How board gender and knowledge-based diversity influence firm process innovation

Article

Accepted Version

HOW BOARD GENDER AND KNOWLEDGE-BASED DIVERSITY INFLUENCE FIRM PROCESS INNOVATION

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ABSTRACT

The paper aims to concurrently examine effects of knowledge-based diversity and gender diversity on firm process innovation. It also investigates board chairpersons' gender effect on these relationships using the categorization–elaboration model (CEM). The paper benefits from the survey method and applies structural equation modeling (SEM) to examine responses of 462 CEOs of publicly listed firms and private firms. We find that knowledge-based diversity has a more substantial impact on process innovation than gender diversity. Meanwhile, it is more likely for female board chairpersons to utilize gender diversity to improve firm process innovation. For male chairpersons, they are more likely to use knowledge-based diversity to improve process innovation. The finding suggests that social categorization processes based on gender matter to some extent. Practitioners should pay particular attention to the skills and quality makeup of boards while being cognizant of the varied support to gender diversity between female and male chairpersons.

INTRODUCTION

Research shows that board gender diversity enhances firm innovation outcomes (Torchia et al., 2018). Board gender diversity is measured by a composition degree between male and female directors. Researchers also show that the knowledge-based diversity of a board can also improve firm innovation. Knowledge-based diversity is measured by the variety in directors' educational background, functional background, and industry experience (Forbes & Milliken, 1999). Independently, both diversities exert a desirable impact on innovation. Together, their implications are, however, seldom explored. The fruitfulness of examining multiple dimensions of group diversity underlies our research interests (e.g., Guillaume et al., 2017; Homan et al., 2007). We intend to investigate how board gender diversity and knowledge-based diversity affect firm process innovation.

Firm process innovation is one critical innovation outcome (Crossan & Apaydin, 2010; Galia & Zenou, 2012), which influences a firm's product innovation (Martinez-Ros, 2000) and overall firm performance (Adner & Levinthal, 2001). Process innovation describes the

introduction of new process technologies that may comprise changes to the production process and adaptations of modern management practices to achieve lower costs and higher quality (Adner & Levinthal, 2001; Reichstein & Salter, 2006). For example, a lean production method is process innovation, involving new material-processing technologies, task designs, and management practices (Reichstein & Salter, 2006). It is reasonable to expect that board knowledge-based diversity and gender diversity can improve firm process innovation. However, the effects become complicated through a social categorization lens when there are distinctions between subgroups of "we vs. they" and "in-group vs. out-group" due to diversity (We apply a categorization–elaboration model (CEM) to understand the boardroom's social categorization effect. The CEM suggests that some demographic variables, such as gender, can create separation between males and females, leading to conflicts between subgroups and ultimately slowing down creative solutions in a group (Van Knippenberg et al., 2004; Van Knippenberg & Schippers, 2007). Unless certain conditions/mechanisms are in place, women directors' diverse talent may not be fully realized due to the negative consequences of social categorization processes (Eagly, 2016; Harrison & Klein, 2007; Kanadlı et al., 2018a).

The CEM also emphasizes contingency factors that can reduce the separation effect by facilitating information elaboration (Van Knippenberg et al., 2004). Board leadership is one such factor that promotes the use of directors' diverse talent and reduces the adverse effects of social categorization (Åberg & Shen, 2020; Guerrero et al., 2015; Kakabadse et al. 2015; Kanadlı et al., 2018a). The chairperson's gender is particularly interesting in this regard, which may influence the board leadership style. For example, a female chairperson might be more aware of and sensitive to the social categorization processes (Eagly, 2007; Huse & Solberg, 2006; Kakabadse et al., 2015). She might put more emphasis than a male chairperson on managing social categorization by acting as a mentor and helping women minorities fit into male-dominated boardrooms (Eagly, 2007; Huse & Solberg, 2006; Kakabadse et al., 2015). Hence, chairperson gender presents an interesting opportunity in understanding the leadership style. We present our research model in Figure 1.

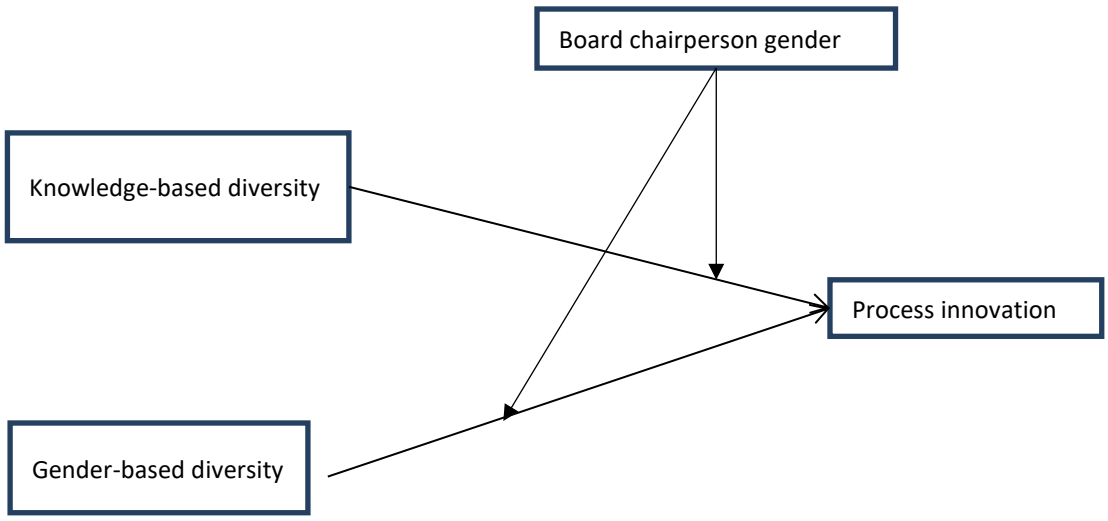

FIGURE 1. RESEARCH MODEL

The contribution of this study is three-fold. First, we introduce CEM as a novel approach to board diversity research by drawing scholarly attention to the interaction between social categorization processes and the use of directors' knowledge and skills. Contrary to the

argument that knowledge-based and gender-based diversity both have favorable influences on strategic decisions (Page, 2007), we hypothesize and demonstrate the two types of diversities can elicit different effects on process innovation. As a result, our study echoes the multifaced nature of board diversity (Harrison & Klein, 2007; Milliken & Martins, 1996). Second, the paper contributes to the field of board leadership research. A growing body of research has acknowledged the importance of board leadership on the utilization of diversity potential (e.g., Eagly, 2016; Gabrielsson et al., 2007; Guerrero et al., 2015; Kakabadse et al. 2015; Kanadlı et al., 2018a; Pugliese et al., 2015). We confirm the fruitfulness of this line of research by extending the analysis towards the gender of board chairpersons (Eagly, 2016; Guerrero et al., 2015; Kakabadse et al. 2015). Finally, the finding of the paper may enrich the discussion of corporate governance practices regarding controlling the negative impact of social categorization.

THEORETICAL BACKGROUND AND HYPOTHESES

Categorization–Elaboration Model

Integrating information processing and social categorization perspectives, Van Knippenberg et al. (2004) have introduced the categorization-elaboration model (CEM). The information-processing theory postulates that information creates value through individual contributions such as ideas, decisions, and judgments in the group information-processing space, such as in group discussions and meetings (De Dreu et al., 2008; Hinsz et al., 1997). The purpose of group-level information processing is to produce a "*coherent, feasible, sensible, and, if needed, creative group judgment or decision*" (De Dreu et al., 2008, p. 28). First, the information-processing view postulates that information creates value through individual contributions such as ideas, decisions, and judgments in a group setting (De Dreu et al., 2008). The quality of group-level information processing varies greatly, as group members "*differ in the depth with which information is searched and processed*" (De Dreu et al., 2008, p. 26).

In the context of boards of directors, group-level information-processing is exemplified by board meetings and discussions. Variety in directors' skills, knowledge, and experience enables them to contribute with a broader range of unique information and increases the comprehensiveness of decision-making at the group level (Gabaldon et al., 2018; Van Knippenberg et al., 2004). Informational diversity could also come from gender difference, where a gender-diverse board is more likely to take up various issues and initiate different approaches (Eagly, 2016; Huse & Solberg, 2006; Terjesen et al., 2009). Given the rich bundle of informational diversity, groups may use in-depth information to understand problems better. Such comprehensiveness improves group performance, especially group decision-making creativity and quality (Van Knippenberg et al., 2004).

Still, in a group of apparent informational diversity, not all members' information is added to the group information-processing space. Whereas some information is shared among all group members, other information remains unshared and individually possessed (Brodbeck et al., 2007; Scholten et al., 2007). Information bias occurs if the unshared information becomes critical to decision-making, resulting in groupthink and more inferior decision-making quality (Brodbeck et al., 2007).

To limit groupthink's potential damage, CEM posits that the elaboration of task-related information is the primary process underlying the positive effects of diversity on deep and deliberate information processing at the group level. Van Knippenberg et al. (2004, p. 1101) explain that "*elaboration is defined as the exchange of information and perspectives, individual-level processing of the information and perspectives, the process of feeding back the results of this individual-level processing into the group, and discussion and integration of its* implications." Furthermore, by disseminating and processing unshared task-related information, groups make superior quality decisions (Scholten et al., 2007).

Social categorization is the second pillar of the CEM. It calls attention to the impact of social barriers and intergroup biases on the information-elaboration process (Van Knippenberg et al., 2004). Social categorization offers explanations through social identity and self-categorization theories (Turner et al., 1987). Social identity theory explains why a group may be separated into "us" and "them" (in-groups/out-groups), and the self-categorization theory explains the consequences of such a categorization on minority members, such as female directors in the board.

When gender becomes a salient observable, social categorization starts to form, and intergroup biases emerge. Intergroup bias refers to more favorable perceptions of and attitudes and behavior toward, for example, a gender-based group category (e.g., woman vs. man) rather than individual merits. Moreover, negative attributes are exaggerated, and positive ones are discounted in intergroup biases, while the permissible behavior of the stereotyped person is constrained (Van Knippenberg et al., 2004). In this case, the information generated by an out-group member tends to be perceived as less relevant or credible than the information from an in-group member. As a result, in-group members are more inclined to cooperate with other in-group members than out-group members (Balliet et al., 2010). In-group members are also likely to resist out-group members' influence and dismiss or devalue their inputs in group decision-making (Tanford & Penrod, 1984).

It is interesting to point out that threats or challenges to the value of group identity between in- and out-group members can also trigger intergroup biases (Branscombe et al., 1999). Consequently, we observe social competition for status and prestige, outright derogation, discrimination of the group, and unequal status between groups (Van Knippenberg et al., 2004). In short, CEM enables us to address one key question in diversity research: "How differences between workgroup *members affect group process and performance, as well as group member attitudes and subjective well-being*" (Van Knippenberg & Schippers, 2007, p. 517). While we acknowledge that board diversity affects board processes and board task performance (e.g., Kakabadse et al., 2018; Kanadlı et al., 2018a; Zhang, 2010) as well as directors' attitudes towards minority directors (Zhu et al., 2014), we propose that social categorization in the board may be a crucial factor moderating the above processes.

Impacts of Board Diversity on Process Innovation

Corporate boards of directors are expected to be active players in facilitating innovation through board diversity (Adams et al., 2015). They are also identified as the primary determinant of firm process innovation (Crossan & Apaydin, 2010). It means directors are enablers of introducing new technologies, involving the use of new material-processing technologies, task designs, and management practices. Board diversity can play a role in

spreading new ideas through its network ties. Information and knowledge from external partners through board networks are valuable in opportunity recognition (Reichstein & Salter, 2006). Specifically, directors form boundary-spanning activities that help focal firms explore opportunities from the external environment by bringing in information about new technologies, advanced processes, and best management practices adopted by other firms (Hillman & Dalziel, 2003). As articulated by Galaskiewicz and Wasserman (1989, p. 456), network ties between boundary-spanning personnel, such as board members, "*act as a conduit to disseminate ideas and innovation.*" It is essential to point out that, with board diversity, board members are in a stronger position to seek more unique information from their network ties (Gabaldon et al., 2018; Kakabadse et al., 2018; Shropshire, 2010; Zhang, 2010). Additionally, diverse boards act as a catalyst for strategic change and contribute to the adaptation of new processes, technologies, and practices (Haynes & Hillman, 2010).

Following the above discussions, we expect knowledge-based diversity to enhance information depth and the number of perspectives in the group information-processing space, facilitating firm process innovation. Similarly, gender-based diversity could also positively influence process innovation through social networks of female directors that bring in non-redundant knowledge from other firms (Hillman et al., 2002;), supporting innovative activities in focal firms (Torchia et al., 2018). However, there may be differences between gender-based diversity and knowledge-based diversity (Harrison & Klein, 2007).

Gender is a salient observable among upper echelons, and it can quickly create a social categorization divide between female and male directors (Zhu et al., 2014). Studies have shown that female directors influence not only the type of issues to be considered but also how they are discussed (Eagly, 2016; Huse & Solberg, 2006; Terjesen et al., 2009). For example, females may be more willing to bring new problems and perspectives to the table, start lively debates, and broaden the content of boardroom discussions. They are sensitive to the interests of others and usually consider the views of multiple parties. They may also ask critical questions of their peers or managers and pursue answers. It is noticed that, in an attempt to help to break the glass ceiling, female directors can be impatient to take leading roles or influence board decisions to show that women in the upper echelons have it all (Singh et al., 2008). The behaviors and attitudes of female directors, therefore, can be perceived as challenges or threats to the male directors' status and prestige, or to existing norms and distinctiveness of the dominant male group (Kakabadse et al., 2015). It can create friction between female and male directors, which results in a longer decision-making time in the boardroom.

Female directors, as a result, may face adverse consequences of social categorization from their male colleagues. In a male-dominated board, information from female directors about firm process innovation is likely to be overlooked or not taken seriously when the male directors perceive them as a threat. Male directors may thus neglect female directors' involvement, creating unshared information in the group information-processing space. Under such a circumstance, the CEM predicts that the elaboration of task-related information cannot reach its potential. On the other hand, knowledge-based diversity does not seem to lead to a similarly intense social categorization between female and male directors.

Hypothesis 1: Board knowledge-based diversity has a stronger impact on process innovation than gender-based diversity.

Impact of Chairperson's Gender

A board chairperson is an official leader in the board and positively influences how directors share and exchange information in board meetings and discussions (Kakabadse et al., 2015; Pugliese et al., 2015). Studies show that the board chairperson contributes to the creation of a safe (Guerrero et al., 2015) and an open (Gabrielsson et al., 2007) atmosphere in board meetings, enabling the elaboration of task-related information and exchange of different views, benefiting a board's contributions to strategy process (Kakabadse et al., 2015; Zhang, 2010).

There is evidence suggesting that gender may explain why some chairpersons make better use of directors' diverse talent than others (Eagly, 2016; Nielsen & Huse, 2010). For example, studies of gender have shown that female chairpersons tend to display a collaborative leadership style (Eagly, 2007, 2016; Huse & Solberg, 2006). These studies suggest that female leaders demonstrate a strong focus on listening, an inclination to gain social support, a desire to achieve a win-win solution, an attitude to bring in new perspectives, and a willingness to engage in various discussions. Indeed, such a leadership style underlies a general finding of women in the workforce. Women are more sensitive to other people's interests than their male colleagues, and they are more likely to consider multiple perspectives (Terjesen et al., 2009). The collaborative leadership style feature even discusses how a female chairperson is better than a male chairperson when the utilization of directors' unique knowledge and perspectives becomes the concern (Brodbeck et al., 2007; Nielsen & Huse, 2010). As process innovation calls for informational diversity, a female chairperson can take advantage of knowledge-based diversity and gender diversity through her collaborative leadership style.

Nevertheless, when social categorization is considered, CEM suggests that a chairperson's influence might be complicated, where a female chairperson's attention could differ between knowledge-based diversity and gender diversity. The unequal attention could affect the relationship between gender diversity and process innovation as well as knowledge-based diversity and process innovation. We present two arguments below.

First, women directors have long faced struggles in the corporate boardroom, such as unfavorable social status (Huse & Solberg, 2006; Kakabadse et al., 2015). Support in the form of legalizing a gender quota system, for example, is called on to help women break away from these obstacles. However, even with the progress made by implementing a gender quota system, female directors' involvement is still limited (Labelle et al., 2015). It seems that women directors need additional assistance beyond the quota system. A female chairperson might be considered helpful for women directors. A female chairperson could systematically divert more attention to women directors, helping them break away from the weak and out-group members (Eagly, 2007; Kakabadse et al., 2015; Nielsen & Huse, 2010; Tate & Yang, 2015). As such, in a board chaired by a female, there could be more exchange of gender-related issues than task-related issues. Everything else equal, a female chairperson is thus likely to favor the value-creation from gender diversity more than knowledge-based diversity.

Second, from an operational perspective, a female chairperson can limit potential resentment from the male directors when the chairperson helps women directors advance in the boardroom (Kakabadse et al., 2006, 2015). As mentioned earlier, when women are aware of the adverse impact of social categorization, they become more sensitive to these issues than their male colleagues (Terjesen et al., 2009). It is reflected in their actions of mentoring. Researchers have shown that a female chairperson is careful in selecting and implementing mentoring practices,

which help women directors interact with their male counterparts without rocking the boat (Kakabadse et al., 2015). Under a female chairperson's leadership, women directors may "sit back, observe others, and learn. Once [they] understand the issues, question [the male directors] in the contextually acceptable manner" to limit unwanted personal conflicts (Kakabadse et al., 2015, p. 273). The practices could reduce hostilities against women directors and create an open and safe boardroom atmosphere for both female and male directors (Kakabadse et al., 2006). Consequently, mentoring practices encourage sharing unique information, increase the communication of diverse views, and promote the value-creation from gender diversity.

To conclude, female chairpersons could become sympathetic towards female directors, and they may favor a greater gender diversity when male directors dominate a typical board. As a result, female chairpersons could focus more on tapping the benefits of gender diversity to improve firm process innovation. It leads to the following hypothesis:

Hypothesis 2a: Gender diversity will have a greater positive impact on process innovation when the board is led by a female chairperson.

Male chairpersons, on the other hand, may not be equally enthusiastic about gender-related issues. They may not prioritize the active participation and contribution of women directors in board discussions. In particular, when value differences surface between male and female directors, male directors may perceive threats from the participation of women directors (Branscombe et al., 1999). In this case, a male chairperson could downplay the importance of gender diversity and focus more on knowledge-based diversity instead. As a result, we have the following hypothesis:

Hypothesis 2b: Knowledge-based diversity will have a greater positive impact on process innovation when the board is led by a male chairperson.

METHOD AND ANALYSIS

Data

We have used the survey method in this study. We obtained survey data from a public survey database, the Value Creating Board from Norway, collected in 2005 (Sellevoll et al., 2007). There are several benefits of using a public database, such as the Value Creating Board. First, the data collection process is rigorous, providing quality data in statistical analysis (Huse, 2018; Huse et al., 2011; Sellevoll et al., 2007). Publications using this database have covered a broad area such as board knowledge, power, trust, and board task performance (Huse et al., 2011; Zhang, 2010). Second, the database contains information on board diversity and firm process innovation, which are the key variables of our investigation. In particular, the gender issue during the data collection period had received great attention, resulting in a 40% female director quota system to be enforced shortly after (Sweigart, 2012). Therefore, data collected during the period provides rich information to examine the mechanism of social categorization due to gender. Third, the development of the boards of directors in Norway has been greatly influenced by corporate governance systems and practices of other countries such as the U.S.A. and the U.K. (Huse, 2007; Oxelheim & Randøy, 2003). Studies that have used Norwegian

governance data may thus contribute to interesting discussions for the international audience (Oxelheim & Randøy, 2003).

2,954 CEOs participated in the survey with a response rate of 33%. For this study, companies selected are publicly listed firms and private firms with the number of employees at or more than 50. Among these firms, 42% are in manufacturing, 30% in service, 6% in banking and finance, and the rest in other industries. We have excluded data without information on firm process innovation and board chairperson gender. The final size of the data is 462. We have not found selection bias when checking the data against sales revenue. The descriptive statistics and data correlations are presented in Table 1.

In Table 1, 60% of the boards have women directors. The average size of the board is six, and the mean of women directors is one. Eight percent of all cases have a female board chairperson. The data suggests that male directors dominated the Norwegian boards at the time of data collection. The correlation between board size and the number of female directors is significant at 0.61. The correlation between board size and gender-based diversity (Blau Index, 1977) is also significantly positive. It indicates the women directors are more likely to serve on a big board. The correlation between chairperson tenure and the board size is significant but negative at -0.17, suggesting the bigger the board size, the newer the board chairperson. Past product innovation and past technology innovation are positively correlated with each other at 0.44.

Constructs and Variables

We have applied Structural Equation Modeling (SEM) in the analysis. SEM is a powerful tool that combines Explanatory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) and simultaneously runs linear equations between observed variables and latent constructs, and among latent constructs themselves (Nunnally & Bernstein, 1994). Constructs are measured by survey items, where a 7-point Likert scale is used to measure the perception. A short description of the constructs and variables are presented below.

Knowledge-based diversity. This is a three-item construct measuring board knowledge-based diversity. The items capture the perception of CEOs regarding the degree of variation of their board members in 1) functional knowledge, 2) industry knowledge, and 3) educational background.

Gender-based diversity. We approach gender-based diversity by using the Blau Index (1977), and it is calculated as $1 - \Sigma Pi\text{^}2$, where Pi is the proportion of the group members in the category i. The value of the Blau Index of gender diversity varies between 0 and 0.5. The higher the number, the more diverse the board is. The mean value of the Blau Index for this study is 0.21.

Firm process innovation. This construct measures the perception of respondents regarding the degree of the process innovation of the firm. It includes three items: 1) the firm invests heavily in R&D to create innovative process technology; 2) The firm is the first in the industry to develop and introduce completely new process technology; 3) The firm is the pioneer in creating new process technology.

TABLE 1. DESCRIPTIVE STATISTICS AND CORRELATION

	Minimum Statistic	Maximum Statistic	Mean Statistic	Std Error									
Number of employees	50	25,000	636	103.66	1								
Revenues ($ million)	0.67	10,000	181	172.88	-.05	1							
Board size	3	14	6	.08	-.07	.33**	1						
No. of female directors	0	6	1	.05	-.04	.34**	.61**	1					
Blau Index	0	.5	.23	.00	.001	.18**	.39**	.87**	1				
Board chair tenure	0	32	5.10	.22	-.18**	-.07	-.17**	-.07	-.03	1			
Age of chairperson	25	82	54	.39	-.08	.01	.07	.01	.001	.29**	1		
Past technology innovation	1	7	4.31	.08	-.06	.09	.08	.07	10*	-.05	.02	1	
Past product innovation	1	7	4.62	.07	-.01	.08	.05	.03	.06	-.13**	.03	.44**	1

Number of cases: 426
**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

In this study, we control board chair tenure, which is likely to influence a diverse board (Buchanan, 1974). Board chairperson tenure may signal a degree of complexity in the understanding of the board's work, which may influence how effectively the board chairperson handles gender-related and task-related issues. We also control board size, which is positively associated with firm process innovation (Zahra et al., 2000). Last, we control the degree of product innovation and technology innovation in the past three years. Studies have found a strong complementary effect between technology innovation, product innovation, and process innovation (Adner & Levinthal, 2001; Martinez-Ros, 2000). We thus expect that technology innovation and product innovation in the past can influence process innovation.

Measurement of Constructs

The results of the two constructs—knowledge-based diversity and firm process innovation—are strong (see Table 2 below). The values of five indices for the measurement model fit are presented in 1A of the Appendix. The five indices are also used in the assessment of the structural model fit later on. The index CMIN/df measures the minimum discrepancy, and a value between 1 and 3 indicates an acceptable fit (Carmines & McIver, 1981). The other four indices also suggest a good fit. The Comparative Fit Index (CFI) has a value higher than 0.95 (Joreskog & Sorbom, 2009). Root Mean Square Error of Approximation (RMSEA) is lower than 0.06 (MacCallum et al., 1996) or 0.08 (Diamantopoulos & Siguaw, 2000). PCLOSE (p of Close Fit) is higher than 0.05 (Hair et al., 2010). Standardized Root Mean Square Residual (SRMR) is lower than 0.08 (Hair et al., 2010). All indices have met the requirement of a good model fit.

TABLE 2. CONFIRMATORY FACTORY ANALYSIS

Items (N=462)	**Factor loading**
Firm process innovation: Cronbach's α=0.87, CR=0.87, AVE=0.68, MSV=0.25	
The firm invests heavily in the R&D to create innovative process technology.	0.81
The firm is the first in the industry to develop and introduce completely new technology.	0.84
The firm is the pioneer in creating new process technology.	0.84
Board diversity: Cronbach's α=0.76, CR=0.74, AVE=0.49, MSV=0.04	
There is a high level of board diversity regarding: – functional knowledge	0.75
– industry knowledge	0.64
– educational background	0.70

It is vital to check the reliability and validity of the constructs. The reliability of a construct measures the consistency of items in a construct. Factor loadings suggest the item consistency in Table 2, where all loadings are higher than 0.60 (Bollen, 1989). Also, Cronbach's Alpha is 0.87 for firm process innovation and 0.76 for knowledge-based diversity, implying no reliability

concerns (Bollen, 1989). Last, Composite Reliability (CR) that considers an items' errors is another often-used assessment, with a value above 0.7 as the threshold (Hair et al., 2010). We have no reliability concerns with the two constructs.

The validity of constructs measures the degree of the quality of the measurement. The Norwegian database has ensured the validity of constructs by using items that have been theoretically suggested and empirically tested (Sellevoll et al., 2007). We have applied additional statistics to check the validity (see Table 2): Average Variance Extracted (AVE) and Maximally Shared Variance (MSV). A desirable validity is obtained when the AVE is higher than 0.50, and the MSV is lower than the AVE (Hair et al., 2010). The construct of knowledge-based diversity has an AVE at 0.49, which is slightly smaller than 0.50. After a careful evaluation, the less desirable AVE of knowledge-based diversity is acceptable for two reasons. First, this construct has met the reliability measurement threshold, where CR is higher than 0.70, and Cronbach's Alpha is also higher than 0.70. Second, the discriminant validity has met its requirement, where the MSV is lower than the AVE (Hair et al., 2010). We, therefore, conclude that the validity of knowledge-based diversity is not optimal but acceptable.

Analysis and Results

We have tested two structural models in the analysis. One is the basic model, and the other is the model addressing the effect of board chairperson gender (see Table 3). Standardized coefficients are reported.

TABLE 3. STRUCTURAL MODEL RESULTS

	Structural Model 1		Structural Model 2			
	Whole dataset		Male Chair		Female Chair	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Board size	0.04	0.03	0.01	0.04	0.29*	0.11
Board chair tenure	0.03	0.01	0.02	0.01	0.08	0.07
Past technology innovation	0.15***	0.04	0.17***	0.04	0.13	0.17
Past product innovation	0.35***	0.04	0.37***	0.04	0.09	0.18
Knowledge-based diversity	0.14***	0.07	0.15***	0.07	0.13	0.22
Gender-based diversity	-0.05	0.32	-0.04	0.33	0.29*	3.18
R^2	0.22		0.24		0.24	
No. of cases	462		428		34	
Model fit indices	CMIN/DF=2.25 CFI=0.95 RMSEA=0.05 PCLOSE=0.41 SRMR=0.06		CMIN/DF=1.45 CFI=0.97 RMSEA=0.03 PCLOSE=0.92 SRMR=0.06			

Notes: *** p-value < 0.01; ** p-value < 0.05; * p-value < 0.10

In Table 3, all five model fit indices satisfy the threshold requirement for a good model fit. The strong model fit has considered the potential correlations between independent and control variables, as suggested by AMOS. They include the correlation between board size and gender-based diversity, past technology innovation and past product innovation, and board chairperson tenure and board size. These three correlations are consistent with the earlier descriptive statistics and data correlations in Table 1.

Hypothesis 1 states that knowledge-based diversity has a stronger impact on process innovation than gender-based diversity. In Table 3, the standardized coefficient of knowledge-based diversity on process innovation is significant and positive at 0.14, and while the coefficient of gender-based diversity is non-significant at -0.05. Hypothesis 1 receives support.

Hypothesis 2a proposes that the impact of gender diversity on process innovation is more pronounced than that of knowledge-based diversity under a female chairperson. The standardized coefficient of gender-based diversity is positive and significant at 0.29, and while the coefficient of knowledge-based diversity is positive at 0.13 but non-significant. We could conclude that gender-based diversity has a stronger effect on process innovation than knowledge-based diversity under a female chairperson. Hypothesis 2a receives support.

Hypothesis 2b proposes that knowledge-based diversity is more important than gender-based diversity influencing process innovation under a male board chairperson. In Table 3, the coefficient of knowledge-based diversity is significant and positive at 0.15. The coefficient of gender-based diversity is -0.04 and non-significant, suggesting gender diversity has little, if any, impact on process innovation. The result supports Hypothesis 2b.

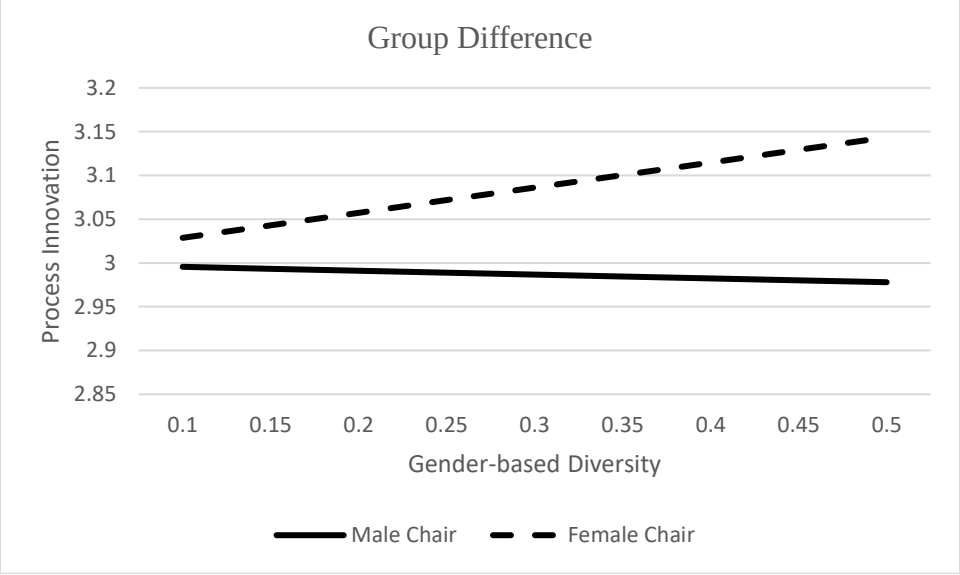

FIGURE 2. GENDER-BASED DIVERSITY ON PROCESS INNOVATION

There is a cautionary note that the subset we used to examine the relationship between board diversity and process innovation under the female board chairperson's impact has limited

observations of 34. Albeit a ratio of 10:1 between sample size and the number of variables is generally used to evaluate the adequacy of the sample size for SEM analysis (Bentler & Chou, 1987), there are exceptions for the sample size as small as 30. That is when the model is simple with one or two constructs, and the result is robust with high factor loadings (Wolf et al., 2013). It fits our study, where the model consists of two constructs—board knowledge-diversity and firm process innovation—with a strong model fit (see Table 3). Overall, we may conclude that we have found support for all hypotheses.

DISCUSSION AND IMPLICATIONS

The study applies the categorization-elaboration model (CEM) to examine board diversity's impact on firm process innovation. We hypothesize and have found that knowledge-based diversity has a more significant impact on firm process innovation than gender-based diversity (H1). The conclusion is consistent with the perspective that we should differentiate the dimensions of group diversity (Guillaume et al., 2017; Harrison & Klein, 2007; Homan et al., 2007; Milliken & Martins, 1996). The study results are also in line with board leadership research, where chairpersons can influence the board effectiveness by activating the use of directors' knowledge and skills (e.g., Guerrero et al., 2015; Kakabadse et al., 2015; Zhang, 2010). Specifically, a potential difference exists between female and male chairpersons such that the type of diversity—knowledge-based diversity and gender-based diversity—elicit different responses to process innovation (H2a and H2b). Overall, the study results suggest that it is relevant to investigate gender issues to understand board diversity's effectiveness (Palvia et al., 2015; Nekhili et al., 2016).

Implications

Researchers of group diversity encourage us to investigate barriers in group work such as out-group categorization (Sun et al., 2015), tokenism (e.g., Torchia et al., 2011), perceptions of unequal membership (e.g., Nielsen & Huse, 2010), power asymmetry in decision-making (Haynes & Hillman, 2010; Triana et al., 2013), and cognitive biases in a group (Westphal & Bednar, 2005). CEM equips us with two theoretical approaches to this call: information processing and social categorization, inviting us to explore factors that facilitate and hinder a diverse group. Therefore, the study's theoretical implication suggests that CEM could be seen as a novel approach to shed light on the directors' dynamic relationship.

There are two implications for practitioners. First, the study result highlights the importance of selecting directors based on their diverse knowledge, skills, and experience, as suggested by hypothesis 1. Second, the study result strongly supports that the chairperson's gender matters (Cheng & Groysberg, 2020; Kakabadse et al., 2015). Everything else equal, chairpersons can interact with the social categorization processes due to their gender, potentially changing a board dynamic. In our study, under a female chairperson, gender diversity receives more attention to improve process innovation, and while under a male chairperson, gender diversity receives less attention. As a result, practitioners should be aware of the social barriers due to gender differences.

To limit the hindrance caused by gender, we propose practitioners pay attention to the priority of the type of board diversity, such that they can take coherent actions to meet the need. For example, suppose gender diversity becomes the focus of discussion in a male-dominated board. In that case, selecting a female chairperson is more likely to facilitate practices encouraging gender-diversity.

Limitations and Future Research

There are three limitations to this paper, which also form potential opportunities for future studies. First, the complexity of gender is regarded as a 'double-edged sword' (e.g., Palvia et al., 2015; Nekhili et al., 2016; Triana et al., 2013). It could create both positive and negative influences. In this paper, we have only argued that a female chairperson is likely to create a positive influence on firm process innovation, leaving the potential negative influence to be examined. For example, one study has suggested that female leaders can exacerbate emerging problems between in- and out-groups, reduce the team effectiveness, and ultimately produce an adverse effect on firm performance (Zhang et al., 2015). Therefore, it is interesting to investigate circumstances, such as specific favoritism that a female chairperson shows to women directors, which become detrimental for the firm process innovative.

Second, we have only analyzed social categorization due to a board chairperson's gender. Other demographic observables could also be interesting to explore. For example, researchers have shown the impact of age diversity of boards of directors on the performance of banks (Talavera et al., 2018). Future studies can thus examine how age diversity shapes social categorization between younger and senior board directors, and how the difference further affects firm process innovation.

Third, we have used data collected when hiring female directors started to gain considerable attention. Today, most boards participating in the survey may have more women directors because of the gender quota system (Nielsen & Huse, 2010). The situation could make studying gender issues in boards more relevant when many question the value of increasing female participation (Kanadli, et al., 2018a). If their appointment to the board has less to do with experiences and skills than the law requirement, female directors may face a profound hindrance due to the social-categorization processes (Kakabadse et al., 2015; Matsa & Miller, 2013; Nielsen & Huse, 2010). Investigating contingencies that fully utilize gender diversity amid the impediment may be a fruitful research avenue.

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APPENDIX

The goodness fit statistics of measurement model are presented in the following table

1A. MEASUREMENT MODEL FIT INDEXES

	Observed Value	Ideal Threshold
CMIN/df	2.02	Between 1 and 3
CFI	0.99	>0.95
RMSEA	0.04	<0.06
PCLOSE	0.50	>0.05
SRMR	0.03	<0.09