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Jeanelle Midavaine Wilfred Dolfsma Rick Aalbers

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Board diversity and R&D investment

Jeanelle Midavaine

*School of Economics and Business, Innovation Management and Strategy,
University of Groningen, Groningen, The Netherlands*

Wilfred Dolfsma

*Glendonbrook Institute for Enterprise Development,
Loughborough University London, London, UK and*

*School of Economics and Business,
University of Groningen, Groningen, The Netherlands, and*

Rick Aalbers

*Institute of Management Research, Radboud University,
Nijmegen, The Netherlands*

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Abstract

Purpose – The purpose of this paper is to investigate the effect of board diversity on the extent to which firms invest in R&D.

Design/methodology/approach – Based on data collected about the composition of the board of directors, the authors determine statistically if the characteristics of directors predicts the extent to which firms invest more in R&D.

Findings – The authors find, unexpectedly, that tenure diversity lead firms to invest less in R&D, while education diversity and gender diversity makes firms invest more. Gender diversity positively moderates education diversity as well, strengthening the effect found.

Research limitations/implications – The sample of firms the authors include in the paper is restricted due to the overwhelming difficulty in collecting data about the composition of boards of directors, and their backgrounds.

Practical implications – The paper offers insights into how boards of directors might need to be composed in order to try have firms invest more in R&D.

Social implications – Innovative firms are more competitive and more sustainable. Knowing what contributes to a firm's investment in R&D is thus of great social value.

Originality/value – The authors include a much larger set of diversity measures than any previously published study, and provide counter-intuitive findings that have implications for practice, society, as well as theory about team composition.

Keywords R&D investment, Board diversity, Board decision making

Paper type Research paper

1. Introduction

Certain characteristics of teams, and especially the diversity of characteristics among members of a team, can contribute favorably to the team's performance outcomes (van Knippenberg and Schippers, 2007). This should hold, too, for boards of a firm, a firm's management team. There have been studies indicating that board member characteristics such as age and experience enhance the financial performance of a firm (Carter *et al.*, 2003; Chapple and Humphrey, 2013), its social performance (Boulouta, 2013) and its strategic change (Goodstein *et al.*, 1994). Yet, boards of firms decide as a team, based on the information and insights brought to bear collectively. The focus should then be on the composition of a board (cf. Barker and Mueller, 2002; Chen, 2013).



Some studies have focussed on how firm boards collect relevant outside information (e.g. Li *et al.*, 2013). How members of a board search for relevant information is determined in large part, the upper echelon literature suggests as well (e.g. Hambrick *et al.*, 1996; Carpenter *et al.*, 2004; Nielsen, 2009), by the characteristics of those who search. The cognitive frameworks that members of the board maintain determine search strategies they employ (Hodgkinson and Johnson, 1994; Reger and Palmer, 1996). If all members of a firm board have the same characteristics, they may end up making decisions quickly (Marcel *et al.*, 2010), but they may draw on more limited information.

Diversity in the board may give rise to disagreement and (task oriented) conflict, among professionals which may prompt active information search and processing. When diversity relates to tasks, possible disagreement and even conflict gives rise to additional evidence gathering, and debate, as well as subsequent resolution and consensus building (Marcel *et al.*, 2010). Proper composition of the board of a firm, such that input and insights from all relevant sources are taken into account, may then reduce uncertainty, enhance information exchange between external organizations and the firm, increase access to resources, and aid in the formulation of firm strategy (Salancik, 1978; Hillman and Dalziel, 2003).

Board diversity enhances the alternatives available to, or considered by, the firm. Differences in the cognitive frameworks that executives possess have thus been linked to the effectiveness of strategic decision making (Marcel *et al.*, 2010). Studies focussing on a limited number of indicators of diversity have indicated that board diversity may enhance performance outcomes (Hutzschenreuter and Horstkotte, 2013). Whether board diversity will ultimately affect firm commitment to innovation in terms of R&D investment we do not know, however (cf. van Knippenberg *et al.*, 2011). Given that innovation is of great strategic importance, this paper addresses this important topic for research.

The added effect of board member characteristics such as gender, experience, education, age will only be noticed and contribute to firm performance, however, when they differ from the characteristics of others. Some believe, normatively, that having members on firm boards with certain characteristics, for instance gender, is good per se (Carver, 2002; Keasey *et al.*, 1997; Torchia *et al.*, 2011). Studies of the composition of the firm board, including a number of different forms of diversity, are rare, however, as Hutzschenreuter and Horstkotte (2013) indicate. Research so far has tended to single out one dimension of board diversity (cf. Hutzschenreuter and Horstkotte, 2013). When singling out one dimension along which to study diversity, effects that results in other dimensions of board diversity not being included in a study may unduly be ascribed to the single dimension of board diversity actually included (Hutzschenreuter and Horstkotte, 2013). In addition, various dimensions of board diversity can interact to have effects on firm performance that differ markedly from their main effects. Intricate effects of diversity may be expected in particular when team decisions are made about issues that are shrouded in uncertainty and for which the consequences are visible only in the very long run. Studies on board composition have so far, perhaps surprisingly, shied away from studying innovation as the dependent variable.

This paper, analyzing a cross-section of firms in high-tech industries over a period of several years, contributes two important insights, bridging the literatures on corporate governance and that on innovation management. In contrast to studies that focus on a single industry or only consider a single year, the first insight we offer is that educational diversity in the board of a firm will lead to more R&D investment, but the

same is not true for diversity in terms of experience (tenure). Second, gender diversity, itself having a positive effect, further enhances the positive effect of educational diversity inside firm boards.

We progress along classical lines. We first discuss the relevant literature, developing two pointed hypotheses (Section 2). We elaborate on the data and method in Section 3. Results are presented in Section 4, after which a brief discussion and conclusion section (Section 5) ensues.

2. Theory and hypotheses

In team decision-making research, it is well-established that diversity of input benefits the quality of the decision arrived at (van Knippenberg and Schippers, 2007). While some research (e.g. Barker and Mueller, 2002) has focussed on the CEO in particular and the CEO can be very influential in a firm, he, typically, is not omnipotent. We focus on the management team or firm board. We follow, a.o., Bantel and Jackson (1989) who state that “in contrast to research that focuses on CEOs as solitary decision-makers, we focus on the top management team as the unit of analysis. We assume this dominant coalition acts as a decision-making unit for the organization.”

Diversity can be information or task-based on the one hand, or it can be person related on the other hand. Diversity of input for a team, including a firm board, can refer to the sources from which information is gathered (Marcel *et al.*, 2010). If members of a team have a background in the relevant knowledge sourced themselves, they are better able to establish the value of a piece of knowledge themselves. That is why, contrary to Li *et al.* (2013), we focus on the diversity among team (board) members rather than on the sources from which members source their knowledge. Each member of this decision-making unit responds to ambiguous and complex stimuli in a different way, attending to different cues and constructing different understandings, depending on their backgrounds. Given its position and prominence in a firm, the effect of board diversity may be particularly sizeable (Haynes and Hillman, 2010; Hutzschenreuter and Horstkotte, 2013; Chen, 2013). While information-based and person-related diversity are all argued to be related to attitudes, values and perspectives that people have (Bantel and Jackson, 1989), information-based diversity in a team can be expected to enhance team performance, but person-related diversity in a team may hamper team performance (cf. Barker and Mueller, 2002). The former may in particular stimulate information gathering and processing, while the latter may particularly emphasize the conflicts and disagreements that diversity can induce.

Information-based diversity inside a board, defined as diversity concerning characteristics believed to indicate people’s ability to select, collect and process relevant information, gives rise to enhanced exchange of more fundamental viewpoints between individuals. Tacit knowledge or knowledge that is taken for granted in one field or by many with long tenure inside the firm (organization) may not be equally taken for granted when someone has a different background (Cramton and Hinds, 2005). Information-based diversity in a firm board ensures that its members have a variety of sources of knowledge and related connections with other, outside experts to draw on (Woodman *et al.*, 1993; Paulus, 2000; Reagans and McEvily, 2003). A judicial weighing of relevant information, at the team level, will then lead to better team decisions (Cramton and Hinds, 2005; Williams and O’Reilly, 1998). When shared within the team, the diversity of insights and knowledge at hand benefits the overall team’s knowledge base and enhances team performance (Allen, 1977; Ancona and Caldwell, 1992). Cognitive ability and judicial weighing relate to someone’s formal education

(Bantel and Jackson, 1989; Hülshager *et al.*, 2009; Wiersema and Bantel, 1992). Individuals who have enjoyed a higher formal education may also more likely to take risks and be more favorably inclined to invest in R&D.

Knowledge about the firm's resources and (technological) capabilities that increase with one's tenure may also allow a board member to establish what the firm will be able to do and what knowledge or capabilities in a firm it can build on. On the other hand, board members without long tenure in the firm can consider the firm as if they are an outsider and can perhaps better determine what the firm is supposed to do differently compared to its past (Cramton and Hinds, 2005). Both what is required of the firm toward the future, as well what a firm is able to do (in the short run) given its resources and capabilities may be considered in the board if the board is diverse in terms of tenure.

Especially when making decisions that will impact the firm in the longer term, in an area such as R&D investment that is, as Schumpeter insists, inherently about bringing together knowledge from different domains, information-based diversity should be expected to contribute positively (cf. Oldham and Cummings, 1996). Hence we suggest the following hypothesis:

H1. Information-based board diversity (i.e. education (a), and tenure (b)) contributes positively to firm R&D investment.

Diversity in groups can also have deleterious effects on group-level performance, however. The literatures from organizational psychology and social psychology discuss what is called faultlines as differences within groups separating two (or more) subgroups from another (Bezrukova *et al.*, 2009). Specifically person-related differences are pointed to as differences that may pit one group against another. Gender, age and also ethnicity are mentioned as examples of person-related differences that can become a focal point for faultlines to emerge in a group. The extent to which non-alterable characteristics of individuals become the focus of negative meanings and associations in a group, establishing a faultline or faultlines, can differ by group. Especially age and gender can, however, be signified as faultlines creating (negatively afflicted) stereotypical "us" and "them" (Lau and Murnighan, 1998; Postuma and Campion, 2009).

Stereotypes are activated in some contexts more quickly or more prominently than in others. Management teams, and particularly boards of large firms consist of professionals that are supported by a dedicated staff, however: person-related diversity may not distract members of the management team from the task at hand directly (cf. Jehn, 1995). Board members are also closely scrutinized by people in the firms, by share- and stakeholders, and by the press. When the decision concerns investing in R&D, the focus of the current study, board members are aware of the complexity of the situation and the long-term market and technological uncertainties involved. In such circumstances research shows that team members value information-based diversity since these will mean that the available information is considered from a number of different perspectives and angles (Jehn *et al.*, 1999). Contrary to what literature in organizational psychology suggests (Bezrukova *et al.*, 2009), in how boards decide, person-related differences are not as likely to have an immediate effect on the decisions taken.

Person-related differences, while not having a direct effect since that would decrease the potential diversity of knowledge introduced into the deliberations, may have a moderating effect on information processing, rather than a main effect. The decisions that members of the board make, based on the information they have and given their

expertise, may, however, have an indirect effect on firm performance. Team members from across faultlines may bring different perspectives, considerations and to a degree “languages” into meetings and exchange or interactions generally. How member of the board weigh the arguments or facts that another member of a board brings in may be different if the other member is from across a faultline (van Knippenberg and Schippers, 2007). Levels of trust may be lower between individuals who experience major person-related differences (Li and Hambrick, 2005; Postuma and Campion, 2009). Differences can prevent information from moving between team members, and cliques or coalitions can arise (Stevenson *et al.*, 1985). Arguments and facts brought to bear may then be ignored or given less weight when they are introduced by someone at the same side of the faultline.

Faultlines may thus have a negative moderating effect on the decisions made that are otherwise determined by information-based diversity, as we suggest in the following hypothesis:

H2. Person-related board diversity (faultlines) (i.e. age (a), and gender (b)) will negatively moderate a firm’s enhanced R&D investment due to information-based board diversity.

Our analysis can be presented in the following conceptual framework (Figure 1).

3. Data and method

For a period of seven years, data for the 25 firms in the Fortune 500 that are in industries classified by the OECD as high-tech industries is collected. The industries involved are pharmaceutical, chemical, machinery and aerospace. Firms in these industries on average expend 4.5 percent of total sales into R&D (cf. Hatzichronoglou, 1997) and are also likely to patent a large part of the knowledge that is developed: propensity to patent for these industries is at least 50 percent (Arundel and Kabla, 1998). Firms were included in our study when they met the following criteria: a firm first, must be headquartered in the USA as the USA has a one-tier board structure, ensuring that decisions are made by the board of directors only; second, should be listed continuously in COMPUSTAT (merged and acquisitions are excluded from the sample); third, must be publicly traded; and fourth, listed in the Fortune 500 (explained below).

Our dependent variable is firm spending on R&D – firm boards can affect R&D investment, but have far less influence on the level of patenting, or on what new products are developed and introduced on the market. While many studies interested in research output use this measure, spending on R&D is not an ideal measure of research output (Dolfsma and van der Velde, 2014; Kleinknecht *et al.*, 2002). Our research is, however, not primarily focussed on research output, which is much less dependent on what the board decides and much more on factors outside its own influence, but rather on a firm board’s commitment and decision to invest in R&D. We believe that relying

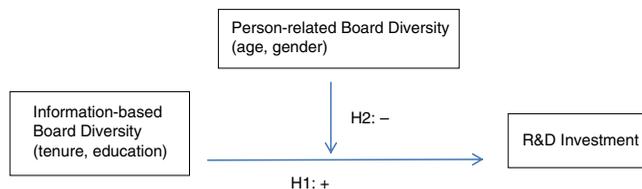


Figure 1.
Conceptual model

on published data about actual efforts by the firm to create and develop new knowledge and products, rather than survey data on board member self-reported assessment of firm innovativeness, as Torchia *et al.* (2011) do, is a robust measure of board decision making. R&D investment by firms is, moreover, a measure of firm innovativeness that is in line with the OECD's Oslo manual (Organisation for Economic Co-operation and Development *et al.*, 1992). In addition to focussing on firms in high-tech industries because of their similar patenting activities, we also focus on large firms only. The reason for this is that it is known that the extent to which firms are efficient at turning R&D investment into innovative output differs by firm size (Cohen, 2010; Shefer and Frenkel, 2005; Stock *et al.*, 2002).

Our primary independent variables relate to diversity in firm boards. While most studies focus on a single dimension for board diversity, we include four dimensions. Two dimensions are information-based as they refer to the information required for a board member to do their job. One such measure for diversity is education, and the other is experience at the firm. Two other dimensions of diversity are person related. We include gender and age. Obviously, a board member's age and tenure at a firm are different things, as individuals can have a relatively long career, but their career can be at different firms or at a single one.

Diversity is measured using the Blau index – an index of dispersion of observations over a number of specified categories, represented by the following formula: $1 - \sum p_i^2$. In this formula, i stands for the number of categories defined. Using the number (or percentage) of individuals in a board who have a particular characteristic, as Torchia *et al.* (2011) do, implicitly assumes that including more individuals who have such a characteristics will have the expected effect on team performance. This assumption is not in line with the diversity argument pursued in this paper.

For gender the number of categories is two: female and male. For age we have seven categories of five years each, starting at 40 years of age. For tenure we have five categories (< 2, 3–5, 6–9, 10–14, > 15). Different definitions of categories do not alter the results found. Rather than looking at the kind of education followed, the level of education is included. Four levels are distinguished: bachelor, master, MBA and PhD. Level of education indicates the extent to which an issue addressed by someone in a practical or rather more abstract manner. A number of scholars have found that this distinction is highly relevant for the current issue (e.g. Stevenson *et al.*, 1985).

We include a number of control variables to be able to exclude alternative explanations. Older and bigger firms are likely to be more aware of the importance of research. These firms might also be more aware of the efficiency of R&D investment turning input into research throughput (patents) or output (newly developed products). We thus include size (ln) and age of the firm. We also include a measure for the business cycle in the form of percentage change in GDP compared with last year, since less may be invested in R&D when the economy is depressed. Given the nature of the data we have, we opt for straightforward OLS regressions – these offer the most readily interpretable findings.

4. Results

Table AI, presents descriptive statistics. Our main findings are presented in Table I below. These findings are remarkable in several respects. Educational diversity is positively related to innovativeness by the firm, while diversity in tenure is negatively related with innovativeness, and both consistently so. These findings are in partial support of *H1*. We find support for *H1a* related to educational diversity (*H1a*), but not for our tenure diversity hypothesis (*H1b*).

Table I.
Effects of board
diversity on firm
R&D investment

	Base models			Moderation: age			Moderation: gender		
	(I)	(II)	(III)	(II)	(IV)	(V)	(VI)	(V)	(VI)
Controls									
Firm size	1.025 (1.280)***	0.865 (6.967)***	0.866 (6.947)***	0.853 (7.068)***	0.823 (6.789)***	0.747 (6.081)***	0.823 (6.789)***	0.747 (6.081)***	0.823 (6.789)***
Firm age	0.002 (0.979)	-0.001 (-0.338)	-0.001 (-0.343)	0.000 (-0.202)	-0.003 (-1.418)	-0.006 (-2.302)**	-0.003 (-1.418)	-0.006 (-2.302)**	-0.003 (-1.418)
GDP (% change)	-0.012 (-0.250)	-0.016 (-0.377)	-0.016 (-0.378)	-0.008 (-0.180)	0.003 (0.074)	0.004 (0.095)	0.003 (0.074)	0.004 (0.095)	0.003 (0.074)
Board diversity									
Education	-	6.889 (6.334)***	6.908 (6.167)***	7.407 (6.804)***	5.865 (5.358)***	7.371 (6.083)***	5.865 (5.358)***	7.371 (6.083)***	5.865 (5.358)***
Tenure	-	-3.843 (-2.830)***	-3.860 (-2.789)***	-3.441 (-2.579)***	-3.915 (-2.975)***	-4.064 (-3.114)***	-3.915 (-2.975)***	-4.064 (-3.114)***	-3.915 (-2.975)***
Age	-	-	0.122 (0.071)	0.585 (0.355)	-	-	0.585 (0.355)	-	-
Gender	-	-	-	-	4.098 (3.460)***	3.735 (3.178)***	4.098 (3.460)***	3.735 (3.178)***	4.098 (3.460)***
Moderations									
Education x age	-	-	-	-0.384 (-3.969)***	-	-	-0.384 (-3.969)***	-	-
Tenure x age	-	-	-	-0.023 (-0.240)	-	-	-0.023 (-0.240)	-	-
Education x gender	-	-	-	-	-	0.240 (2.526)**	-	0.240 (2.526)**	-
Tenure x gender	-	-	-	-	-	0.135 (1.326)	-	0.135 (1.326)	-
R^2	0.250	0.416	0.416	0.467	0.455	0.480	0.467	0.455	0.480
Adj. R^2	0.237	0.398	0.395	0.441	0.435	0.455	0.441	0.435	0.455
F-test	18.983	23.974	15.890	8.002	21.012	4.106	8.002	21.012	4.106

Notes: $n = 175$ firm-year observations. Un-standardized coefficients; t -values in parentheses. ***, **, * Significant at 10, 5, and 1 percent levels

The situation with regard to *H2a* and *H2b* is more mixed. The main effect of age on innovativeness is statistically negligible, while the main effect of gender is positive, in the latter case also after interaction terms are introduced. Age diversity, indeed, as we predict in *H2a*, negatively moderates the main (positive) effect of education diversity. The same is not true for tenure diversity: age diversity does not negatively moderate the effect of tenure diversity. In addition, the effect of gender diversity as a faultline actually positively moderates the main (positive) effect of educational diversity. This finding is in direct contrast with what we predict in *H2b*. Gender diversity plays no moderating role with respect to tenure that is statistically traceable. The negative effect of tenure is not attenuated when one considers interactions with age or gender diversity.

5. Conclusion and implications

In analyzing how the composition of a firm's board affects firm innovativeness (R&D investment), this study includes, uniquely, four different kinds of diversity. Building on diversity and upper echelon literatures, we conceptualize two as information-based types of diversity (education and tenure) and two as person-related types of diversity (gender and age). We argue theoretically, and show empirically, that how a firm's board is composed makes a difference in terms of investment in R&D. We find that the effect of diversity in firm boards, contrary to what some suggest (see van Knippenberg *et al.*, 2011), is not uni-directional.

Conceptually distinguishing and empirically analyzing differences for the categories of information-based and person-related board diversity, we present unexpected results. Sometimes differences are beneficial, and sometimes they are detrimental. Diversity in gender and education contribute to a firm's increased tendency to invest in R&D. What is more, diversity in gender further enhances, or positively moderates, the positive effect of education diversity. Diversity inside a firm board in terms of tenure makes it less likely to invest in R&D. Considerations of legacy and the awareness of path dependency in production, markets catered to and supply chains dependent on might lead to a reduced tendency to innovate and invest in R&D for board members with higher tenure, as these might upset the status quo. The firm-specific experience Tenure provides seems to drive this effect as age diversity does not have the effect of reducing R&D investment. The negative direct effect of tenure diversity is not attenuated by an interaction with age or gender diversity.

From a managerial point of view, knowing what types of diversity will impact likely outcomes of decision processes in top management teams is an important insight. Information-based diversity and person-related diversity have impacts that run counter to what the literature and what common sense would expect. The composition of management teams can now be considered with more confidence. Whom to include in a firm's board will thus significantly affect firm performance, and boards and shareholders should definitely take the composition of the firm board as a whole, and not just the characteristics of single board members, into account. In managing the composition of a firm's board, an organization may need to find a balance between involving the right kind of diversity for firm performance to be enhanced on the one hand, and representing diverse stakeholder interests on the other hand.

The findings in this paper also indicate that properly organizing for firm innovativeness is not limited to an R&D department (cf. Aalbers and Dolfsma, 2015). Sustained firm innovation, made possible by R&D investment, depends on elements organizationally removed from an R&D department: diversity in the top management team drives firm innovativeness in its own right (cf. Metz *et al.*, 2015).

From a policy perspective, our findings suggest policy makers might want to stimulate the right kind of diversity at board level to enhance firms' innovative outcome. Innovation policy might need to be focussed on "soft" issues such as board composition, rather than merely "hard" issues such as patenting, R&D investment.

One would have to carefully consider which diversity to stimulate, keeping in mind what the relevant outcome variable is. Our findings are limited to the outcome variable chosen (R&D investment). Effects of the information-based (education and tenure) and person-related (gender and age) diversity can also change over time. Additional indicators of group diversity may need to be taken into account. There might be interaction effects not yet considered to surface. Also, non-linear effects can at some stage emerge. Future studies could take these possibilities into account when extending our conceptual framework for the effects of information-based and person-related diversity in team composition on performance outcomes. Given how some findings are unexpected from the perspective of existing literature, more insights are required as to why the main and interaction effects we found actually exist.

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Further reading

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Appendix

	Mean	SD	1	2	3	4	5	6	7
1 R&D	13.2042	1.50276							
2 GDP	1.2000	2.04827	-0.19						
3 Size firm	10.7785	0.74227	0.495**	-0.002					
4 Firm age	89.52	40.653	-0.19	-0.16	-0.169*				
5 Education (diversity)	0.620593	0.0850223	0.462**	0.041	0.189*	0.187*			
6 Tenure (diversity)	0.711853	0.0653503	-0.137	0.070	0.055	-0.002	0.020		
7 Gender (diversity)	0.255678	0.0815016	0.337**	-0.113	0.094	0.340**	0.331**	0.016	
8 Age (diversity)	0.722402	0.0544446	-0.137	0.030	-0.067	0.078	-0.208**	0.170*	0.128

Notes: $n = 175$. * $p < 0.05$; ** $p < 0.01$

Table A1.
Descriptive statistics

Corresponding author

Wilfred Dolfsma can be contacted at: w.a.dolfsma@lboro.ac.uk

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