against this backdrop, Kanter (1977) proposed the critical mass theory and coined the term of tokenism. Women as minority groups on the corporate level are often viewed through sex-role stereotypes by the majority group, hindering their advancement. This leads to gender-segregated jobs where women focus on secretarial tasks (Kanter, 1977, p. 28) are relegated to "the 'emotional' end of management" (Kanter, 1977, p. 25). It follows that women, when compromising only a marginal fraction of a team or a firm, are viewed as tokens and therefore treated as female representatives rather than as individuals (Kanter, 1977, pp. 214–215), which refers to the effect of tokenism (Kanter, 1977, pp. 207–208). She, therefore, argued that the presence of two or more women in the boardroom attenuates this effect (Kanter, 1977, pp. 237–238). Research on sociology and organizational behavior has further analyzed the critical mass. In this context, Konrad et al. (2008, p. 154) have stated that the positive effect of gender diversity is even more greater when three or more females are appointed to the boardroom compared to lower levels so that women's presence in the boardroom is normalized beyond tokenism. These findings are consistent with further research confirming the critical mass of three or more women on corporate boards (Joecks et al., 2013, p. 61; Torchia et al., 2011, p. 299). However, Torchia et al. (2011, p. 300) stated that the contribution of the critical mass of female directors to the level of firm innovation is mediated by board strategic tasks, i.e., the degree to which board members are involved in the "initiation and implementation phases of the strategic process" (Torchia et al., 2011, p. 305). In principle, most studies reported three as a magic number that may change the dynamics in corporate boards and is conducive to innovation activities. Despite the importance of a greater female presence, it does not imply any superiority of either women or men over their counterparts (Dai et al., 2019, p. 520).

2.2. Contextual Factors of Firm Innovation

Researchers highlight that these direct and indirect effects depend on contextual factors, which affect innovation and moderate the impact of gender diversity on firm innovation.

A company's *organizational context*, particularly the degree of innovation orientation, represents a critical contextual factor. Dezsö and Ross (2012, p. 1078) assessed the impact of female representation in top management on firm performance, using panel data of firms that belong to the Standard & Poor's 1,500 index. Their findings showed that female participation improves firm performance only to the extent that a firm is to some degree focused on innovation, i.e., innovation intensity positively influences the effect of female presence on firm performance (Dezsö & Ross, 2012, p. 1084). The more the corporation strategically focuses on tasks requiring innovative solutions, the more valuable gender diversity is. Additionally, this relationship can be transferred to lower hierarchical levels, i.e., the more women in lower-level managerial positions are entrusted with innovation-related tasks, the stronger the impact of females at top management levels or boardrooms for motivation of these women (Dezsö & Ross, 2012, p. 1077). In this respect, Dezsö and Ross

(2012) contrasted their findings with those of firms that are less strategically focused on innovation. If innovation only plays a minor role in strategic orientation, the functions of top management are accordingly highly routinized. In the case of standardized routine tasks, a lengthy elaboration of alternatives can be counterproductive and offset the benefits of gender diversity (Dezsö & Ross, 2012, pp. 1085–1086). Therefore, homogenous groups perform slightly better on simple tasks than heterogeneous teams (Hambrick & Mason, 1984, p. 202). Gender diversity in administration teams with highly standardized procedures is hence expected even to weaken a firm's performance (Alshirah et al., 2022, p. 4). This explains that studies drawing on performance measures other than innovation, such as productivity growth and effectiveness, find no significant relationship between gender diversity and firm performance, as these measures are not necessarily related with innovation (Østergaard et al., 2011, pp. 13–14). Further, previous studies have found that board size harms firm performance, as a larger supervisory board ensures better supervision of executives, but agency costs outweigh this advantage due to communication and coordination difficulties (Cao et al., 2021, p. 2). However, financial performance, as often measured by return on equity and leverage ratio, are found to benefit innovation, as better performing firms tend to have more financial resources to conduct research and development (Balsmeier et al., 2014, p. 1804).

In addition to the organizational context, Dai et al. (2019, pp. 520–521) noted that the impact of gender diversity also depends on external factors, such as the *industrial environment*. Using data from male-dominated environments, their study has revealed that gender diversity positively influences innovation performance. This is because, given the premise of a male-dominated industry, such as high-technology industries, women's different cognitive approaches are seen as a valuable source of knowledge, as they tend to provide unique insights into key tasks, thereby diversifying the knowledge base and allowing for more advanced knowledge synthesis (Dai et al., 2019, p. 521). This is supported by previous research supporting that factors external to female entrepreneurs, such as the social structure of an industry, are partially causal to the positive impact of gender diversity on corporate innovation (Godwin et al., 2006, p. 636).

The *institutional context* in which a company operates is another contextual factor. According to institutional theory, organizations are determined to a large extent by an interplay of societal components of the institutional environment, such as political, social, and legal requirements (for example, Scott, 2001, p. 75; North, 1990, p. 3). These requirements also refer to an organization's corporate governance systems. On average, female board representation is greater in countries with mandated or voluntary board quotas (BoardEx, 2022, p. 13). Furthermore, in countries with a two-tier system, as shared in many European countries, women directors' power is greater if they are represented as both shareholder and employee representatives, further strengthening the link between female board members and firm innovation (Joecks et al., 2023, p. 1209). By focusing on conforming to institutional expectations and societal norms, institutional pressures can shape organizational behaviors and structures (Scott, 2001, pp. 22–23), including processes effectiveness, also innovation-related processes (Yamak et al., 2014, p. 90). This influences the extent to which firms can engage in internal and external knowledge generation and how knowledge gained can be captured for innovation (Torres de Oliveira et al., 2022, p. 1405). Companies thus consider engaging in lobbyism as "one of the most frequent tools used for [...] influencing governments" (Yamak et al., 2014, p. 97).

Ultimately, firm innovation is shaped by the *cultural context*. Firstly, Griffin et al. (2021, pp. 137–138) referred to the relevance of culture by stating that the probability of female board members is higher in less masculine cultures with narrower gender gaps and higher female participation in the labor market. To understand cultural differences, it is crucial to introduce the concept by Hofstede (2001, p. 29), in which the social psychologist originally proposed four cultural dimensions: individualism, power distance, uncertainty avoidance, and masculinity. Although Hofstede's cultural dimensions were derived from a sample of IBM employees in the 1960s and 1970s (Hofstede, 2001, pp. 41–42), he identified tendencies prevalent within each culture and laid the foundation for further research. Gender differences in subsequent studies thus mainly relate to different manifestations of Hofstede's masculinity dimension, later considered as an attitude towards gender equality (Hofstede et al., 2017, p. 58). On this basis, a study by Schwartz and Rubel-Lifschitz (2009, p. 171) across 68 countries revealed gender differences in preference for achievement. While females attach more importance to the community and values, such as benevolence and harmony, males tend to place more value on self-direction, power, and individual success. Although these findings were not directly related to the prediction of corporate decision-making, they imply that these gender-based value differences influence female directors' decisions. Research by Griffin et al. (2021, p. 128) revealed that women in an advisory capacity may avoid unprofitable investments driven by an overemphasis on achievement and instead pursue more exploratory innovation projects in the prospect of long-term benefits. Women tend to demand a higher payoff and likelihood of success in agreeing to investment projects, thereby promoting more efficient innovation. Despite this cross-national finding, Schwartz and Rubel-Lifschitz (2009, p. 180), however, stated that these gender-based value differences were more prominent in countries with greater gender equality, which is typically associated with feminine culture (Hofstede et al., 2017, p. 145). How gender diversity affects firm innovation is hence moderated by the attitude towards gender equality imposed by the prevalent culture.

As summarized in *Figure* 1, the situation a strategic decision-maker faces is complex and made up of far more phenomena than can possibly be comprehended. The effect of board gender diversity is determined by the interplay of direct and indirect effects and shaped by contextual factors. No form of gender diversity can be universally applied to

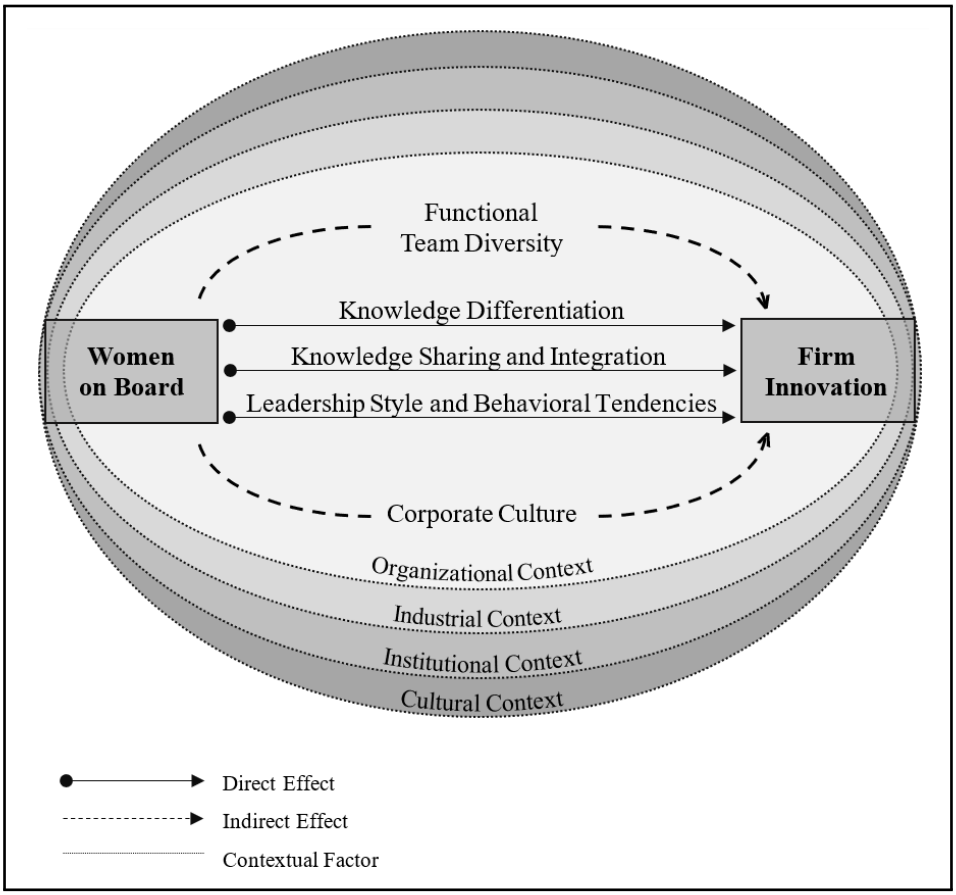

Figure 1: Effects of Female Board Representation on Firm Innovation (Source: Own Illustration)

other firms subject to different contexts, affecting innovation and moderating the impact of board gender diversity on firm innovation. When analyzing the relationship, it is essential to understand the concept as a situational approach, which needs to be evaluated contextually.

Despite sustained and widespread research, academic literature to date predominantly focused on examining single countries and sought to understand dynamics within national boards that explain female board presence and their impact on firm innovation. Although most empirical studies point to a positive link, researchers are not in agreement about the extent to which board gender diversity contributes to firm innovation. One level of analysis that has received comparatively little scholarly attention in this debate is the international level. Aside from a few notable exceptions (for example, Griffin et al., 2021), comparative cross-national research designed to reveal national-level differences in the effect of female board representation on firm innovation remains scarce. It is this gap this study begins to address. The research presented in this paper thus seeks to address this void by first studying the relationship separately on a national level in Germany and France and subsequently comparing results to identify potential underlying components for differing results among countries. This will contribute a cross-country consideration to the existing perspectives and enhance the understanding of direct and indirect effects and contextual factors that impact the link between women directors and firm innovation.

3. Theoretical Framework: Impact of Women on Corporate Boards on Firm Innovation

When analyzing the impact of women on supervisory boards on firm innovation, Hambrick and Mason's (1984) upper echelons theory can be understood as guiding literature. According to neoclassical economic theory, top managers and executives have until then been viewed as homogeneous and rational optimizers who can exert minimal influence on company outcomes or decisions (Weintraub, 1985, p. 26). In contrast, the upper echelons theory describes the idea that upper echelons, i.e., top level leadership including boards, view their situation through their own highly personalized lenses. This is due to differences in their experiences, values, personalities, and other human factors. Hambrick and Mason (1984, p. 198) thus stated that organizational outcomes are determined to some extent by managerial characteristics consisting of psychological traits, such as values and the cognitive base, and observable characteristics, such as age, socioeconomic roots, and education, among other things. Even though gender is not explicitly mentioned as part of the

managerial characteristics, research from psychology (e.g., Silverman, 2003, p. 451) and management (e.g., Croson and Gneezy, 2009, p. 1) has shown gender differences in values and cognitive base, so gender is implicit in the psychological characteristics.

Since introducing the upper echelons theory, a stream of studies has emerged showing that leaders' personal characteristics are critical determinants of organizational decision-making and outcomes. Accordingly, after more than 35 years, this management theory is considered "one of the most influential perspectives in management research" (Neely Jr. et al., 2020, p. 1029). Their theoretical framework laid a critical foundation for the discussion of board gender diversity by describing organizations "as a reflection of its top managers" (Hambrick & Mason, 1984, p. 193). This implies that leaders' psychological characteristics, which differ among genders, enter into strategic choices by affecting managerial perceptions so that information is selectively chosen for processing and "interpreted through a filter woven by one's cognitive base and values" (Hambrick & Mason, 1984, p. 195). This notably applies to strategic decisions, characterized by a substantial behavioral component, such as innovation-related decisions, as opposed to operational choices, such as inventory decisions and credit policy, which are more amenable to a calculable solution (Hambrick & Mason, 1984, p. 195).

In the context of innovation and the exploration of alternatives and new ideas at every stage of the process, it is essential for management and corporate boards to deliberate and for the board members to act as a source of external perspective, providing thoughtful and timely feedback on strategic orientations (Griffin et al., 2021, p. 126). Since women are cognitively different from their male counterparts, women's presence enriches board discussions. In this context, women's relational information processing allows for more precise knowledge integration among divergent opinions and, thus, the realization of synergies of gender-diverse boards and the exploitation of their potential, leading to better strategic decisions. This is why women directors focus more on business strategies that improve performance outcomes in the long-term than short-term results, creating a more failure-tolerant and, thus, more innovative culture in a gender-diverse board (Joecks et al., 2023, p. 1206). This is reflected in women's leadership style shaped by cooperation, coalition building, and collaboration, referred to as the "feminine model of leadership" (Klenke, 1993, p. 334). Hence, the paper ultimately hypothesizes that the female transformational leadership style is an underlying mechanism through which female directors positively influence supervisory board decisions so that board gender diversity is conducive to "innovative corporate culture", as suggested by Griffin et al. (2021, p. 148). For these reasons, the link between female board representation and firm innovation is expected to be positive, leading to the following hypothesis:

> ***Hypothesis:*** *The higher the proportion of women in corporate boards in a given firm, the higher the firm's innovation performance.*

4. Cross-Country Empirical Analysis

Before testing the relationships between female directors and firm innovation in French firms in *Section 4.1.3* and in German firms in *Section 4.2.3*, an explanation for the country selection is provided. In this context, *Table* 1 shows the percentage proportion of board seats occupied by women in the most recent year for various European countries and internationally. With a proportion of 44 percent of women on corporate boards, France

is the country with the highest proportion of female board members and was selected for the analysis to investigate whether French firms are correspondingly more innovative. A recent study on German firms by Joecks et al. (2023) is suitable for contrasting the result because Germany represents the midfield in a European and international comparison with a proportion of 31 percent of women directors. Further, the corporate government system of both countries, Germany and France, is characterized by a two-tier board structure including an executive board and a supervisory board (Joecks et al., 2023, p. 1204), which allows for comparability of results. Focusing on a single country at a time also has the advantage that the sampled firms are subject to the same national innovation system and macroeconomic environment.

4.1. Descriptive Analysis of the Impact of Women on Corporate Boards on Innovation in French Firms

4.1.1. Sample and Variables

The initial sample consists of all 120 companies listed on one of the French exchange stock markets, such as CAC40, CAC Next 20, or CAC Mid 60, which together form the SBF 120 index. Data was collected on a one-year period for 2022 to use the most recent available data for the analysis. However, due to missing values for the proxy of firm innovation performance, the initial sample had to be reduced, so the final data set consists of 60 companies, all listed on the index SBF 120, on December 31st, 2022.

Firm innovation as the dependent variable, and thus the primary variable of interest, is measured by the number of patents granted to the sampled firm in 2022. Despite various proxy variables for innovation, patent count is a generally accepted indicator among researchers. Focusing on patents as an outcome-based measure of firm innovation, the model follows the recent claim by scholars (for example, Joecks et al., 2023, p. 1207; Griffin et al., 2021, pp. 124–125) who argued that output-based innovation variables are more precise than input-based innovation measures, such as the expenditures on research and development (R&D). This is because patents are more closely related to firm innovation strategy and thus likely to be affected by the corporate board. For these reasons, patents are considered intermediate innovation outputs that measure the success of firm innovation activities more directly than R&D expenditures (Balsmeier et al., 2014, p. 1803), which firms rarely publish. Information on patent count was taken from the PATENTSCOPE database provided by the World Intellectual Property Organization (2023) and

Table 1: International Data on Proportion of Board Seats Held by Women (in Percent)
(Source: Own Illustration based on BoardEx (2022, p. 10))

France	44.0	United States	31.1
Italy	39.8	Germany	31.0
United Kingdom	39.8	Switzerland	30.4
Sweden	36.4	Singapore	24.2
Australia	35.6	India	18.0
Netherlands	35.3	Hong Kong	15.8
Spain	34.7	Brazil	15.2
Canada	34.4	Russia	12.7
South Africa	33.8	Japan	12.5
Ireland	33.0	United Arab Emirates	6.3

the ESPACENET database, which has been developed by the European Patent Office (2023). To ensure high data quality, every match was checked manually. Descriptive statistics for the variables in the regression sample are presented in *Table* 2, thereby providing a way to evaluate the broad characteristics of the data. The number of patents granted to the sampled companies ranges from 1 to 1671, with an average of patents per firm of 132.95 patents. The significant difference in the median and mean suggests that the number of patent data follows a non-normal distribution.

The primary explanatory variable of interest refers to the *proportion of women on supervisory boards* and thus captures the gender composition of supervisory boards. The respective data was collected from the DATASTREAM database of Refinitiv Eikon (2023). According to articles L. 225-27-1 and L. 22-10-7 of the French Commercial Code (Légifrance, 2023), directors representing employees or employee shareholders are not considered for calculating board gender balance. Each supervisory board has, on average, a female representation of 44.58 percent, with the lowest proportion of women directors on the supervisory board at 30.00 percent and the highest at 62.50 percent.

In accordance with the literature and previous studies on board composition (Balsmeier et al., 2014; Griffin et al., 2021; Joecks et al., 2023), the model controls for a set of board and firm variables that impact firm innovation. Information on firm-level and board-level controls is taken from the DATASTREAM database by Refinitiv Eikon (2023). At the board level, the model includes *board size* measured by the overall number of board members. The average board size amounts to 13 members. As firm-level controls, the regression includes *market value*, also known as market capitalization, calculated by multiplying the current stock price by the total number of outstanding shares as a proxy for firm size. Moreover, *return on equity (ROE)* accounts for firm performance. The *leverage ratio*, measured as long-term debt divided by total capital, is used to control a firm's financial potential. The average market value is 36,058 million Euros, the average ROE is 0.13 percent, and the average leverage ratio amounts to 39.69 percent.

4.1.2. Methodology

The operationalization of the dependent variable is decisive in selecting a suitable methodology. Since the number of patents is a non-negative continuously scaled variable, the ordinary least squares method is appropriate for describing the relationship between women directors and firm innovation. This statistical procedure attempts to explain an observed dependent variable by independent variables by minimizing the squared distances between the observation points and the regression line. The model used for this purpose is linear in the parameters, with the dependent variable being a function of the independent variables. The linear estimators obtained by using the method of least squares are those that minimize the variance (Wooldridge, 2016, pp. 64–65).

In the first regression model (I), the overall proportion of women on the board was used as a single explanatory variable to explore whether female board representation is positively linked in the selected sample. This results in the following regression function, where i denotes the firms in the data set, β_j represents the regression coefficients, and ε_i contains unobserved factors for firm i that affect its number of patents issued (Wooldridge, 2016, p. 74):

$$\textbf{Model (I):}\ Number\ of\ patents_i = \beta_0 + \beta_1 \cdot Women_i + \varepsilon_i$$

However, various board-level and firm-level third variables also impact firm innovation. The effect of the respective independent variable flows into the disturbance term, and the more systematic the disturbance term, the less reliable the results. To avoid an omitted variable bias, which occurs by excluding a relevant variable (Wooldridge, 2016, p. 78), the model is extended to a multiple linear regression by controlling for further explanatory variables and their effects on the dependent variable. This results in the regression function of the model (II):

$$\textbf{Model (II):}\ Number\ of\ patents_i = \beta_0 + \beta_1 \cdot Women_i + \beta_2 \cdot Board\ size_i + \beta_3 \cdot Market\ value_i + \beta_4 \cdot Return\ on\ equity_i + \beta_5 \cdot Leverage\ ratio_i + \varepsilon_i$$

The results are to be interpreted in such a way that if the independent variable x_i increases, depending on the scaling

Table 2: Descriptive Statistics (Source: Own Compilation)

Variables	Mean	SD	Median	Min	Max
Number of patents	132.95	276.95	8.5	1	1671
Women – *percent*	44.58	6.52	44.44	30.00	62.50
Board size	13	3	13	7	20
Market value	36,058	68,737	10,598	961	428,011
ROE	0.13	0.19	0.14	–0.73	0.67
Leverage ratio	39.69	18.19	38.65	3.74	78.14
N (firms)			60		

of the variables, by one unit or by one percentage point, the dependent variable y_i, the number of patents, increases or decreases, on average, by the size of the regression coefficient β_i, *ceteris paribus. The estimated regression coefficients* β_i are therefore of particular relevance because they have partial effect, or ceteris paribus, interpretations, i.e., under the condition of all else being constant (Wooldridge, 2016, p. 66).

To assess how much of the variation in the dependent variable can be explained by the model, the coefficient of determination R^2 is used in statistics as an indicator for model fit. The higher R^2, the more strongly empirical y-values are determined by theoretical y-values (Bamberg et al., 2017, p. 42). For mathematical reasons, however, the measure increases continuously with the inclusion of further variables. For this reason, in a multiple regression, the *adjusted* coefficient of determination is assessed, which corrects for the degrees of freedom (Stock & Watson, 2020, pp. 223–224).

As with all statistical procedures, multiple regression is subject to certain assumptions that allow for mathematical development and that must be checked accordingly (Cohen et al., 2003, p. 117). Based on econometrics research (for example, Stock and Watson, 2020, pp. 225–227; Wooldridge, 2016, pp. 74–82), six major assumptions referred to as 'Gauss-Markov Theorem' must be examined. Firstly, the model must be linear in all predicated parameters and, secondly, defined by a random sample so all variables are independently and identically distributed. Thirdly, there must not be a perfect correlation between the independent variables to rule out multicollinearity. Fourthly, independent variables need to be exogenous so that the error u has an expected value of zero given any values of the independent variables. Fifthly, the dependent variable must be characterized by homogeneity of variance, often called homoscedasticity. Ultimately, the disturbances must be normally distributed, i.e., the conditional distribution of u_i given the independent variables is normal (Stock & Watson, 2020, p. 715). Under these assumptions, the estimators are the "best linear unbiased estimators" (Wooldridge, 2016, p. 90), meaning that the estimated sampled coefficients correspond, on average, to the true values of the regression coefficients. Violating one of the assumptions can lead to a biased estimate of the regression coefficients (Cohen et al., 2003, p. 117).

4.1.3. Results

Table 3 presents the bivariate correlations between the regression variables of primary interest. Although correlations cannot be interpreted causally, they provide information about whether the variables are related to some extent. The correlation matrix indicates no significant correlation between the proportion of women and the number of patents, so the magnitude of –0.11 cannot give any indication.

Table 4 presents the regression analysis. In model (I), the coefficient of the variable *women* is statistically not significant different from zero, as the p-value ($p = 0.42$) exceeds common significance levels. The magnitude and direction of the coefficients can thus not be interpreted, and the hypothesis can be rejected, indicating that there is no relationship between female board members and firm innovation. However, this finding may potentially be biased, for instance, caused by omitted variables, reflected in the low value of the determination coefficient ($R^2 = 0.01$). To control for neglected effects, further explanatory variables are included in the model (II). Hence, the model fit increases to 10 percent (*Adjusted* $R^2 = 0.10$), i.e., the model (II) explains 10 percent of the variation in the dependent variable. Nevertheless, despite including further explanatory variables, the coefficient of the variable *women* remains statistically insignificant. Two reasons could potentially underlie this: First, it could be a country effect, i.e., that the link between women directors and firm innovation simply does not exist across French firms. Second, the estimate may be biased due to the methodology, as the number of patents does not seem normally distributed, and due to the coarse data structure, as both the simple and multiple linear regression rely on cross-sectional data from 2022.

Thus, the OLS assumptions must be tested to account for endogeneity frequently associated with studies on board impacts (Brahma et al., 2020, p. 5716). Although the relationship is not strictly linear, the first assumption is not violated since a non-linear relationship is often transformed into a linear relationship by transforming the variables (Wooldridge, 2016, p. 74). Random sampling is fulfilled as firms were randomly selected according to data availability. By calculating variance inflation factors (VIF), all below the usual threshold of 10 (Wooldridge, 2016, p. 86) and the more conservative of 2 (O'Brien, 2007, p. 688), multicollinearity is ruled out. Exogeneity of independent variables is given, as the conditional distribution of the disturbance term given the inde-

Table 3: Bivariate Correlations (Source: Own Compilation)

Variables	Mean	SD	(1)	(2)
(1) Number of patents	132.95	276.95	1	
(2) Women – *percent*	44.58	6.52	–0.11	1

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

Table 4: Regression Results on Number of Patents (Source: Own Compilation)

Independent variables	(I)	(II)
Women – *percent*	–4.52 (5.54)	–7.56 (5.46)
Constant	334.46 (249.75)	164.89 (291.62)
Board size		29.51** (11.95)
Market value		0.00 (0.00)
ROE		–398.22** (198.58)
Leverage ratio		–0.79 (2.08)
N (firms)	60	60
R^2	0.01	0.18
Adjusted R^2	–0.01	0.10

Note: Estimation is by OLS. Numbers in parentheses are standard errors.
*p < .10. **p < .05. ***p < .01.

pendent variables has a mean of zero. However, neither homoscedasticity is fulfilled, as the residuals increase in a funnel shape, indicating heteroscedasticity (Field, 2018, p. 258; Cohen et al., 2003, p. 132), nor are the disturbances normally distributed, as outliers can be detected. The latter is probably due to the small number of observations, as this assumption is usually fulfilled with a sufficiently large sample (Field, 2018, p. 235).

Although the OLS regression provides unbiased estimates of coefficients despite homoscedastic variance, the violation of homoscedasticity distorts the standard error of the coefficients used to compute significance tests based on which the hypothesis decision is made (Field, 2018, p. 239). Hypotheses can thus be falsely rejected due to biased results. This suggests that the insignificance of the results is not caused by a country effect but instead by a bias, for instance, due to the methodology and the data structure. This also explains why previous studies on French firms using more complex regression models and panel data (for example, Galia and Zenou, 2012, p. 635; Galia et al., 2015, p. 123) found a positive relationship between women directors and firm innovation. This provides the motivation to consider empirical evidence investigating companies over a longer period. Two reasons further support this approach: First, there exists a time lag of innovation between the patent issue date and innovation activities (Griffin et al., 2021, p. 125). Therefore, researchers use one-year explanatory variables to account for this time lag (see similar procedure, e.g., Joecks et al., 2023, p. 1208; Balsmeier et al., 2014, p. 1803). Second, panel data allows controlling for potential reversed causality, which might be a concern when analyzing the impact of board composition on firm innovation, as it cannot be ruled out 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" (Joecks et al., 2023, p. 1208).

4.2. Empirical Evidence on the Impact of Women on Corporate Boards on Innovation in German Firms

4.2.1. Sample and Variables

Using panel data on a 16-year period of 105 companies listed on one of the German stock exchange indices, such DAX30, MDAX50, SDAX, and Tec-DAX30, Joecks et al. (2023, p. 1207) found a positive link between female board representation and firm innovation. Since German firms are analyzed, the corporate governance system of all sampled firms is characterized by a co-determined supervisory board, i.e., consists of both shareholder and employee representatives (Joecks et al., 2023, p. 1204). Firm-year observations were collected in the years from 2000 to 2015, leading to unbalanced data, as not all firms listed in one of the indices on December 31st, 2015, were continuously listed in the indices over the entire observation period.

As a dependent variable, the researchers use *patent propensity* as an outcome-related measure of firm innovation efficiency with data powered by the IPLYTICS database by the European Patent Office (2023). In accordance with previous studies (e.g., Belderbos et al., 2010, p. 876), the patent propensity is calculated by putting the number of firm patent fillings in a given year in relation to R&D expenditures of 1000 Euros. In this context, patent filing dates instead of issue dates were chosen, as the former more closely reflects the time of the invention and allows an estimate with

more accurate data. The average patent propensity is 0.30, i.e., R&D expenditures of 1000 Euros result on average in 0.3 patents. To account for a possible time lag, the patent propensity is measured with a lag of one year. To capture gender board composition, the model refers to the *overall proportion of women on the board* as the primary explanatory variable of the model. The analysis draws on hand-collected data from annual reports and information provided in a report by Weckes (2016). On average, supervisory boards consist of 12.2 percent female members, with the highest proportion of women directors at 50 percent.

Further variables are included in the model to control for board-level and firm-level effects that impact firm innovation performance. Data on board-level controls is provided by Weckes (2016) and data on firm-level controls is taken from the DATASTREAM database integrated into Refinitiv Eikon (2023). Joecks et al. (2023, p. 1207) include *board size*, *one-third co-determination*, *outside directorships* as indicator of multiple directorships, and *board tenure*. The variable *outside directorships* measures the external knowledge inflow and thus is calculated by the average supervisory board memberships a board member holds in one of the listed companies. The average board size amounts to 14.59, the average outside directorship is 1.28, and the average board tenure is 6.62 years. At the firm level, the model contains *market value*, *return on equity (ROE)*, and *leverage ratio* to account for firm size and performance. The average market value is 11.48 million Euros, the average ROE is 11.34 percent, and the average leverage ratio is 29.19 percent.

4.2.2. Methodology

Joecks et al. (2023, p. 1208) panel data investigation is based on a Poisson regression. The Poisson estimator is used when the dependent variable comprises counts, for instance, the number of patents, not containing negative values but zero observations (see for similar procedure, e.g., Balsmeier et al., 2014, p. 1806). Thus, the outcome variable is nominally assumed to have a Poisson distribution, conditional on the explanatory variables (Wooldridge, 2016, pp. 543–544). This mathematical distribution is used to describe the probability of occurrence of count data. As a count variable can take on values of zero, it cannot be logarithmized, so the link is approached by modeling the expected value as an exponential function (Wooldridge, 2016, p. 544). The count data model is moreover estimated with fixed effects so that the model accounts for unobserved firm heterogeneity that is time-invariant and constant across industries (see similar procedure, e.g., Balsmeier et al., 2014, p. 1806). The following equation results:

$$\begin{aligned} E(y_{it}|\boldsymbol{x}) = exp(&\beta_0 + \beta_1 \cdot Women_{it} + \beta_2 \cdot Board\ Size_{it} \\ &+ \beta_3 \cdot One\ Third\ Co{-}Determination_{it} \\ &+ \beta_4 \cdot Outside\ Directorships_{it} + \beta_5 \cdot Board\ Tenure_{it} \\ &+ \beta_6 \cdot Market\ Value_{it} + \beta_7 \cdot ROE_{it} \\ &+ \beta_8 \cdot Leverage\ Ratio_{it} + \alpha_i + \lambda_t + \varepsilon_{it}) \end{aligned}$$

where y_{it} describes the patent propensity of firm i in year t, the vector $\boldsymbol{x}$ is shorthand for all explanatory variables, β_j represent the regression coefficients, ε_{it} contains unobserved factors that affect the patent propensity of a firm, α_i denotes the time-fixed effects and λ_t denotes the industry-fixed effects (Stock and Watson, 2020, pp. 372–373, 369; Wooldridge, 2016, p. 544). The logarithm of the expected values can be modeled by a linear combination of parameters (Wooldridge, 2016, p. 544):

$$\begin{aligned} log[E(y_{it}|\boldsymbol{x})] = &\beta_0 + \beta_1 \cdot Women_{it} + \beta_2 \cdot Board\ Size_{it} \\ &+ \beta_3 \cdot One\ Third\ Co{-}Determination_{it} \\ &+ \beta_4 \cdot Outside\ Directorships_{it} + \beta_5 \cdot Board\ Tenure_{it} \\ &+ \beta_6 \cdot Market\ Value_{it} + \beta_7 \cdot ROE_{it} \\ &+ \beta_8 \cdot Leverage\ Ratio_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \end{aligned}$$

Hence, the Poisson regression takes the form of a log-linear model. However, similar to probit, logit, and Tobit models, the magnitude of the estimates of an exponential function as a nonlinear function cannot be interpreted as the OLS estimates of a linear function but can only be approximated (Wooldridge, 2016, p. 544):

$$\%\Delta E(y_{it}|\boldsymbol{x}) \approx (100\beta_j)\Delta x_j$$

More accurate estimation can only be identified by calculating discrete changes in the expected values (Wooldridge, 2016, p. 544). The study of Joecks et al. (2023, p. 1209) uses the pseudo maximum likelihood method, typically applied to Poisson models (Gouriéroux et al., 1984, p. 701). The above approximation is thus not sufficient for interpretation (Wooldridge, 2016, pp. 544–546); instead, the coefficient's algebraic sign gives an indication of the direction of the relationship. The log pseudo-likelihood value shown in *Table* 5 measures the model fit, ranging from negative infinity to positive infinity (Gouriéroux et al., 1984, p. 703). Although higher values indicate a better model fit, the absolute value cannot be interpreted; it can only be compared between multiple models.

4.2.3. Results

Table 5 presents the Poisson regression analysis on *patent propensity*. Several robustness checks were conducted, for instance, to account for the differing industries in the sample (Joecks et al., 2023, p. 1209). The coefficient of the variable *women* is highly statistically significant different from zero on a one percent significance level, and has a positive value of 2.612. The direction of the coefficient indicates that the percentage of women on supervisory boards is positively related to firm innovation, which is in line with the vast majority of previous studies and supports the hypothesis in *Section 3*.

4.3. Comparison of Descriptive Analysis and Empirical Evidence

As the data analysis in *Section 4.1* provides insignificant results, findings are contrasted with further empirical evi-

Table 5: Poisson Regression Results on Patent Propensity (Source: Own Illustration based on Joecks et al. (2023, p. 1209))

Independent variables	**Coefficient (Standard errors)**
Women – *percent*	2.612*** (0.589)
Board size	0.15 (0.12)
One third co-determination *(reference: parity co-determination)*	–2.37*** (0.40)
Outside directorships	1.31 (2.34)
Board tenure	0.09*** (0.03)
Market value	–0.27 (0.43)
ROE	0.02** (0.008)
Leverage ratio	0.043 (0.03)
Year and Industry FE	Yes
Log pseudo-likelihood	–1752.1
N (obs)	745
N (firms)	74

Note: Estimation is by Poisson regression. Numbers in parentheses are standard errors.
*p < .10. **p < .05. ***p < .01.

dence from *Section 4.2*, which argues for a positive relationship between women directors and firm innovation. Differences in the results are, among other things, due to methodological differences that make comparisons difficult:

First, studies on board composition are generally difficult to compare across countries as they are subject to contextual factors. This aligns with *Section 2.2*, which emphasizes contextual factors and a situational approach at national levels.

Second, data availability determines model specifications and, thus, its explanatory power, leading to differing results. Regarding the operationalization of variables, both analyses selected other variables to capture firm innovation quantitatively. While the patent count is used as a proxy for innovation in the descriptive analysis, the empirical evidence by Joecks et al. (2023, p. 1207) relies on patent propensity. The latter is considered to capture innovation activity more accurately by using patent applications per year instead of patent grants per year (Balsmeier et al., 2014, p. 1803). Furthermore, the analysis by Joecks et al. (2023, p. 1207) controls for outside directorships, which is a variable of particular relevance, as external directors are perceived to provide "scarce specific knowledge and experience" (Balsmeier et al., 2014, p. 1801). As only unreliable data was available, this variable could not be included in the descriptive analysis, potentially leading to an omitted variable bias.

Third, differences in data structure can also be identified. While the empirical study based on German firms assesses panel data with firm-year observations collected over 15 years (Joecks et al., 2023, p. 1207), the descriptive analysis uses cross-sectional data limited to the year 2022. However, as recent data on patent grants in 2022 was not available for some firms in the initial samples of 120 firms, the data set had to be reduced considerably. This causes a loss of valuable data and leads to the data being subject to the circumstances in 2022, such as the Covid-19 pandemic. This would explain significant differences in the variables compared to the following year (e.g., ROE for Arcelor Mittal: 0.19 percent in 2022 and 7.69 percent in 2023) (Refinitiv Eikon, 2023). This is supported by the central limit theorem, which states that the more observations a model contains, the more accurately the parameters can be estimated (Field, 2018, p. 233). According to Balsmeier et al. (2014, p. 1803), panel data is moreover crucial to account for possible time lags in innovation. Most previous studies, therefore, relied on panel data analyses, as noted in Joecks et al. (2023, p. 1205).

Fourth, an important factor determining the quality of the results is the choice of an estimation method. Using the Poisson regression as a non-linear function may capture the link between women on boards and firm innovation better than a linear function, as the distribution may deviate from a normal distribution if the dependent variable takes on very few values (Wooldridge, 2016, p. 544). This is presumably the reason why the analysis of Joecks et al. (2023, p. 1209) leads to statistically significant results.

5. Conclusion

The question of the extent to which gender diversity on supervisory boards contributes to firm innovation and thus to the long-term success of a company was investigated on the basis of Hambrick and Mason's (1984) upper echelons theory and empirically tested on the basis of a bivariate analysis of French firms with non-significant results and a panel data study of German firms, arguing for a positive relationship. Among the arguments presented in the literature, particular emphasis is placed on the female leadership style, which promotes cooperation, collaboration, and participation and, thus, an open-minded and more innovative corporate culture. However, this is put into perspective by contextual factors that need to be considered.

Several policy, managerial, and practical implications emerge from this result. The dynamic business environment

forces firms to consider factors that promote innovation performance to ensure corporate survival or even to gain an edge over competitors. Thus, entrepreneurial and forward-thinking firms should focus on modernizing human resource management practices by viewing gender diversity as a key innovation component. This may create more gender-diverse teams that motivate identifying and implementing novel marketable ideas or even inspire employees to transform their entrepreneurial aspirations into actual entrepreneurial acts by creating ventures under their organizations' umbrella. These actions will generate multiple benefits at an individual level due to professional advancement, at an organizational level through sustainable innovation, and at the social level due to economic and social outcomes. Gender diversity, therefore, holds great potential for a firm's innovation performance. In addition, further political requirements will establish gender diversity as a business imperative of the early twenty-first century so that, sooner or later, it will be part of the strategic orientation of most companies.

However, given the framework conditions under which the studies were conducted, no claim to general validity can be made. Regional, cultural, and industrial differences make it difficult to compare study results. A further obstacle to the systematic analysis was the loose application of the term 'innovation', which is often employed as a substitute for creativity, knowledge, or change. Researchers not only use different input or output-based proxies for innovation, such as the number of patents, patent propensity, or R&D expenditures but also refer to performance measures other than innovation outcomes, such as productivity growth and effectiveness. Moreover, using patents as an innovation indicator can be misleading to the extent that not every invention is patented and some granted patents are not used to introduce a novel process or product or to improve established processes or products (Balsmeier et al., 2014, p. 1803). Even if granted patents result in innovation activity and outputs, they take several years to develop, so it is uncertain whether granted patents will prove novel and impactful (Griffin et al., 2021, p. 124). These circumstances impede making generally valid statements and question the accuracy of previous studies and their results. This inevitably leads to the question of how firm innovation can be quantitatively captured and made comparable in the context of studies on the board composition of supervisory boards.

Forthcoming studies should, therefore, focus on examining the concept of innovation more closely, for instance, by differentiating between the forms of innovation, such as product innovation, process innovation, marketing innovation, and organizational innovation. In addition, future studies should examine more intensively the impact of gender diversity and complementary attributes of women and men that create synergy in improving innovation performance. Additional qualitative interviews may help to deepen our understanding of the relationship between board members and innovation. Gender diversity could also be explored in the context of corporate venturing activities, and the effect of either a male or female entrepreneur on the firm's strategic focus examined. Gender-based differences in the engagement in corporate venturing and the application of corporate venturing strategies could be identified to enrich the discussion on gender diversity. Due to the rise of a younger generation of managers and executives to the corporate top, including supervisory boards, subsequent research should explore how the effects of gender diversity on firm innovation may change. It would be interesting to investigate whether the advantages of female representation remain when greater gender equality is achieved in the upper echelons. Although innovation can be seen as a gender-biased phenomenon, focusing only on gender diversity and innovation, gender diversity is not the only component impacting firm innovation. Indeed, it is an interplay of several dimensions that collectively contribute to organizational diversity, such as diversity of age, nationality, and culture. Therefore, researchers should investigate how the impact of gender diversity varies when not only other genders, such as non-binary, but also other diversity dimensions are considered. These and other questions can be answered by further empirical research on diversity and innovation.

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