**The impact of board diversity on corporate innovation performance**

**Abstract**

**Research Question/Issue:**

This study investigates the relationship between board diversity and innovation performance. Examining demographic diversity, cognitive diversity, and structural diversity we analyse how board diversity affects corporate innovation performance and demonstrate which diversity types are most beneficial for highly innovative companies.

**Research Findings/Insights:**

The empirical results of the study contrast the current state of knowledge on diversity impacts. We find positive effects of age diversity on innovation performance while an increased board size reduces innovation performance. On the contrary, gender diversity, which previously was deemed effective, as well as knowledge diversity and diversity in experience, do not show significant impacts in our study.

**Theoretical/Academic Implications:**

Building on Upper Echelons theory, we suggest positive impacts of age diversity on innovation performance can be attributed to behavioral characteristics of age-diverse board members such as risk preference, human capital and accumulated social capital. Building on research regarding group dynamics, we suggest that the negative relationship between board size and innovation performance can be attributed to difficulties to find an agreement among differing opinions, which are slowing down innovation-related decision-making. Furthermore, more diverse boards create agency-, coordination- and communication problems which may negate diversity potentials.

**Practitioner/Policy Implications:**

Firms thus benefit from reduced board sizes and including different age groups which improve their innovation performance. However, diversity advantages favoring innovation performance only exert their positive effect to a certain level of diversity. When diversity or the board size is exceeding, diversity-induced conflict and costs can have negative effects on innovation performance.

**1 | INTRODUCTION**

In times of intense competition, rapid technological development, continuously changing customer needs (Rejeb et al., 2020) and external pressures such as climate-related events (Zaman et al., 2023) firms are compelled to innovate to maintain competitiveness. Corporate innovation is referred to as the ‘procedure of making changes to a firm’s products, processes, and services to add value to the company and its customers’ (O’Sullivan & Dooley, 2009). It is seen as a key factor for enhanced competitiveness, increased productivity, and higher company value (Hitt et al., 2017; Mohnen & Hall, 2013; Hall et al., 2005).

To successfully implement innovations, long-term, partly risky decisions need to be made (Aghion et al., 2013; Sierra-Morán et al., 2021), in which the board of directors as the management and control mechanism of a firm has a decisive role to play (Adams & Ferreira, 2007). Research has emphasized the relevance of identifying board characteristics that are relevant for fostering innovation (Sierra-Morán et al., 2021). In this context, board diversity is considered as one of the most important issues (Galia & Zenou, 2012; Miller & Triana, 2009; Cumming & Leung, 2021).

Unlike the effects of board diversity on corporate performance (Carter et al., 2003; Carter et al., 2010; Siciliano, 1996), its impact on corporate innovation is barely researched (Belkacemi et al., 2021a; Makkonen, 2022) and the presented studies do not provide clear results (Miller & Triana, 2009; Sierra-Morán et al., 2021; Midavaine et al., 2016; Griffin et al., 2021). Belkacemi et al. (2021a, 2021b) criticized in the literature that this far only one or few diversity factors were considered, and that innovation and diversity were not adequately measured. Miller and Triana (2009) highlighted that innovation inputs such as R&D expenditure don’t always guarantee increased innovation outputs and Zahra (1996) pointed out that using the number of patents as an innovation output indicator has limited significance. Furthermore, a high share of the minority group such as the percentage of women doesn’t indicate a high level of diversity (Belkacemi et al., 2021b).

More recent research increasingly aims to answer whether and under what conditions board diversity is relevant for promoting innovation and which types of board diversity are most beneficial (Makkonen, 2022; Li & He, 2021). In this context, the consideration of a variety of diversity factors (Galia & Zenou, 2012; Huse, 2007) and an adequate measurement of diversity and innovation metrics is required (Belkacemi et al., 2021b; Miller & Triana, 2009). Resulting from these demands and the current state of knowledge, this paper answers the following question: What is the relationship between board diversity types and innovation performance and which ones are particularly relevant?

We meet the demand for considering several diversity factors and include demographic diversity (gender and age diversity) cognitive diversity (knowledge and experience diversity) and structural diversity (board size). By using the innovation premium and the Blau’s index as indicators for innovation and diversity, we address the request for considering more realistic and precise innovation and diversity measures (Belkacemi et al., 2021b; Miller & Triana, 2009). We test five hypotheses based on innovation and board data from 81 companies by means of multiple linear regression.

We advance the current state of empirical knowledge by offering contrasting results, as we don’t confirm that gender diversity increases innovation performance. Furthermore, the assumption that knowledge diversity, experience diversity and board size have a significant positive impact on innovation performance is not supported. Instead, we confirm that age diversity has a positive influence on innovation performance and show that board size decreases it.

Our findings contradict the pertinent literature on gender diversity. Instead, they support most findings regarding age diversity. In terms of cognitive diversity our analysis counteracts the relatively sparsely examined diversity in experience and knowledge that identified associations to innovation measures. Our findings support the literature regarding negative effects of large board size and implicate that this factor may impair corporate innovation performance. We offer a broader and more specific assessment of board diversity effect by including different diversity categories (demographic, cognitive and structural diversity) and comparing them with each other.

**2 | LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT**

**2.1 | Diversity and Corporate Innovation**

In the case of boards, directors are predominantly considered a homogeneous group consisting of “old boys” (Allemand et al., 2022). Board members are typically men in the later stages of their professional careers with lots of experience in top management positions, matching educational profiles and common social networks (Allemand et al., 2022; Huse, 2007). Diversity or heterogeneity takes the different backgrounds and skills of board members into account. A diverse group of directors can bring access to new networks, the availability of alternative competencies and the critical questioning of existing rules into the board (Huse, 2007). Consistent with this, Wright et al. (2023) showed how important the variety in board composition can be for effective corporate governance by enhancing the board’s abilities in oversight, decision-making, and conflict resolution.

Upper echelons theory emphasizes the role of top management teams in achieving operational results (Hambrick & Mason, 1984). The approach assumes that managers perceive situations and alternatives based on their personal attributes. These include demographic characteristics, professional experiences, values, and personal characteristics (Hambrick, 2007). According to this theory, the composition of senior management teams influences internal processes that affect decisions, strategies, and other outcomes (Hambrick et al., 2015). As innovation decisions are strategic decisions under uncertainty and increasingly complex (Moenaert et al., 2010) the approach may offer insights into the impacts of board composition.

Influences of board diversity on innovation have been studied primarily through demographic characteristics (Makkonen, 2022; Torchia et al., 2015; Miller & Triana, 2009; Belkacemi et al., 2021a). Demographic diversity is often referred to as ‘surface’ diversity (Belkacemi et al., 2021b) and includes attributes such as age, nationality, gender, and ethnicity (Kang et al., 2007). Such characteristics are immutable and directly identifiable (Jackson et al., 1995). Harrison et al. (1998) pointed out, that cognitive characteristics may be more important in the study of diversity effects and therefore should also be considered. Cognitive diversity is also referred to as ‘deep-level’ diversity and includes variables that are less visible (Li & He, 2021). Examples include education, expert knowledge, and experience (Harjoto et al., 2018). Cognitive factors are difficult to objectify and often require interpretation (Jackson et al., 1995). In comparison to the reference to individual attributes of board members, structural diversity involves group attributes of a board that distinguish the board from another (Sierra-Morán et al., 2021). For example, it includes variables such as the board size, the board system (duality or unification model), or the frequency of board meetings (ibid.). Scholars draw attention to the fact that structural characteristics should also be considered as a category when diversity influences are examined (Sierra-Morán et al., 2021; Hafsi & Turgut, 2013). Different board diversity forms appear to entail differential influences. This is the starting point of the present work.

Thus, for demographic and cognitive diversity diversity-related impacts regarding corporate innovations are explained building on Upper Echelons theory. As structural diversity isn’t related to differences within the board, but between boards, it can’t be referred to this theory. Instead, influences are explained by examining approaches on group processes of different board sizes.

**2.2 | Gender Diversity and Corporate Innovation**

Galia and Zenou (2012) analyzed corporate innovation efforts and found a positive correlation between board gender diversity and marketing innovation. This result was explained by the gender scheme that women bring to boards. Women are deemed to be better at understanding the behavior of customers and their needs (Kang et al., 2007; Galia & Zenou, 2012) and thus enable the board to develop relevant innovations fitting to customer- and market needs (Galia & Zenou, 2012). Also, Del Mar Fuentes-Fuentes et al. (2023) examined a positive impact of gender diversity on the board of directors on inclusive innovation and argued that women promote this form of innovation as they have more social characteristics. This is contrasted by Galia and Zenou’s (2012) results on process innovation who found no significant relationship with gender diversity, which was explained by a decreased influence of the board on process-related content, as this is more operational than strategic.

Gender differences in terms of overconfidence, risk-taking and time perspective orientation play an important role in innovation performance (Griffin et al., 2021). Employing a questionnaire study, Torchia et al. (2011) found a positive link between board gender diversity and organizational innovation through an increased focus on people and their individual characteristics (Kimberly & Evanisko, 1981) which can be addressed better if women are part of the board (Torchia et al., 2011). They also showed that the influence of female board members, such as diverse problem-solving approaches and improved decision-making in favor of organizational innovation, only takes place at a critical mass of three women on board. Otherwise, the contributions and opinions of minority group members are not respected, and they are subject to tokenism (Kanter, 1977).

Na and Shin (2019) found female top managers to be more risk-averse and evaluate operational issues without overestimating themselves thus enabling a better innovation performance (ibid.). Miller and Triana (2009) identified a positive relationship between gender diversity and innovation in terms of a firm's research and development expenditures. They stated that the complexity in decision-making can be reduced and referred to Mintzberg et al. (1976) who suggested that diversity can support the identification, development, and selection of decisions. Valenti and Horner (2020) found that women contribute to innovation results via different human capital than their male colleagues. Women on the board behave more prudently and carefully than their male counterparts and are more likely to question board issues. This specific human capital influences corporate board processes (Huse & Solberg, 2006), which in turn has an impact on the innovative capacity of companies (Valenti & Horner, 2020). Also, Lakhal et al. (2024) examined that board gender diversity enhances both corporate and green innovation arguing that women bring certain skills, educations and experiences to the board that favor a firm’s innovation capabilities. Belkacemi et al. (2021b) examined the impact of gender diversity on innovation performance measured by the innovation premium and found a positive correlation. They argue that the diversity-related connection to a broader network enables the establishment of communication channels of a firm to other external actors and improves consulting which can be relevant elements for a firm's innovative purposes. Chen et al. (2018), who found a positive relationship between gender-diverse board composition and R&D investments explained that a diverse board is better at performing its control function and solving agency problems whilst innovation decisions. Cumming and Leung (2021) showed that board gender diversity facilitates innovation in male-dominated industries and argued that gender diversity on boards has a stronger effect on reducing fraud within industries where men hold the majority of positions.

The cited studies show how the characteristics of gender diverse board members can promote corporate innovation due to an increased presence of women. Therefore, we suggest the following hypothesis:

*H1: Board gender diversity increases corporate innovation performance.*

**2.3 | Age Diversity and Corporate Innovation**

Galia and Zenou (2012) found a positive influence of board age diversity on product innovation through an increased variety of perspectives by questioning managers regarding their innovation efforts. Age diversity influences learning and development in the board and thus creative and innovative ideas are supported (Walt & Ingley, 2003). Furthermore, customers’ interests in different age categories can be considered in the decision-making process and innovation in the sense of a broader range of products and services is enabled (ibid.; Kang et al., 2007). Sierra Moran et al. (2021) analysed papers regarding the relationship between age-diverse board composition and firm innovation in the form of innovation inputs -and outputs. Although they couldn’t find a significant relationship, they didn’t rule out the possibility that the characteristics of different age groups can be important determinants for strategic decisions and supportive conditions for corporate innovation. Studies also showed age diversity can have a negative effect on decision-making. Kunze et al. (2011) claimed that age diversity can lead to an age-discriminatory climate between more experienced and less experienced directors, which may affect a firm's performance outcomes. Also, other authors noted that diversity leads to disagreements that can reduce innovative performance (Zajac et al., 1991; Galia & Zenou, 2012). In contrast to the finding regarding product innovation, Galia and Zenou (2012) concluded that age diversity is negatively associated with firm innovation. They referred to the fact that the shift in characteristics of different age groups can lead to generational conflicts, which hinder board collaboration and organizational change. Belkacemi et al. (2021b) found that age diversity and innovation were not significantly related due to similarities regarding the age-related structure of corporate boards, which make it difficult to identify a link between age diversity and innovation performance. The findings of Janahi et al. (2022), who investigated the influence of age diversity on the board's monitoring function, show that boards perform their monitoring function more efficiently when they consist of members of different ages. According to the authors, conflicts due to age differences make the board more independent and thus improve the monitoring possibilities.

Although the diversity-related risk of conflict can be a barrier for innovation outcomes, it is assumed that such negative effects only appear at very high levels of diversity, which are unlikely in upper management teams (Bantel and Jackson, 1989). For the mentioned reasons, the following hypothesis is proposed:

*H2: Board age diversity increases corporate innovation performance.*

**2.4 | Knowledge Diversity and Corporate Innovation**

When studying knowledge diversity, academic careers were the most frequently analyzed variables (Belkacemi et al., 2021a; Wiersema & Bantel, 1992). Midavaine et al. (2016) analysed the relationship between the diversity of academic degrees among board directors and the R&D expenditures of companies. They concluded that educational diversity and a firm's innovative capacity are positively related and argued that decision-making is improved by the availability of different knowledge. Differently educated board members bring divergent cognitive abilities to the board (Bantel & Jackson, 1989; Hülsheger et al., 2009). Those can improve the evaluative skills of relevant information at team level and thus have a positive impact on group decision-making. On the one hand, people with high educational levels are more willing to take risks and therefore more open to investing in R&D (Wiersema & Bantel, 1992; Midavaine et al., 2016). On the other hand, people with lower degrees bring divergent views to the board that in addition can benefit innovation (Midavaine et al., 2016). Wincent et al. (2010) investigated the relationship between educational diversity on the board and innovation performance of strategic networks and found a positive correlation. They attributed this to the fact that a strong connection between cooperation partners can be established through educational diversity by addressing the different skills of managers of the partner company and thus improving cooperation. Since innovations are often linked to changes in corporate strategy (Storsul & Krumsvik, 2013), companies benefit from directors with high educational qualifications. This aspect was demonstrated by Wiersema and Bantel (1992), who revealed the positive contribution of highly educated managers to strategic changes in a company. In line with this, Østergaard et al. (2011) discovered that educational diversity among employees with a higher education has a positive impact on the likeliness to innovate. Also, Cumming and Leung (2021) showed that diverse educational backgrounds can lead to enhanced innovation by fostering the synthesis of different ideas and approaches.

The mentioned studies show that knowledge-based diversity is advantageous regarding innovation. For this reason, the following hypothesis is formulated:

*H3: Board knowledge diversity increases corporate innovation performance.*

**2.5 | Experience Diversity and Corporate Innovation**

Bantel and Jackson (1989) studied top managers to identify the relationship between diversity in managerial tenure and a firm's innovativeness through interviews. The authors assumed that boards would benefit from also having members with short board tenure, as members with long tenure rather tend to resist change (ibid.) and directors with short tenures probably aren’t as entrenched in corporate processes (Li & Wahid, 2018). Besides the emerging efficiencies in discussion and learning the diversity of perspectives can also hinder communication processes and cause conflicts and therefore hamper innovation (Bantel & Jackson, 1989; Katz, 1982). Neither the positive nor negative aspects of diversity showed their effect here as the authors didn’t find significant results and no further interpreted them (Bantel & Jackson, 1989). Wiersema and Bantel (1992) examined the relationship between the tenure heterogeneity of top managers and the likelihood that the management team will change corporate strategy. The authors did not find significant effects of different managerial employment durations on strategic changes in the firm. They attributed this to the fact that diversity-related contributions to decision-making may be more likely to take their effect at lower levels than the top management level (ibid.). Midavaine et al. (2016) examined the relationship between board tenure diversity and corporate research and development spending. According to the authors, directors with different board tenures contribute to the board with different characteristics. For example, the knowledge of more experienced board members can help determine which resources and capabilities the company should focus on in the future. On the other hand, less experienced board members can judge the company as an outsider. The combination of these two aspects leads to improved decision-making as both the short- and long-term developments of the company are considered (ibid.). Contrary to these assumptions, Midavaine et al. (2016) concluded that diversity of board tenure reduces the likelihood of investing in research and development. They suspected that the reluctance of long-serving directors to innovate and their high level of influence are responsible for the result. Sierra-Morán et al. (2021) found a positive correlation between boards with different lengths of service and innovation outputs in their review article. Studies stated that a mixture of directors with short and long tenures improves the efficiency of boards (e.g. more intense monitoring, higher independence of directors, better alignment of shareholders’ and managers’ interests) and thus enables firms to meet their innovation goals (Munir et al., 2020; Christensen & Knudsen, 2008). Munir et al. (2020) also found a positive relationship between board tenure heterogeneity and research and development expenditures. They attributed the finding to diversity-related network potentials and improved execution of board functions.

In summary, the studies regarding the effects of diversity of experience show mixed tendencies of influence. However, the theoretical assumption suggests a positive influence. Therefore, the following hypothesis is stated:

*H4: Board experience diversity increases corporate innovation performance.*

**2.6 | Board size and corporate innovation**

Sierra-Morán et al. (2021) found a positive relationship between board size and innovation outputs. They argued that the higher complexity in strategic decision-making and the risk that comes along with innovation requires a detailed analysis of situations (Hambrick & Mason, 1984; Moenaert et al., 2010). The higher the number of directors on the board, the more resources, knowledge, and information sources are available to a board (Barney, 1991). Thus, the multiple perspectives of a variety of board members can improve board decision making (Sierra-Morán et al., 2021). Chen et al. (2015) identified a positive link between board size and a firm's innovation activities as measured by patents. They attributed the result, among other things, to the fact that small boards are more likely to question innovation strategies. Also, Wincent et al. (2013) concluded that board size and innovation performance are positively related to some extent. They claim that large boards are better at recognizing deficient projects and self-serving behavior of managers that tends to hamper successful innovation. However, there are also arguments in favor of improved decision making when the board is small. Goodstein et al. (1994) suggested that larger boards could delay the decision-making process when tasks and decisions become more complex, as in the case with innovations. In addition, the different views and personal interests may damage the company's goals. Large boards may lose their effectiveness in ensuring organizational responsiveness to environmental changes. Confirming these assumptions, they found a negative correlation between board size and the initiation of strategic change. The strategic decision-making process is extended and the ability to introduce critical strategic change decreases when the board is large. In line with this and in contrast to the result regarding innovation outputs, Sierra-Morán et al. (2021) found a negative relationship between board size and a firm's innovation input. They referred to the longer decision-making process in large boards and assumed that communication and coordination problems would occur. Therefore, it would be hard to find a consensus when it comes to questions regarding innovation inputs such as R&D expenditures. Nakano and Nguyen (2012) examined the relationship between board size and corporate risk taking and concluded, that the impact of board size depends on the circumstances. Companies with fewer growth options may benefit from streamlining their decision-making processes through smaller boards. However, if these companies are overly focused on avoiding risks, they could potentially limit their long-term expansion potential and fall behind their competitors in terms of corporate results.

All in all, evidence regarding the relationship between board size and innovation is mixed. Decision making in large boards could benefit from the multiplicity of opinions but also suffer from conflict. However, studies specifically looking into innovation outcomes instead of processes predict a positive relation. Therefore, we propose the following hypothesis:

*H5: Board size increases corporate innovation performance.*

Figure 1 summarizes all developed hypotheses of this chapter.

Demographic board diversity

Cognitive board diversity

Structural board diversity

Gender diversity

Age diversity

Knowledge diversity (educational diversity)

Experience diversity (tenure diversity)

Board size

H1: +

H2: +

H3: +

H4: +

H5: +

Innovation performance

+ positive correlation.

- negative correlation.

**Fig. 1:** Conceptional Model.

**3 | RESEARCH METHODOLOGY**

**3.1 | Sample**

Our sample consists of companies listed in the latest published ranking of the 100 most innovative companies worldwide by Forbes Magazine in 2018 (Forbes, 2018). Similar approaches were used for example by Midavaine et al. (2016), who selected 25 companies from the Fortune 500 list of high-revenues firms to analyse the relationship between board composition and innovation. Also, Robeson and O'Connor (2013) based their sample on 98 of the 1000 most prestigious companies listed by Fortune and Belkacemi et al. (2021a; 2021b) who respectively examined influences of demographic and cognitive diversity employed the list of the world's most innovative companies published by Forbes in 2017. To reduce endogeneity problems and avoid reverse causality (Cumming & Leung, 2021; Atallah et al., 2021) and as the influence of board diversity takes time to show its effect in performance measures (Carter et al., 2010), we follow Chen et al. (2018) and consider independent variables with a one-year gap to the dependent variable. Board members appointed to the board during the reference year are not considered, as their impact would be negligibly low during the early months of their tenure (Belkacemi et al., 2021b). Data on diversity variables (gender diversity, age diversity, knowledge diversity, experience diversity and board size) were obtained from Refinitiv Eikon. Missing data, particularly concerning knowledge diversity and age diversity was gathered from the sample companies’ 2017 annual reports and websites. Otherwise, data were gathered from online information providers such as Bloomberg and the Wall Street Journal (WSJ). Data for control variables were also considered for the year 2017 and collected from Forbes website (Forbes, 2018). Corresponding to the independent variables, missing data were obtained from annual reports, company websites and other online information providers such as Bloomberg and the Wall Street Journal (WSJ). After excluding 19 companies due to missing data the final sample includes 81 companies.

**3.2 | Dependent variable**

Often research relied on common measures such as R&D expenditures or the number of patents as innovation indicators (Miller & Triana, 2009; Midavaine et al., 2016; Chen et al., 2015; Chen et al., 2018). Miller and Triana (2009) drew attention to the fact that R&D expenditures reflect efforts in innovation, but don’t necessarily translate into innovation outcomes. Regarding the number of patents, the limitation of informativeness was mentioned. For example, Zahra (1996) highlighted the difficulty in assessing their financial viability. Our study aligns with the research of Belkacemi et al. (2021a; 2021b) and uses the innovation premium in 2018 as an indicator of innovation performance. As it considers the difference between overall firm value and net present value and compares it to the stock price, it reflects the investors’ ability to identify those companies, that can successfully generate current and future growth.

**3.3 | Independent variables**

Most studies measured diversity within boards through the amount or share of board members with certain characteristics (Ariff et al., 2017; Torchia et al., 2011). This implies that diversity effects are a result of including more people with these characteristics. Since it is more about the ratios of mixture, we follow studies from several authors who used the Blau’s index to measure diversity (Midavaine et al., 2016; Miller & Triana, 2009; Belkacemi et al., 2021b; Belkacemi et al., 2021a) and calculated it for the year 2017. The Blau’s index represents the probability that two randomly selected group members belong to different categories and is suitable for observing the distribution of diversity data across a specific number of categories (Harrison & Klein, 2007). It is given by the formula (Blau, 1977):

(1)

where Pi represents the proportion of board members in the i-th category of a group and n reflects the number of categories for a diversity characteristic (ibid.). B can take a minimum value of 0 and a maximum value of (Agresti & Agresti, 1978). Gender diversity includes two categories: male and female. Age diversity is divided into four generational groups that differ regarding their opinions and behaviours: "The Silent Generation" (born between 1922 and 1945), "Baby Boomers" (born between 1946 and 1964), "Generation X" (born between 1965 and 1983), and "Generation Y" (born between 1984 and 2002) (Sullivan et al., 2009; Twenge et al., 2010). Therefore, the following age categories are: 15-33 years, 34-52 years, 53-71 years, and 72-95 years. When examining knowledge diversity at higher levels of corporate hierarchy, academic careers are considered the most frequently analysed variables (Midavaine et al., 2016; Belkacemi et al., 2021a; Wiersema & Bantel, 1992). In accordance with Midavaine et al. (2016) we distinguish between directors that have undergraduate, graduate, MBA and postgraduate degree as they differ according to how they handle problems in a rather abstract or practical way. A fifth category “others” is introduced to represent people without academic degrees. Following Khan et al. (2019) and Midavaine et al. (2016) experience diversity is represented by five board tenure categories that are taken over slightly modified. It is ensured that the third category which is situated in the middle, covers the period, in which the median and mean of the directors’ board tenures lies. Thus, the categories are ≤3 years, 4-6 years, 7-9 years, 10-12 years and >12 years. As board size represents the diversity between boards it is represented by the number of board members in 2017 and can directly be used as independent variable.

**3.4 | Control variables**

Mir-Babayev et al. (2017) and Marinova et al. (2016) showed that diversity effects on innovation and other performance outcomes can be influenced by further variables such as firm age. Also, the amount of annual assets (Zaman et al., 2023; Cumming & Leung, 2021) or annual revenues (De Lomana et al., 2019) could be responsible for impacts of board diversity on innovation. Thus, firm age in years, annual assets and annual revenues are considered as control variables for 2017.

Table 1 shows an overview of the variables, which hypothesis they relate to and how they are measured and represented.

**Table 1:** Definition of variables

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Diversity category** | **Variable** | **Hypothesis** | **Measurement** |  | **Label** |
|  | *Dependent variable* |  | (2018) |  | *DV* |
|  | Innovation performance |  | Innovation premium in percent. |  | IPt |
|  | *Independent variables* |  | (2017) |  | *IV* |
| Demographic diversity | Gender diversity | H1 | Blau’s index including following categories: male, female. |  | Blau\_Gendert-1 |
|  | Age diversity | H2 | Blau’s index including following categories: 15-33 years, 34-52 years, 53-71 years, 72-95 years. |  | Blau\_Aget-1 |
| Cognitive diversity | Knowledge diversity (Educational diversity) | H3 | Blau’s index including following categories: undergraduate, graduate, postgraduate, others. |  | Blau\_Educationt-1 |
|  | Experience diversity  (Tenure diversity) | H4 | Blau’s index including following categories: ≤ 3 years, 4-6 years, 7-9 years, 10-12 years, >12 years. |  | Blau\_Tenuret-1 |
| Structural diversity | Board size | H5 | Number of board mem-bers. |  | Board sizet-1 |
|  | *Control variables* |  | (2017) |  | *CV* |
|  | Firm age |  | Number of years passed since company for-mation. |  | Firm aget-1 |
|  | Assets |  | Annual assets in billion US$. |  | Assetst-1 |
|  | Revenue |  | Annual revenue in bil-lion US$. |  | Revenuet-1 |

To analyse the effect of board diversity, grouped into demographic diversity represented by gender and age, cognitive diversity represented by knowledge (education) and experience (board tenure) and structural diversity represented by board size on innovation performance the first estimation model (model 1) is formulated:

*IPt = β0t-1 + β1· Blau\_Gendert-1 + β2 · Blau\_Aget-1 +*   
*β3 · Blau\_Educationt-1 + β4 · Blau\_Tenuret-1 + β5· Board sizet-1*. (2)

The three control variables are gradually added depending on the Pearson correlation with the dependent variable. Thereby model 4 is expressed by the formula:

*IPt = β0t-1 + β1· Blau\_Gendert-1 + β2 · Blau\_Aget-1 +*   
*β3 · Blau\_Educationt-1 + β4 · Blau\_Tenuret-1 + β5· Board sizet-1*.

*+ β6 · Control1t-1 + β7 · Control2t-1 + β8 · Control3t-1*. (3)

Equations for model 2 -and 3 end after *β6 · Control1t-1* and *β7 · Control2t-1* respectively.

**4 | RESULTS**

**4.1 | Descriptive statistics and correlations matrix**

The descriptive statistics for independent variables and control variables are shown in Table 2. When examining the calculated Blau’s Index for gender diversity, ranging between 0 and 0.5, it becomes evident that the maximum extent is reached. The sample includes both companies with complete gender homogeneity and firms with an even male-female ratio on the board. The gender-related diversity mean of 0.3047 implies that two randomly selected individuals on the board have approximately a 30% probability of being of different genders. This value is high compared to other studies with a similar sample and measurement method. Belkacemi et al. (2021b), who analysed diversity data in 2016 from the 100 most innovative companies globally published by Forbes in 2017, found an average gender diversity of 0.2856. Midavaine et al. (2016) calculated a value of 0.2557 when looking at Fortune 500 companies for seven years. Miller and Triana (2009) who examined Fortune 500 companies in 2005, measured a value of 0.21.

In comparison to gender diversity, it appears that the analysed boards are less age diverse. As age diversity can take on values between 0 and 0.75, an average diversity of 0.3478 suggests low to medium diversity. The value indicates that, on average, most directors are in more similar categories, and they are unevenly distributed across the categories. Compared to the result of Midavaine et al. (2016) the value is low. The authors calculated an average Blau’s index of 0.7224 for age diversity. Since they measured age diversity in seven categories, and the value could potentially range from 0 to 0.8571, it is not directly comparable to the index of the present study. Nevertheless, the diversity index calculated here can be considered relatively low.

**Table 2:** Descriptive statistics

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *Minimum* | *Maximum* | *Mean* | *SD* | *Median* |
| *IV* |  |  |  |  |  |
| Blau\_Gendert-1 | 0.0000 | 0.5000 | 0.3047 | 0.1385 | 0.3457 |
| Blau\_Aget-1 | 0.0000 | 0.6531 | 0,3478 | 0.1787 | 0.3750 |
| Blau\_Educationt-1 | 0.0000 | 0.7812 | 0,6190 | 0.1231 | 0.6528 |
| Blau\_Tenuret-1 | 0.3200 | 0.7917 | 0,6783 | 0.0779 | 0.6990 |
| Board sizet-1 | 4.0000 | 30.0000 | 11,4444 | 3.7647 | 11.0000 |
| *CV* |  |  |  |  |  |
| Firm Aget-1 | 0.0000 | 231.0000 | 51.7407 | 50.5583 | 32.0000 |
| Assetst-1 | 0.1000 | 246.1000 | 26.0346 | 36.5965 | 15.1000 |
| Revenuet-1 | 0.1000 | 148.3000 | 16.7667 | 25.9427 | 8.2000 |
| *DP* |  |  |  |  |  |
| IPt | 34.9200 | 89.2200 | 48.3670 | 12.8555 | 43.1700 |

n = 81.

The potential value range, considering five diversity categories, encompasses a range from 0 to 0.8 for the diversity types educational and tenure diversity. With averages of 0.6190 and 0.6783, the two cognitive diversity types exhibit relatively high diversity rates. Regarding educational diversity, this trend is also evident in the study of Belkacemi et al. (2021a), who examined these diversity measures for 2016. They analysed educational diversity on the board based on three categories and found a value of 0.5139 with a maximum possible index of 0.6667. Regarding the diversity of directors' employment periods in the board, reference can again be made to the study by Midavaine et al. (2016), who, with a value of 0.7119 and the use of five categories, found a similarly high diversity rate as observed here. When comparing the diversity of experience diversity and knowledge diversity, it is evident that the boards in this sample are more diverse in terms of board employment periods (0.6783 > 0.6190). A notable aspect is the minimum value of board tenure diversity, which, at 0.3200, is clearly greater than 0. Thus, in the sample, there is no company whose board is not at least 32 percent diverse concerning the tenure of board members. No less than about one-third of directors are assigned to different board employment duration categories and are evenly distributed across the five categories.

The maximum board size of 30 board members appears to be high compared to other studies. For instance, Saibaba and Ansari (2012) found a maximum board size of 21 in their sample of companies listed in BSE-100. Similarly, Belkacemi et al. (2021a), identified a maximum of 15 members on the board. The differences can be explained by the fact that, in this study, members of the supervisory board are counted to the size if the company has a two-tier board structure, whereas in other works focusing on companies with board duality structure, only the executive board was considered. The average size of 11.4444 is close to the previously mentioned study by Belkacemi et al. (ibid), who determined an average board size of 11 members. Other research demonstrates that this value can vary significantly depending on the country. Torchia et al. (2011) examined Norwegian firms and found an average board size of 7.12. Kang et al. (2007), studying Australian boards, identified a value of 8.19.

When looking at the control variables firm age, assets, and revenues it becomes visible that respectively mean and median are relatively far apart. Additionally, the standard deviation is relatively high at 50.5583, 36.5965 and 25.9427. This implies that the data concerning these variables are widely dispersed, and there are outliers that significantly impact the mean (Kuckartz et al., 2010).

The innovation premium shows a range from 34.9200 to 89.2200 with a mean of 48.3670 which implies the data is distributed relatively evenly throughout the range of values. A broad coverage of the independent variable within a specific range may enhance internal validity.

Table 3 shows the Pearson correlations. It reveals a positive association between age diversity and innovation performance at 10 percent level significance level. In contrast, it is found that board size is significantly negatively correlated with innovation performance at one percent level. The positive association of firm age and innovation performance at five percent supports using company age in the multiple models for control purposes. Out of all control variables - although not significantly - assets exhibit the second strongest correlation with the dependent variable followed by revenue. This order effects the gradual development of regression models analysed in the following chapter. Furthermore, Pearson correlation coefficient of all explanatory variables is less than 0.8 indicating that there is no multicollinearity problem (Senaviratna & Cooray, 2019).

To examine the influence of each independent variable when interacting with the remaining predictor variables and to test the hypotheses in this context, the results of the multiple linear regressions are crucial. The next chapter will delve into this.

**Table 3:** Pearson correlation

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Blau\_Gendert-1 | Blau\_Aget-1 | Blau\_Education t-1 | Blau\_Tenure t-1 | Board size | Firm Age t-1 | Assets t-1 | Revenue t-1 | IP t |
|  |  |  |  |  |  |  |  |  |  |
| Blau\_Gendert-1 | 1 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Blau\_Aget-1 | 0.0122 | 1 |  |  |  |  |  |  |  |
|  | (0.9142) |  |  |  |  |  |  |  |  |
| Blau\_Educationt-1 | 0.3653\*\*\* | 0.2336\*\* | 1 |  |  |  |  |  |  |
|  | (0.0008) | (0.0358) |  |  |  |  |  |  |  |
| Blau\_Tenuret-1 | 0.0998 | -0.0301 | 0.0064 | 1 |  |  |  |  |  |
|  | (0.3754) | (0.7895) | (0.9544) |  |  |  |  |  |  |
| Board sizet-1 | 0.2294\*\* | 0.1375 | 0.2495\*\* | 0.1152 | 1 |  |  |  |  |
|  | (0.0393) | (0.2210) | (0.0247) | (0.3056) |  |  |  |  |  |
| Firm Aget-1 | 0.1940\* | -0.1926\* | 0.0002\*\*\* | 0.2845\*\* | 0.1684 | 1 |  |  |  |
|  | (0.0827) | (0.0850) | (0.0086) | (0.0101) | (0.1329) |  |  |  |  |
| Assetst-1 | 0.0996 | -0.1579 | 0.1788 | -0.0182 | 0.4653\*\*\* | 0.0214 | 1 |  |  |
|  | (0.3763) | (0.1591) | (0.1102) | (0.8717) | (<0.001) | (0.8497) |  |  |  |
| Revenuet-1 | 0.2703\*\* | -0.2362\*\* | 0.1730 | 0.0686 | 0.1681 | 0.0567 | 0.5877\*\*\* | 1 |  |
|  | (0.0147) | (0.0338) | (0.1225) | (0.5429) | (0.1335) | (0.6151) | (<0.001) |  |  |
| IPt | -0.1715 | 0.2105\* | -0.0113 | 0.0264 | -0.3161\*\*\* | -0.2458\*\* | -0.1111 | 0.0224 | 1 |
|  | (-0.1258) | (0.0593) | (0.9203) | (0.8151) | (0.0040) | (0.0270) | (0.3232) | (0.8424) |  |

n = 81.

Significance at α = \*\*\*1%, \*\*5% and \*10%.

() associated p values.

**4.2 | Discussion**

In Table 4 the regression results for the four models are shown. Model 1 demonstrates the influence of demographic, cognitive, and structural diversity factors on innovation performance. The models 2 to 4 incrementally include control variables based on their correlation strength with the dependent variable from Pearson correlations. Thus, model 2 additionally includes firm age, model 3 also involves assets and model 4 moreover revenues.

The findings of models 1 to 4 don’t reveal a significant impact of gender diversity on innovation performance, thus not confirming hypothesis 1. The results contradict the positive effect reported in the relevant literature (Miller & Triana, 2009; Griffin et al., 2021; Belkacemi et al., 2021b; Chen et al., 2018). The findings can’t confirm that a board benefits from gender differences regarding factors such as people orientation, confidence, risk-taking and time perspective in favour of innovation performance. Also, an innovation-promoting improvement in decision-making based on the Upper Echelons Theory (Miller & Triana, 2009) is rejected. Instead, a critical mass of women on boards may explain the result since Torchia et al. (2011) demonstrated that decision-making processes can only be improved in favour of innovation when at least three board members are female.

In comparison to gender diversity the findings of our four models show a significant influence of age diversity in boards on corporate innovation performance. This confirms hypothesis 2 and is in line with Galia and Zenou’s (2012) finding regarding product innovation. It validates the assumption that age diversity influences learning and development in the development in the board and thus supports creative and innovative ideas (Walt & Ingley, 2003). Furthermore, it provides evidence for the postulation that customers’ interests in different age categories can be considered in the decision-making process and innovation in the sense of a broader range of products and services is enabled (ibid.; Kang et al., 2007). The hindrance of board collaboration

**Tab. 4:** Results from multiple linear regressions

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | |  |  |  |
| *Model* | | | | | |
|  |  | |  |  |  |
| *Variables* | Model 1 | | Model 2 | Model 3 | Model 4 |
|  |  | |  |  |  |
| Blau\_Gendert-1 | -0.1266 | | -0.1004 | -0.0963 | -0.1355 |
|  | (0.2715) | | (0.3842) | (0.4048) | (0.2573) |
| Blau\_Aget-1 | 0.2476\*\* | | 0.2150\* | 0.2461\*\* | 0.2689\*\* |
|  | (0.0249) | | (0.0535) | (0.036) | (0.0231) |
| Blau\_Educationt-1 | 0.0631 | | 0.0550 | 0.0401 | 0.0309 |
|  | (0.5914) | | (0.6377) | (0.7339) | (0.7929) |
| Blau\_Tenuret-1 | 0.0860 | | 0.1272 | 0.1333 | 0.1198 |
|  | (0.4171) | | (0.2439) | (0.2235) | (0.2741) |
| Board sizet-1 | -0.3468\*\*\* | | -0.3230\*\*\* | -0.3792\*\*\* | -0.3495\*\*\* |
|  | (0.0023) | | (0.0046) | (0.0038) | (0.0081) |
| Firm aget-1 |  | | -0.1667 | -0.1562 | -0.1529 |
|  |  | | (0.1444) | (0.1738) | (0.1814) |
| Assetst-1 |  | |  | 0.0796 | 0.0040 |
|  |  | |  | (0.3656) | (0.9702) |
| Revenuest-1 |  | |  |  | 0.1732 |
|  |  | |  |  | (0.2127) |
| *Model characteristics* |  | |  |  |  |
|  |  | |  |  |  |
| R | 0.4301 | | 0.4564 | 0.4660 | 0.4837 |
| R2 | 0.1850 | | 0.2083 | 0.2172 | 0.2340 |
| Adj. R2 | 0.1307 | | 0.1441 | 0.1421 | 0.1489 |
| F | 3.4050\*\*\* | | 3.2448\*\*\* | 2.8933\*\*\* | 2.7493\*\*\* |
| F crit. | 0.0079 | | 0.0069 | 0.0100 | 0.0100 |
|  |  | |  |  |  |
|  |  | |  |  |  |
| n = 81.  Significance at α = \*\*\*1%, \*\*5%, \*10%.  Standardized coefficients.  () associated p values. | |  |  |  |  |

and organizational change due to an age discriminating climate or generational conflicts resulting from diversity (Kunze et al., 2011; Galia & Zenou, 2012) does not become evident here. Instead, our comparably low age diversity level is in line with Bantel and Jackson (1989) who stated that such negative effects only appear at very high levels of diversity.

Our findings don’t reveal a significant impact of knowledge diversity measured by the diversity of academic degrees on corporate innovation performance and therefore, aren’t able to confirm hypothesis 3. This result is in contradiction to Midavaine et al. (2016) who found a positive influence of educational diversity on a firm’s innovative capabilities. Also, the assumption that differently educated board members bring divergent knowledge and cognitive abilities to the board that are favourable for decision-making towards innovation (Wiersema & Bantel, 1992; Midavaine et al., 2016) can’t be supported quantitatively. It was suggested that people with high educational degrees are more willing to take risks and thus are more open to investing in R&D and people with lower degrees bring more pragmatic views to the board (Midavaine et al., 2016). The expectation that this mixture would promote innovation (ibid.) isn’t confirmed through our findings. Our result is also in contrast with Wincent et al. (2010) who found a positive relationship between educational diversity within a board and innovation performance of strategic networks. The assumption that different age groups within a board can enable a company to strengthen cooperation capabilities by addressing different skills of managers at partner companies to the advantage of improved innovation can’t be supported. Instead, our findings are in line with Belkacemi et al. (2021a) who didn’t find a significant association between knowledge diversity and innovation performance and argued that it could be advantageous to focus on the degree program instead if the different levels of education.

Hypothesis 4 that suggested a positive effect of experience diversity measured by board tenure diversity on innovation performance is not supported. This is in contrast to Midavaine et al. (2016) who identified a negative relationship between board tenure diversity and R&D expenditures and argued that the reluctance of long-serving directors to innovate and their high level of influence hampers innovation. Furthermore, the findings contrast the results regarding innovation outputs of Sierra-Morán et al. (2021) and R&D expenditures of Munir et al. (2020) who respectively revealed a positive impact of tenure-diverse boards. The assumption that a mixture of directors with different tenures improves the efficiency of boards (e.g., through more intense monitoring, higher independence of directors) and thus enables firms to meet their innovation goals (ibid.; Christensen & Knudsen, 2008) can’t be supported. Instead, the findings align with Wiersema and Bantel (1992) who couldn’t find a significant association of tenure heterogeneity of top managers and the likelihood that the management team will change the corporate strategy and argued that positive diversity contributions to decision-making may be more likely to show its effects on lower levels than top management.

Hypothesis 5 is rejected within our analysis. All four models show a significantly negative influence of board size on corporate innovation performance, the opposite of what was expected. The results contradict the findings of a positive correlation reported by Chen et al. (2015) and Sierra-Morán et al. (2021) regarding innovation outputs. Consequently, arguments supporting improved innovation performance are to be disproved. The board does not seem to benefit from increased resources, knowledge, and information sources, as well as improved decision-making (ibid.). The assumption that larger boards are better at identifying flawed projects and self-serving behaviour of managers (Wincent et al., 2013) is not supported by the results. Furthermore, it cannot be argued that larger boards are more capable of building relationships with the external business environment (Zahra, 2000). Instead, the results align with Goodstein et al. (1994) and the findings regarding the impacts on innovation inputs by Sierra-Morán et al. (2021) indicating that the decision-making process in larger boards is slowed down at the expense of innovation performance, and such boards lose their responsiveness to environmental changes (Goodstein et al., 1994). Additionally, the assumptions that agency problems are more prevalent in larger boards (Jensen, 1993) and coordination and communication problems become more evident (Cheng, 2008) are supported. As indicated by the descriptive analysis, the average board size in this study is relatively high. Therefore, it seems unsurprising that the challenges of large boards manifest at the expense of innovation performance.

The confirmation or rejection of our hypotheses through multiple linear regressions is integrated into the conceptual model and illustrated in Figure 2.

**X**

**X**

**X**

**✓**

**X**

Demographic board diversity

Cognitive board diversity

Structural board diversity

Gender diversity

Age diversity

Knowledge diversity (educational diversity)

Experience diversity (tenure diversity)

Board size

H1: +

H2: +

H3: +

H4: +

H5: +

Innovation performance

+ positive correlation.

- negative correlation.

**✓**

Hypothesis confirmed.

**X**

Hypothesis declined.

**Fig. 2:** Integration of regression results into the conceptual model.

**5 | CONCLUSION**

Our study offers new insights to the optimal constitution of boards, specifically addressing the question of board diversity and its relation to corporate innovation performance. We respond to demands to abstain from treating board diversity in a one-dimensional construct by taking multiple forms of diversity and various diversity categories into account and by analysing their respective effects (Huse, 2007; Galia & Zenou, 2012; Griffin et al., 2021). In addition to more commonly examined demographic characteristics, less evident cognitive diversity features were considered (Hillman et al., 2000), and structural characteristics were also included (Hafsi & Turgut, 2013). Instead of analysing diversity influences on corporate performance, the focus of this work was on the impact on corporate innovation performance. By using multiple linear regression analysis, the influences of individual diversity variables on innovation performance were identified and compared, while simultaneously considering the other diversity variables included in the statistical analysis. The one-year lag period between independent variables and the dependent variable, along with the use of three control variables, contributed to reducing endogeneity issues and ensuring the robustness of the models. It is thus recommended for future studies. The comparison of diversity factors leads to the conclusion that board size is the most significant factor for innovation performance. However, there is also a relationship between age diversity and innovation performance, though statistically less pronounced than with board size. The other diversity variables were as insignificant regarding their impact on innovation performance, which opens the door to test our model in different samples.

Building on Upper Echelons theory, we attribute the positive correlation between age diversity and corporate innovation performance to the characteristics of board members in different age groups (e.g. risk preference, human capital and social capital). The comparably low diversity level suggests that diversity caused conflicts are less apparent. Expanding upon previous research on group dynamics we assume that the negative association between board size and innovation performance can be explained by discrepancies arising from the very high number of different viewpoints that decelerate decision-making. In general, the patterns suggested by Upper Echelons theory and group theory partially still hold true across our analysis and thus showcase their strength. This leads us to the conclusion that board research and particularly diversity research on boards may still benefit from this theoretical lens.

The results of the study lead to two conclusions for the composition of boards in practice. Firstly, it seems appropriate to keep the board size moderate. A smaller board is advantageous for innovation performance. Secondly, an age-diverse board has a positive impact on corporate innovation performance. Therefore, when appointing board members, attention should be paid to different age groups.

The main limitation of our study is a result of the sample data, which is restricted to the most innovative companies. We acknowledge the presence of selection bias in our sample, as our data collection focused on a specific subset of companies, potentially impacting the generalizability of our findings to less innovative companies. However, our study provides valuable insights within the defined scope and leaves room for generalizations to less innovative companies in further studies.

Additionally, the absolute number of female board members is not evident from the diversity degree measured using the Blau’s index. Consequently, it seems advantageous to consider the number of female board members in addition to the Blau’s index when examining the influences of gender diversity.

Furthermore, linear regression analysis is subject to methodological limitations that must be considered when evaluating empirical statements. One limitation is that linear regression maps linear trends of data in the positive or negative direction and, therefore, does not allow for a detailed analysis of where changes in direction may occur (Hope, 2020). It could be the case that an overall positive linear relationship was observed, but negative correlations may dominate in specific value ranges. Such aspects can only be identified by applying more complex regression models in further studies.

Another limitation of the regression models used here is the absence of moderating variables. The relevance of considering such variables when examining the relationship between board diversity and innovations was emphasized by Midavaine et al. (2016). It is possible that a variable determines the interaction between two other variables. For example, in the present study, a positive relationship was found between age diversity and innovation performance, while no relationship was found between knowledge diversity and innovation performance. Nevertheless, it seems plausible that knowledge diversity could be responsible for the positive connection, as different age groups usually have different levels of knowledge. The correlation analysis would benefit from examining such moderation effects in future analyses. This could provide a more detailed assessment of the interplay between diversity variables and their influences on innovation performance.

Overall, more fine-grained analyses of diversity influences may result in a clearer picture of diversity impacts on boards. Future studies should assess various diversity factors on other performance outcomes such as sustainability performance or the success of international diversification strategies, as well as effects of inter-firm relationships.

**6 | REFERENCE LIST**

Abdallah, W., Goergen, M. & O'Sullivan, N. (2015). Endogeneity: How failure to correct for it can cause wrong inferences and some remedies. *British Journal of Management, 26*(4), 791–804. https://doi.org/10.1111/ 1467-8551.12113.

Adams, R. B. & Ferreira, D. (2007). A theory of friendly boards. *The Journal of Finance, 62*(1), 217–250. https://doi.org/10.1111/j.1540-6261. 2007.01206.x.

Aghion, P., Van Reenen, J. & Zingales, L. (2013). Innovation and institutional ownership. *American Economic Review, 103*(1), 277–304. <https://doi.org/10.1257/aer.103.1.277>.

Agresti, A. & Agresti, B. F. (1978). Statistical analysis of qualitative variation. *Sociological Methodology, 9*, 204–237. https://doi.org/10.2307/ 270810.

Allemand, I., Bédard, J., Brullebaut, B., & Deschênes, J. (2022). Role of old boys’ networks and regulatory approaches in selection processes for female directors. *British Journal of Management, 33*(2), 784-805. <https://doi.org/10.1111/1467-8551.12485>.

Ariff, A. M., Salleh, Z., Noor, M. N. H. M., Mohamad, N. R., & Ismail, N. (2017). Board diversity and innovation performance in Malaysia. *International Journal of Business Governance and Ethics*, *12*(3), 241-261. <https://doi.org/10.1504/IJBGE.2017.088247>.

Atallah, G., De Fuentes, C. & Panasian, C. A. (2021). Ownership, compensation and board diversity as innovation drivers: A comparison of U.S. and Canadian firms. *International Journal of Innovation Management, 25*(3), 1–43. <https://doi.org/10.1142/S1363919621500250>.

Bantel, K. A. & Jackson, S. E. (1989). Top management and innovations in banking: Does the composition of the top team make a difference? *Strategic Management Journal, 10*(1), 107–124. https://doi.org/10.1002/ smj.4250100709.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120. https://doi.org/10.1177/ 014920639101700108.

Belkacemi, R., Bouzinab, K. & Papadopoulos, A. (2021a). A cognitive approach to diversity: Investigating the impact of board of directors’ educational and functional heterogeneity on innovation performance. *International Journal of Business and Management, 16*(2), 1–20. https:// doi.org/10.5539/ijbm.v16n2p1.

Belkacemi, R., Papadopoulos, A. & Bouzinab, K. (2021b). Board of directors’ surface level diversity and innovation performance. *Journal of Leadership, Accountability and Ethics, 18*(2), 131–151. https:// doi.org/10.33423/jlae.v18i2.4260.

Blau, P. M. (1977). *Inequality and heterogeneity: A primitive theory of social structure.* New York. Free Press.

Carter, D. A., D'Souza, F., Simkins, B. J. & Simpson, W. G. (2010). The gender and ethnic diversity of US boards and board committees and firm financial performance. *Corporate Governance: An International Review, 18*(5), 396–414. https://doi.org/10.1111/j.1467-8683.2010.00809.x.

Carter, D. A., Simkins, B. J. & Simpson, W. G (2003). Corporate governance, board diversity, and firm value. *The Financial Review, 38*(1), 33–53. <https://doi.org/10.1111/1540-6288.00034>.

Chen, J., Leung, W. S. & Evans, K. P. (2018). Female board representation, corporate innovation and firm performance. *Journal of Empirical Finance, 48*, 236–254. <https://doi.org/10.1016/j.jempfin.2018.07.003>.

Chen, S., Bu, M., Wu, S., & Liang, X. (2015). How does TMT attention to innovation of Chinese firms influence firm innovation activities? A study on the moderating role of corporate governance. *Journal of Business Research*, *68*(5), 1127-1135. <https://doi.org/10.1016/j.jbusres>.

Christensen, M. & Knudsen, T. (2008). Entry and exit decisions in flexible teams. *Journal of International Business Studies, 39*(8), 1278–1292. <https://doi.org/10.1057/palgrave.jibs.8400413>.

Cumming, D. & Leung, T. Y. (2021). Board diversity and corporate innovation: Regional demographics and industry context. *Corporate Governance: An International Review, 29*(3), 277–296. <https://doi.org/10.1111/corg.12365>.

De Lomana, G. G., Strese, S., & Brinckmann, J. (2019). Adjusting to the digital age: The effects of TMT characteristics on the digital orientation of firms. *Academy of Management Proceedings, 2019*, 13589. https://doi.org/10.5465/AMBPP.2019.13589abstract.

Del Mar Fuentes-Fuentes, M., Quintana-García, C., Marchante-Lara, M., & Benavides-Chicón, C. G. (2023). Gender diversity, inclusive innovation and firm performance. *Sustainable Development*, *31*(5), 3622-3638. https://doi.org/10.1002/sd.2615.

Forbes (Ed.) (2018). *The world's most innovative companies.* Retrieved from https://www.forbes.com/innovative-companies/list/#tab:rank (Accessed December 1, 2023).

Galia, F. & Zenou, E. (2012). Board composition and forms of innovation: Does diversity make a difference? *European Journal of International Management, 6*(6), 630–650. https://doi.org/10.1504/EJIM. 2012.050425.

Goodstein, J., Gautam, K. & Boeker, W. (1994). The effects of board size and diversity on strategic change. *Strategic Management Journal, 15*(3), 241–250. <https://doi.org/10.1002/smj.4250150305>.

Griffin, D., Li, K. & Xu, T. (2021). Board gender diversity and corporate Innovation: International evidence. *Journal of Financial and Quantitative Analysis, 56*(1), 123–154. <https://doi.org/10.1017/S002210901900098X>.

Hafsi, T. & Turgut, G. (2013). Boardroom diversity and its effect on social performance: Conceptualization and empirical evidence. *Journal of Business Ethics, 112*(3), 463–479. <https://doi.org/10.1007/s10551-012-1272-z>.

Hall, B. H., Jaffee, A. & Trajtenberg, M. (2005). Market value and patent citations. *The RAND Journal of Economics, 36*(1), 16–38.

Hambrick, D. C. & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review 9*(2), 193–206. <https://doi.org/10.2307/258434>.

Hambrick, D. C. (2007). Upper echelons theory: An update. *Academy of Management Review, 32*(2), 334–343. https://doi.org/10.5465/amr. 2007.24345254.

Hambrick, D. C., Humphrey, S. E. & Gupta, A. (2015). Structural interdependence within top management teams: A key moderator of upper echelons predictions. *Strategic Management Journal, 36*(3), 449–461. <https://doi.org/10.1002/smj.2230>.

Harjoto, M. A., Laksmana, I. & Yang, Y. W. (2018). Board diversity and corporate investment oversight. *Journal of Business Research 90*, 40–47. [https://doi.org/10.1016/j.jbusres.  
2018.04.033](https://doi.org/10.1016/j.jbusres.2018.04.033).

Harrison, D. A. & Klein, K. J. (2007). What's the difference? Diversity constructs as separation, variety, or disparity in organizations. *Academy of Management Review, 32* (4), 1199–1228. https://doi.org/10.5465/ amr.2007.26586096.

Harrison, D. A., Price, K. H. & Bell, M. P. (1998). Beyond relational demography: Time and the effects of surface- and deep-level diversity on work group cohesion. *Academy of Management Journal, 41*(1), 96–107. <https://doi.org/10.5465/256901>.

Hillman, A. J., Cannella, A. A. & Paetzold, R. L. (2000). The resource dependence role of corporate directors: Strategic adaptation of board composition in response to environmental change. *Journal of Management Studies, 37*(2), 235–256. <https://doi.org/10.1111/1467-6486.00179>.

Hitt, M. A., Hoskisson, R. E., Johnson, R. A. & Moesel, D. D. (2017). *The Market for Corporate Control and Firm Innovation, 39*(5), 1084–1119.

Hope, T. M. H. (2020). Linear regression. In: *Mechelli, A. & Vieira, S.* (Eds.), *Machine Learning. Methods and applications to brain disorders* (67–81). Cambridge. Academic Press.

Hülsheger, U. R., Anderson, N. & Salgado, J. F. (2009). Team-level predictors of innovation at work: A comprehensive meta-analysis spanning three decades of research. *The Journal of Applied Psychology, 94*(5), 1128–1145. <https://doi.org/10.1037/a0015978>.

Huse, M. & Solberg, A. G. (2006). Gender‐related boardroom dynamics. *Women in Management Review,* *21*(2), 113–130. https://doi.org/ 10.1108/09649420610650693.

Huse, M. (2007). *Boards, governance and value creation: The human side of corporate governance.* Cambridge. Cambridge University Press.

Jackson, S. E., May, K. E. & Whitney, K. (1995). Understanding the dynamics of diversity in decision-making teams. In: *Guzzo, R. A. & Salas, E.* (Eds.). *Team effectiveness and decision making in organizations* (204–261). San Francisco. Jossey-Bass.

Janahi, M., Millo, Y. & Voulgaris, G. (2022). Age diversity and the monitoring role of corporate boards: Evidence from banks. *Human Relations*, 1–35. <https://doi.org/10.1177/00187267221108729>.

Jensen, M. C. (1993). The modern industrial revolution, exit, and the failure of internal control systems. *The Journal of Finance, 48*(3), 831–880. <https://doi.org/10.1111/j.1540-6261.1993.tb04022.x>.

Kang, H., Cheng, M. & Gray, S. J. (2007). Corporate governance and board composition: Diversity and independence of Australian boards. *Corporate Governance: An International Review, 15*(2), 194–207. <https://doi.org/10.1111/j.1467-8683.2007.00554.x>.

Kanter, Rosabeth Moss (1977). *Men and women of the organization*. New York, Basic Books.

Katz, R. (1982). The effects of group longevity on project communication and performance. *Administrative Science Quarterly, 27*(1), 81–104. <https://doi.org/10.2307/2392547>.

Khan, I., Khan, I. & Senturk, I. (2019). Board diversity and quality of CSR disclosure: Evidence from Pakistan. *Corporate Governance: The International Journal of Business in Society, 19*(6), 1187–1203. <https://doi.org/10.1108/CG-12-2018-0371>.

Kimberly, J. R. & Evanisko, M. J. (1981). Organizational innovation: The influence of individual, organizational, and contextual factors on hospital adoption of technological and administrative innovations. *Academy of Management Journal, 24*(4), 689–713. <https://doi.org/10.2307/256170>.

Kuckartz, U., Rädiker, S., Ebert, T. & Schehl, J. (2010). Means and measures of dispersion. In: *Kuckartz, U., Rädiker, S., Ebert, T. & Schehl, J.* (Eds.). *Statistics* (57–80)*.* Wiesbaden. Springer.

Kunze, F., Boehm, S. A. & Bruch, H. (2011). Age diversity, age discrimination climate and performance consequences - A cross organizational study. *Journal of Organizational Behavior, 3*(2), 264–290. <https://doi.org/10.1002/job.698>.

Lakhal, F., Hamrouni, A., Jilani, I., Mahjoub, I., & Benkraiem, R. (2024). The power of inclusion: Does leadership gender diversity promote corporate and green innovation? *Research in International Business and Finance*, *67*, https://doi.org/10.1016/j.ribaf.2023.102128.

Li, N. & Wahid, A. S. (2018). Director tenure diversity and board monitoring effectiveness. *Contemporary Accounting Research, 35*(3), 1363–1394. <https://doi.org/10.1111/1911-3846.12332>.

Li, Y. & He, C. (2021). Board diversity and corporate innovation: Evidence from Chinese listed firms. *International Journal of Finance & Economics*, 1–24. https://doi.org/10.1002/ijfe.2465.

Makkonen, T. (2022). Board diversity and firm innovation: A meta-analysis. *European Journal of Innovation Management, 25*(6), 941-960. <https://doi.org/10.1108/EJIM-09-2021-0474>.

Marinova, J., Plantenga, J. & Remery, C. (2016). Gender diversity and firm performance: Evidence from Dutch and Danish boardrooms. *The International Journal of Human Resource Management, 27*(15), 1777–1790. <https://doi.org/10.1080/09585192.2015.1079229>.

Midavaine, J., Dolfsma, W. & Aalbers, Rick (2016). Board diversity and R & D investment. *Management Decision, 54*(3), 558–569. <https://doi.org/10.1108/MD-09-2014-0574>.

Miller, T. & Triana, M. C. (2009). Demographic diversity in the boardroom: Mediators of the board diversity-firm performance relationship. *Journal of Management Studies, 46*(5), 755–786. <https://doi.org/10.1111/j.1467-6486.2009.00839.x>.

Mintzberg, H., Raisinghani, D. & Theoret, A. (1976). The structure of "unstructured" decision processes. *Administrative Science Quarterly, 21*(2), 246–275. <https://doi.org/10.2307/2392045>.

Mir-Babayev, R., Gulaliyev, M., Shikhaliyeva, S., Azizova, R., & Ok, N. (2017). The impact of cultural diversity on innovation performance: Evidence from construction industry of Azerbaijan. *Economics & Sociology, 10*(1), 78. <https://doi.org/10.14254/2071-789X.2017/10-1/6>.

Moenaert, R. K., Robben, H., Antioco, M., De Schamphelaere, V. & Roks, E. (2010). Strategic innovation decisions: What you foresee is not what you get*. Journal of Product Innovation Management, 27*(6), 840–855. <https://doi.org/10.1111/j.1540-5885.2010.00755.x>.

Mohnen, P., Hall, B. H. (2013). Innovation and productivity: An up-date. *Eurasian Business Review, 3*(1), 47–65. https://doi.org/10.14208/ BF03353817.

Munir, S. A., Rangel, G. J., Subramaniam, R. K. & Mustapha, M. (2020). Do heterogeneous boards promote firm innovation? Evidence from Malaysia. *Capital Markets Review, 28*(1), 25–47.

Na, K. & Shin, K. (2019). The gender effect on a firm’s innovative activities in the emerging economies. *Sustainability, 11*(7), 1–24. <https://doi.org/10.3390/su11071992>.

Nakano, M., & Nguyen, P. (2012). Board size and corporate risk taking: Further evidence from Japan. *Corporate Governance: An International Review, 20*(4), 369-387. <https://doi.org/10.1111/j.1467-8683.2012.00924.x>.

Østergaard, C. R., Timmermans, B., & Kristinsson, K. (2011). Does a different view create something new? The effect of employee diversity on innovation. *Research policy*, *40*(3), 500–509.

O'Sullivan, D. & Dooley, L. (2008): *Applying innovation.* SAGE publications.

Rejeb, W. B., Berraies, S. & Talbi, D. (2020). The contribution of board of directors’ roles to ambidextrous innovation: Do board’s gender diversity and independence matter? *European Journal of Innovation Management, 23*(1), 40–66. <https://doi.org/10.1108/EJIM-06-2018-01>.

Robeson, D. & O'Connor, G. C. (2013). Boards of directors, innovation, and performance: An exploration at multiple levels. *Journal of Product Innovation Management, 30*(4), 608–625. https://doi.org/10.1111/ jpim.12018.

Saibaba, M. D. & Ansari, V. A. (2012). Impact of board size: An empirical study of companies listed in BSE 100 index. *Indian Journal of Corporate Governance, 5*(2), 108–119. https://doi.org/10.1177/ 0974686220120202.

Senaviratna, N. & Cooray, T. (2019). Diagnosing multicollinearity of logistic regression model. *Asian Journal of Probability and Statistics, 5*(2), 1–9.

Siciliano, J. I. (1996). The relationship of board member diversity to organizational performance. *Journal of Business Ethics, 15*(12), 1313–1320. [https://doi.org/10.1007/  
BF00411816](https://doi.org/10.1007/BF00411816).

Sierra-Morán, J., Cabeza-García, L., González-Álvarez, N. & Botella, J. (2021). The board of directors and firm innovation: A meta-analytical review. *BRQ Business Research Quarterly,* 1-26. https://doi.org/ 10.1177/23409444211039856.

Storsul, T. & Krumsvik, A. H. (2013). *Media innovations. A multidisciplinary study of change*. Göteborg, Nordicom.

Torchia, M., Calabrò, A. & Huse, M. (2011). Women directors on corporate boards: From tokenism to critical mass. *Journal of Business Ethics, 102*(2), 299–317. <https://doi.org/10.1007/s10551-011-0815-z>.

Valenti, A./Horner, S. (2020). The human capital of boards of directors and innovation: An empirical examination of the pharmaceutical industry. *International Journal of Innovation Management, 24* (06), 1–32. <https://doi.org/10.1142/S1363919620500565>.

Walt, N. & Ingley, C. (2003). Board dynamics and the influence of professional background, gender and ethnic diversity of directors. *Corporate Governance: An International Review, 11*(3), 218–234. https://doi.org/ 10.1111/1467-8683.00320#.

Wiersema, M. F. & Bantel, K. A. (1992). Top management team demography and corporate strategic change. *Academy of Management Journal, 35*(1), 91–121. [https://doi.org/10.2307/  
256474](https://doi.org/10.2307/256474).

Wincent, J., Anokhin, S. & Örtqvist, D. (2010). Does network board capital matter? A study of innovative performance in strategic SME networks. *Journal of Business Research, 63*(3), 265–275. https://doi.org/ 10.1016/j.jbusres.2009.03.012.

Wincent, J., Anokhin, S. & Örtqvist, D. (2013). Supporting innovation in government-sponsored networks: The role of network board composition. International Small Business Journal: Researching *Entrepreneurship, 31*(8), 997–1020. [https://doi.org/10.1177/  
0266242612447970](https://doi.org/10.1177/0266242612447970).

Wright, C., Cortese, C., Al‐Mamun, A., & Ali, S. (2023). Interrogating diversity: Feminism and the destructuration of Australian board appointment practices. *Corporate Governance: An International Review*. <https://doi.org/10.1111/corg.12559>.

Zahra, S. A. (1996). Goverance, ownership, and corporate entrepreneurship: The moderating impact of industry technological opportunities. *Academy of Management Journal, 39*(6), 1713–1735. https://doi.org/ 10.2307/257076.

Zahra, S. A., Neubaum, D. O./Huse, M. (2000). Entrepreneurship in medium-size companies: Exploring the effects of ownership and governance systems. *Journal of Management, 26*(5), 947–976. <https://doi.org/10.1016/S0149-2063(00)00064-7>.

Zajac, E. J., Golden, B. R. & Shortell, S. M. (1991). New organizational forms for enhancing innovation: The case of internal corporate joint ventures. *Management Science, 37*(2), 170–184. https://doi.org/ 10.1287/mnsc.37.2.170.

Zaman, R., Asiaei, K., Nadeem, M., Malik, I. & Arif, M. (2023). Board demographic, structural diversity, and eco-innovation: International evidence. *Corporate Governance: An International Review.* <https://doi.org/10.1111/corg.12545>.