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Gender diversity and innovation performance:
Evidence from R&D workforce in Sweden

Abstract

Compared to gender diversity in top management teams (TMTs) and board of directions, gender diversity in R&D (research and development) organizations, and its relationship with firm's innovation performance, has received little attention. The aim of this paper is to investigate this relationship. Using a longitudinal design with five samples from Sweden the paper explores how gender diversity in R&D units relates to innovation-related employee productivity (measured in monetary value). Both linear and non-linear relationships are tested. The results suggest gender diversity has a non-linear, U-shape, relationship with employee innovation-related productivity, supporting the value-in-diversity perspective.

Keywords

Innovation, performance, employee productivity, gender diversity

Introduction

Research and development (R&D) activity is becoming more central in today's economy (Akhilesh, 2014, Salter and Tether, 2014, Chen, Ni and Tong, 2016). With the rapidly changing demands from customers and end users, firms are under pressure to continuously innovate. As a result, generating creative ideas and transforming them into sellable products or services have become indispensable for the survival of firms (Chen, Chang and Hung, 2008, Salter and Tether, 2014). Product and service development enables organizations to diversify, adapt and reinvent their existence and meet the rapidly changing markets (Brown and Eisenhardt, 1995, Tidd and Bessant, 2018). In the knowledge economy, the existence of any firm rests increasingly on the shoulders of the core resources that generate innovations. R&D employee group is considered such a resource that is crucial for creating and sustaining firm's competitive advantage (Brown and Eisenhardt, 1995, Verona, 1999, Henard and McFadyen, 2012).

The workforce is demographically becoming more heterogeneous and the R&D function is not an exception (Faems and Subramanian, 2012). Nonetheless, gender occupational segregation is still pertaining (Charles and Grusky, 2005), especially in science, technology, engineering and mathematics (Thébaud and Charles, 2018). Knowledge-based environments, such as R&D, are historically dominated by men. In these contexts, gender is so salient that "it functions as cue for identifying team members' skills and expertise" and "regardless of actual expertise, team members are likely to value men's expertise while discounting women's expertise" (Joshi, 2014, p. 203). Empirically, with the exception of few studies exploring the relationship between R&D innovation propensity and gender diversity in Denmark, Spain and Singapore (Østergaard, Timmermans and Kristinsson, 2011, Faems and Subramanian, 2012, Díaz-García, González-Moreno and Jose Sáez-Martínez, 2013, Garcia Martinez, Zouaghi and Garcia Marco, 2017, González-Moreno, Díaz-García and Sáez-

Martínez, 2018), we know little about how gender composition in R&D organizations relates to firm's innovation performance in general, and to its financial performance in particular.

Extensive diversity research has been devoted to studying top management teams (TMT) and board of directors using the upper-echelon framework. Studies suggest that having women in management and governance positions relates positively to strategic performance (Knight, Pearce, Smith, Olian et al., 1999), firm's financial performance (Welbourne, Cycyota and Ferrante, 2007, Post and Byron, 2015), stock price informativeness (Gul, Srinidhi and Ng, 2011), corporate social responsibility (Bear, Rahman and Post, 2010), firms social performance (Byron and Post, 2016), sales (Hoobler, Masterson, Nkomo and Michel, 2018) and innovativeness of the firm (Bantel and Jackson, 1989, Ruiz-Jiménez, del Mar Fuentes-Fuentes and Ruiz-Arroyo, 2016). However, the composition of the board or top management team (TMT) does not necessarily represent the composition of R&D unit in a firm. Also, unlike governance and management work performed by boards and top management, R&D unit actually stands behind what the firm supplies to markets. Nonetheless, in comparison to the scientific attention devoted to board and TMT diversity, research investigating gender diversity in R&D organizations and its relation to firm performance is still scant.

Studies linking innovation with organizational performance generally show positive relationship (for a review, see Bowen, Rostami and Steel, 2010, Rosenbusch, Brinckmann and Bausch, 2011, Rousseau, Mathias, Madden and Crook, 2016). However, studies investigating the link between innovation and firm performance do not take into account the specific contribution of R&D employees. Although firm performance is a result of a collective effort by all units and employees in the firm, it is incontestable that R&D unit's operations have a substantial impact on this performance. Besides, as the composition of R&D units is under-researched, we know little about how gender diversity in these organizations relates to unit-specific performance. Understanding this aspect is crucial because organizational units or departments often receive own budgets and are usually evaluated independently. It is also key for designing and implementing appropriate HR processes (such as selecting, recruiting, compensating, and retaining) pertaining to this group of knowledge workers.

This study is important for various reasons. First, it sheds light on gender diversity in a male-dominated function (R&D). Historically, technical education has been dominated by men. Although evidence points to a change in the trend (Cheryan, Ziegler, Montoya and Jiang, 2017, Stoet and Geary, 2018), women's entry to technical functions that require solid scientific education is still limited. Second, Sweden is a special national context to investigate. Besides its innovation reputation - EU's innovation leader (European Commission, 2019) – Sweden is described as one of the most gender equal countries in the world (World Economic Forum, 2017). Therefore, it is of interest to investigate if (and how) gender composition of the workforce behind the innovation reputation plays out in a historically male-dominated workforce. Third, in their effort to profile themselves as socially responsible, some organizations work systematically to attract and recruit demographically under-represented groups. Although these efforts pay off socially, their financial contribution is still under-researched. Finally, existing research on innovation and financial firm performance focuses mostly on the firm, not R&D unit, level. By focusing on R&D unit, we will be able to learn more about how a salient employee characteristic (gender) relates to unit's innovation performance. General employee productivity is a common key performance indicator in human resource management, yet it is not as specific as innovation-related employee productivity – the latter provides better insights about the precise contribution of R&D work to firm's performance and can be used for – among other things – internal and external benchmarking.

This study aims to contribute to both gender diversity and innovation research by exploring the relation between gender composition in R&D units and innovation-specific performance. More specifically, it explores if (and how) gender diversity in R&D units relates to employee innovation-related productivity. For the analysis, the study uses five matched samples from the Swedish national R&D Survey and the Swedish data from the Innovation Community Survey (CIS).

Theory and Literature Review

Theoretical framework

Diversity is **"**a characteristic of social grouping that reflects the degree to which objective or subjective differences exist between group members" (Van Knippenberg and Schippers, 2007, p. 516). Although this grouping may concern any differentiation, research on diversity investigates mostly demographic differences, such as gender, ethnicity and culture (Bantel and Jackson, 1989, O'Reilly, Williams and Barsade, 1998, Van der and Van de, 2005, Herring, 2009, Ali, Kulik and Metz, 2011), functional differences, such as expertise, skills, occupation, and education (Bunderson and Sutcliffe, 2002), and sometimes both (Jehn, Northcraft and Neale, 1999, Østergaard et al., 2011, Faems and Subramanian, 2012, Garcia Martinez et al., 2017). The three perspectives that have been used to explain the relationship between diversity in organizations and organizational performance are: social categorization, similarity/attraction paradigm, and information/decision making. The first two perspectives suggest diversity is negative for performance while the third promotes diversity as a driver for improved performance.

Social categorization perspective has its roots in Tajfel and Turner's (1986) social identification theory. It argues that individuals have the desire to maintain high self-esteem through social comparison with others. In order to do so, they first classify themselves and others into social categories using salient characteristics, such as gender (sex). This process results in the person identifying him or herself in terms of social identity as a member of a group who is different from members in the compared to group/s. Individuals who are perceived similar to the self are placed in the ‘in-group’ whereas those who are different from the self are placed in the ‘out-group’. This mental categorization can lead members to perceive out-group members as less trustworthy, honest, and cooperative than in-group members. Such attitudes inhibit information exchange and communication – both necessary for group creativity and innovation (Paulus and Nijstad, 2019) – and adversely influence performance on multiple levels.

The second perspective is similarity/attraction perspective (Byrne, 1971). Pfeffer (1983) maintains that process and performance could be affected by the distribution of demographic differences on group and organizational levels. The central idea this perspective holds is that the extent to which members perceive themselves similar to or different from others in the work group strengthens or weakens interpersonal attraction and liking. Similarity ranges from invisible attitudes and believes to visible demographic attributes. Similar to social categorization perspective, similarity/attraction perspective assumes diversity has negative impact on group and organizational processes (e.g., communication, information exchange, collaboration) and outcomes. This theory posits that employees get attracted to, and prefer to spend time and interact with, ‘similar’ others (e.g., others who have similar experiences, values, gender, age). Similarity/attraction perspective suggests diversity impedes group functioning (e.g., accepting to test new ideas, collaborating, sharing information) as it engenders a cognitive distinction between in-group and out-group members and consequently influences social interaction (Roberson, 2019).

The third perspective, information/decision making theory (Williams and O'Reilly, 1998), has its foundation in the resource-based view of the firm (Barney, 1991) which postulates valuable, rare, imperfectly imitable, and non-substitutable resources are crucial for firm’s sustained competitive advantage. Information/decision making perspective maintains that a diverse workforce possesses a larger pool of intangible resources that are beneficial for performance. According to this perspective, demographically diverse workforce has broader range of knowledge and expertise compared to a homogenous one, especially for tasks that require multiple perspectives and diverse knowledge, skills and abilities such as innovation, complex problems, or product, service, or process design (Chen et al., 2008, Østergaard et al., 2011, Díaz-García et al., 2013). In this sense, diversity enhances work outcomes (even if it has negative impact on group processes) as it disrupts groupthink, brings in various perspectives to solve problems, and results in better identification of opportunities and improved decision-making. In contracts, homogeneous groups can hamper performance due to the lack of constructive conflicts and the higher levels of cohesion (Roberson, 2019).

Empirical research

Milliken and Martins (1996) describe diversity as a "double-edged sword" (p. 403). This is because empirical research on the impact of diversity on organizational performance is inconclusive (Milliken and Martins, 1996, Williams and O'Reilly, 1998, McMahon, 2011). Whereas some studies show certain diversity attributes are valuable for performance outcomes (Kiavitz, 2003, Herring, 2009, Østergaard et al., 2011), other studies report that such impact does not exist (Bowers, Pharmer and Salas, 2000, Chowdhury, 2005, Zhang and Hou, 2012) or even negative (Chatman, Polzer, Barsade and Neale, 1998, Cady and Valentine, 1999). Few publications report a non-linear relationship between diversity and performance. But even in these studies the findings point to different directions: an inverted U-shape (Frink, Robinson, Reithel, Arthur et al., 2003, Ali et al., 2011) and an upright U-shape (Earley and Mosakowski, 2000, Richard, Barnett, Dwyer and Chadwick, 2004).

Studying the Australian workfource, Ali et al. (2011) report an inverted U-shape relationship between workforce gender diversity (measured using Blau's index) and employee productivity. Frink et al. (2003) also report a nonlinear inverted U-shape relationship between gender diversity (measured as the proportion of women in the workforce) and performance in two studies from the US. These findings suggest that a moderate level of diveristy relates to the most effective performance. The integration of the two competing perspectives on diversity, namely social categorization and information/decision making, explains, according to Ali et al. (2011), the inverted U-shape relationship. The positive relationship between divesity and performance at low and moderate levels of diversity represents the value-in-diveristy perspective. Different knowledge, skills and ideas consitute significant resources when utilized in situations demanding knowledge-intenstive perspectives as they contribute to creativity, innovation and problem-solving. Based on previous research, Ali et al. (2011) aruge that at very low levels of diversity the dominating group is likely to provide support to the minority group and have a contact with its members. However, this will be most apparent in skewed groups (e.g., a team with a single woman or a single man). In an inverted U-shape relationship, the positive impact of diversity starts to diminish beyond moderate level of diversity. The negative relationship is explained by social categorization perspective. As groups become more diverse, the members start to identify themselves with, and differentiate themselves from, other members. These categorizations generate the dynamics that produce the undesirable outcomes of diversity, such as discrimination, poor communication and uproductive conflicts (Ali et al., 2011).

Studies reporting an upright U-shape relationship between demographic diversity and performance offer own explanations. Drawing on Jackson et al. (1995) and Lau and Murnighan (1998), Earley and Mosakowski (2000) suggest that subgroups cultural identities (us vs. them) dominate with moderate levels of heterogeneity. The argument is that as diversity in groups approaches moderate levels (e.g., 25:75), the psychological processes prompting social categorization (us vs. them) are likely to be activated. This is because at moderate levels groups are concentrated enough to promote, and have common bases for, sub-groups formation. According to Richard et al. (2004), these psychological processes generate behaviors such as conflicts, solidity with others in the same subgroup, conformity to the norms in one's subgroup, poor social interaction, and discrimination against the other subgroups. Moreover, these processes weaken members' attachment to, and identification with, the work team (Earley and Mosakowski, 2000). In highly heterogeneous teams, however, common bases for forming subgroups are few. Members focus on accomplishing the task through creating and establishing role expectations and team processes that constitute solid commonalities. Similar to the members in highly heterogeneous teams, members in highly homogeneous groups already have perceived commonalities and shared expectations that facilitate group processes (Earley and Mosakowski, 2000; Richard et al., 2004). Accordingly, high- and low-diverse groups are expected to outperform moderately diverse groups. Empirically, Earley and Mosakowski (2000) report that nationally homogeneous and highly heterogeneous teams outperform – in the long run – moderately diverse groups.

Gender diversity in R&D

Gender is the most salient demographical attribute in R&D workforce (Joshi, 2014), yet little research has focused on the relationship between gender diveristy in R&D organizations and organizational performance. The scant existing studies point to a mixed evidence. Faems and Subramanian (2012) report a positive relationship between gender diveristy in Singaporean R&D units and technological performance (operationalized as the number of patents). A linear relationship between gender diveristy in R&D units and the probability of producing innovation is reported from Denmark (Østergaard et al., 2011). A Spanish study shows a direct positive relation between gender diversity and firm's percentage of sales from innovations (Garcia Martinez et al., 2017) and the likelihood of producing radical innovations

(Díaz-García et al., 2013). A more recent work from the same national context (Spain) shows an inverted U-shape relationship between R&D gender diveristy and the propensity to produce an innovation (González-Moreno et al., 2018). Clearly, and similar to diversity studies from other contexts (e.g., TMTs and board of directors), the findings from R&D context are not consistent, which calls for further research on this topic.

Cordero et al. (1996) argue that diverse R&D labor force in an organization provides a pool of different ideas that can facilitate the performance of R&D unit and contribute to its innovativeness. In a similar vein, studies (Cox, Lobel and McLeod, 1991, Watson, Kumar and Michaelsen, 1993) report observable attributes, such as ethnicity and nationality, have positive relationship with desirable cognitive outcomes (e.g., decision comprehensiveness and idea quality) attributed to the positive association between group diversity and creativity (Cordero et al., 1996, Chen et al., 2008). This reasoning is not consistent, however, with observations that women entering R&D environments feel isolated (Culotta, Kahn, Koppel and Gibbons, 1993). Isolation perception signifies in-group and out-group categorization. Social categorization leads to intergroup biases that disrupt group functioning (Van Knippenberg, De Dreu and Homan, 2004), resulting in a negative impact on performace.

One of the challenges facing studies of diversity in R&D and its relationship with innovation performance is the used measures. Different indicators have been used to assess firm's innovation-related performance (e.g., patents, likelihood of producing innovations, incremental vs. radical innovations, percentage of sales). Although novelty and number of patents can be indicators of how innovative the R&D unit and firm is, these outcomes are limited in terms of describing how successful the firm has been in capitalizing on these innovations. The study by Garcia Martinez et al. (2017) is the only we found to make a direct link to sales. However, this study does not take into account the contribution of R&D

individuals. Although sales amount per se is critical, average employee contribution to the outcome (i.e., employee productivity) is more informative as a performance indicator. This is because individual level performance indicators are more relevant for human resource practices and employee development (Huselid, 1995). Also, employee productivity is an indicator that can be used for internal and external benchmarking. To the best of our knowledge, no previous study has investigated the link between gender diversity and employee productivity (as a function of turnover stemming from unit's innovations) in R&D context. This study specifically explores this relationship and its direction.

Methods

Sample

The sample consists of Swedish firms having an own R&D unit and fulfilling the two conditions of 1) developing a product or a service without external professional help and 2) participating at least once in both the national R&D Survey and Community Innovation Survey (CIS). Only 'sole-developers' are included in the sample because the extent to which external assistance contributed to the development of new product or service can vary from one firm to another. Statistics Sweden carried out both surveys (R&D and CIS) on behalf of the Swedish government.

Sample selection was based on matching firms from the two national surveys. Firms that participated in R&D 2005 survey and either CIS 2006 survey or CIS 2008 survey were selected; firms that took part in R&D 2007 survey and either CIS 2008 survey or CIS 2010 survey were chosen, and firms that answered R&D 2009 survey and CIS 2010 survey were included. Matched sample sizes from R&D and CIS surveys are reported in Table 1a (time lag ranging from 1 to 3 years). Males dominated R&D employees. In all matched surveys, the percentage of female employees was higher in the service sector than in the manufacturing sector. The matched samples had more manufacturing firms than service firms and the majority of the included R&D units (approximately 80%) had a size of less than 100 employees.

Insert Table 1a here

Measures

Dependent variables. R&D performance was measured using direct output of R&D employees' innovative efforts (innovation-related employee productivity). The product innovation-specific contribution to firm performance, measured as a percentage of total sales stemming specifically from produced innovations, is available in CIS 2006, 2008 and 2010. To obtain the monetary value of this contribution (Swedish Krona), the percentages were multiplied by the reported total sales of the year. The resulting figure explicitly measures sales obtained from introducing new or significantly improved product or service to the firm and/or to the market. In order to obtain the average contribution per R&D employee, this number was divided by the size of R&D unit as reported in R&D surveys and transformed using the natural algorithm formula (Huselid, 1995, Ali et al., 2011).

Independent variables: Unit-level demography constructs describe the pattern or configuration of unit members' demographic characteristics at an aggregate level (Joshi, Liao and Roh, 2011). The number of male and female employees was obtained from R&D survey for the years 2005, 2007 and 2009. Gender diversity measure was calculated using Blau's (1977) index (1-∑pi2, where *p* is the proportion of each group in the sample and *i* is the number of groups). Blau's index is a frequently used measure of categorical diversity attributes such as gender (Joshi et al., 2011). The index for gender diversity ranges between 0 (the unit has only men or women) and .50 (the unit has an equal proportion of men and women). Due to multicollinearity between the variable gender diversity and its nonlinear transformation, the values were standardized by subtracting the mean and dividing by the standard deviation (Østergaard et al., 2011).

Control variables. The following variables were controlled for in the analyses: Firm type (stand-alone = 0, affiliated with a business group (subsidiary) = 1), R&D workforce size (total number of employees in the R&D department, log transformed), involvement in extramural R&D (1 = Yes, 2 = No), amount invested in R&D (log transformed), and industry type (0 = services, 1 = manufacturing). Subsidiaries might benefit from potentially combined resources (Ali et al., 2011). Faems and Subramanian (2012) report a relationship between R&D unit's size and its innovative productivity. Since the nature of R&D function may differ in manufacturing and services industries, the classification of the organization in this regard was accounted for (Garcia Martinez et al., 2017, González-Moreno et al., 2018). Investing in R&D indicates explicit and systematic effort to produce innovations. Information about investment in R&D and R&D unit's size were measured in the national R&D surveys. The remaining variables were obtained from the CIS (Statistics Sweden, 2006, 2008, 2010) and R&D (Statistics Sweden, 2005, 2007, 2009) Surveys. All measures and their sources appear in Table 1b.

Insert Table 1b here

Analysis

To explore the theoretically-driven positive, negative and non-linear relationships, a series of hierarchical regression analyses was used. In the first step (Model 1), the control variables were inserted. In the second step (Model 2), the linear gender diversity variable was added. Finally, in the third step (Model 3), the non-linear transformation of gender diversity was included. Model predictive ability was judged based on the change in the percentage of variance explained after adding the linear and non-linear forms of gender diversity.

Results

Tables 2a, 2b, and 2c report descriptive statistics for the five matched samples. Regression analyses' results are reported in Tables 3a, 3b, and 3c. Model 1 shows the direction and magnitude of the relationship between the control variables and innovation-related employee productivity. In Model 2, the linear form of gender diversity is negatively correlated with employee productivity (R&D 2005 and R&D 2009). The non-linear transformation of gender diversity, added in Model 3, is statistically significant and explains additional variance in the dependent variable. The findings from this study are thus in favor of a non-linear, U-shape, relationship where high gender diversity is associated with highest performance. Figures 1 – 5 illustrate this relationship graphically.

Insert Tables 2a, 2b, and 2c about here

Insert Tables 3a, 3b, and 3c about here

Insert Figures 1, 2, 3, 4, and 5 about here

Discussion

The results of this study support previous research reporting a non-linear, upright U-shape, relationship between gender diversity and performance (Earley and Mosakowski, 2000, Richard et al., 2004). They are also consistent with more recent findings from the boardroom (Joecks, Pull and Vetter, 2013). The right-hand side of the U-shape relationship indicates gender balance is associated with higher innovation productivity per R&D employee. The left-hand side of the non-linear U-shape relationship is not significant for all, but one, of the five analyses. This may indicate low levels of gender diversity have no impact on employee productivity and the positive impact starts to materialize as R&D workforce becomes more heterogeneous. The results support the value-in-diversity discourse and the business case for gender diversity (Ely and Thomas, 1996, Lozano and Escrich, 2017) in R&D units.

One explanation for the higher productivity observed in highly diverse R&D units can be attributed to the different behavioral styles facilitating communication and improving decision making in these groups (Fenwick and Neal, 2001, Henry, Kmet, Desrosiers and Landa, 2002). Another is the broader and more heterogeneous knowledge base that enables these groups to better understand internal and external needs and solve problems (Cordero et al., 1996). For instance, rigorous discussions of various approaches to solve problems and develop products and services lead to better decision quality (Van Knippenberg et al., 2004), nurture the potential to creativity and innovations (Cox et al., 1991, Watson et al., 1993), and enhance the competitiveness of the organization. These arguments are consistent with the information/decision making perspective (Williams and O'Reilly, 1998). According to the resource based view (RBV) of the firm (Barney, 1991), knowledge workers – such as R&D employees – can be perceived as rare, valuable, and hard to imitate resource. The RBV theory also holds that transforming a short-run competitive advantage into a sustained competitive advantage requires heterogeneous resources in nature. Gender diverse R&D unit is an example of such a heterogeneity (even after controlling for tenure and education (Joshi, 2014)).

The statistically non-significant relationships in the non-linear relationship (left-hand side of the curve) in four analyses suggest the dynamics of gender diversity are complex. For instance, considering U-shape relationship between gender diversity and performance, is there a magical (minimum) percentage that is required to reap the benefits of gender diversity in R&D organizations? Although our study does not provide an answer to this question, research on board diversity suggests a "critical mass" of approximately 30% females is associated with higher firm performance (Joecks et al., 2013).

The negative relationship from the fifth analysis (R&D 2009 and CIS 2010 surveys), although consistent with previous research on cultural diversity (Earley and Mosakowski, 2000, Richard et al., 2004), it constitutes an exception in this study. Unlike the other analyses, the lack of data on investment in R&D hindered controlling for this significant variable in the analyses. So empirically, this may have contributed to this inconsistent finding. Yet, the statistical significance of the right-hand side of the curve supports the arguments, and evidence from previous years, that firms capitalize on gender diversity best when having gender-balanced R&D units.

Contribution

The contribution of this study is multifold. First, it focuses on gender diversity in a fundamental function for firms' sustainability and growth in the knowledge-based economy, namely, R&D. Since innovations often initiate and materialize in R&D units, the R&D function is crucial and constitutes the driving force for firm's innovation performance and sustaining competitive advantage. Unlike demographic diversity in TMTs, diversity in this specific, and growing, professional group is under-researched. This study extends the scant available empirical studies on gender diversity in this context (Østergaard et al., 2011, Faems and Subramanian, 2012, Díaz-García et al., 2013, Joshi, 2014, Garcia Martinez et al., 2017, González-Moreno et al., 2018) and adds to recent evidence on the U-shape relationship between gender diversity and firm performance (Joecks et al., 2013). It also extends diversity research beyond TMTs and board of directors. Second, the positive evidence of gender diversity obtained from five samples using longitudinal design provides strength to the existing research that promotes the value-in-diversity perspective (Ely and Thomas, 1996, Williams and O'Reilly, 1998, Lozano and Escrich, 2017) in a non-traditional, historically male-dominated profession. Third, unlike other studies that use the measures of number of patents (e.g., Faems and Subramanian, 2012), the likelihood of producing innovation (Østergaard et al., 2011, González-Moreno et al., 2018), or percentage of innovation-related sales (Garcia Martinez et al., 2017) as a performance indicator, this study focuses on R&D employee innovation productivity as an outcome. This measure is superior to other measures because it represents the direct monetary value stemming from R&D employees' inputs. Additionally, it is one of the meaningful performance indicators used in human resource management for internal and external benchmarking (Huselid, 1995). Fourth, diversity literature has been focusing either on team or overall firm levels (Østergaard et al., 2011). This study investigates gender diversity on the unit level and by that extends existing studies linking diversity to innovation. Finally, the study sheds light on a special national context (Sweden) where both gender equality and innovation production are internationally recognized.

The study has implications for managing R&D units. First, from a human resource management perspective, firms can work actively to attract and recruit qualified candidates from the under-represented gender (sex) for jobs in R&D functions. As the findings reveal, there is a business case for diversity. Second, to alleviate the negative tendency of managers employing people similar to themselves (Triventi, 2015), gender diversity can be discussed professionally in R&D organizations. Communicating the benefits of having a diverse workforce in producing higher quality decisions, despite disagreements and conflicts, may help managers change existing prejudices and stereotypes. Disagreements are natural outcomes when various perspectives meet. When managed well, however, these disagreements have large potential to generate creative solutions and innovations. Third, because sustaining competitive advantage and not merely survival is the goal of all firms, top management (and boards) will benefit from emphasizing climate for inclusion practices (Nishii, 2013). An example can be having clear goals regarding increasing the number of R&D professionals from the under-represented sex. Finally, promoting and working actively with implementing strategies for gender equality in professional roles is positive for organizations. Organizations can lift up this aspect in their corporate social responsibility profile, influence how the society perceives them, and inspire (and bring hope to) future generations to invest in higher education fields that qualify for jobs in historically segregated professions.

Limitations

Despite its unique contributions, this study has limitations. First, only one measure of R&D unit performance is included. Unfortunately, the data received for this study did not include other relevant performance-related indicators to be used for calculating other measures on the unit level. Nonetheless, employee productivity is a widely used indicator in the field (Huselid, 1995, Ali et al., 2011). Second, other visible and invisible attributes of diversity such as ethnicity and age may contribute to innovations (Østergaard et al., 2011) but they are excluded from this study. Nevertheless, by featuring only gender diversity, the study seeks to bring forward one of the under-investigated topics in R&D workforce research. Third, researchers argue that innovation is a collective process involving interaction between employees from all levels in a firm (Laursen, Mahnke and Vejrup-Hansen, 2005, Østergaard et al., 2011). Although we concur, we deem it appropriate for the purpose of this study to focus solely on the function of interest (R&D), its gender composition, and its contribution to the firm's performance (capitalization on produced innovations). Finally, the categorization of gender as men or women has its own limitation. Gender identity is a growing field of study and some countries started to promote gender neutral language. Employees who do not identify themselves in any of the two gender categories (e.g., those who identify themselves as “other”), were treated as ‘men’ or ‘women’ in the two national surveys.

Future research

Future research on R&D and innovative performance is encouraged to investigate if certain diversity characteristics are more valuable in specific branches. Also, exploring how (i.e., the underlying mediating mechanisms of) and under what circumstances (moderators) gender diversity influences firm’s performance would help us understand the dynamics of this demographic attribute. Operationalizing theoretical underpinnings and empirically testing their roles in explaining diversity’s relationship with innovation-related performance would be very insightful. Moreover, a future international comparison of R&D employee diversity and its relationship with firm performance is encouraged. Sweden is special (a leader in gender equality and innovation in Europe) so it would be interesting to investigate how contextual (national but also industry) factors may influence this relationship. Finally, ‘sales’ is an outcome of a collective effort in a firm. It would be interesting to see how the diversity in the other departments play out in relation to the R&D unit.

Notes

Statistics Sweden follows several ethical guidelines in data collection including those adopted by the UN general assembly in 2014, the European Code of Practice, and the International Statistical Institute (ISI). Firms are informed that external actors get access to only anonymized data.

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Table 1a. Matched Samples from R&D and CIS Surveys

Survey	CIS 2006	CIS 2008	CIS 2010
R&D 2005	176	224	
R&D 2007		226	212
R&D 2009			276

Table 1b. Description of measures

Measure	Question	Source
R&D unit's size (males and females)	Please indicate the number of male and female employees in your R&D unit as of 20xx-12-31: • Number of male employees __________ • Number of female employees ___________	R&D Surveys
Subsidiary or stand alone	In 20xx (year), was your enterprise part of an enterprise group? (A group consists of two or more legally defined enterprises under common ownership. Each enterprise in the group can serve different markets, as with national or regional subsidiaries, or serve different product markets. The head office is also part of an enterprise group.) 0-No 1-Yes	CIS Surveys
Type	Firms participating in CIS were coded based on their NACE codes 0 - Services 1 - Manufacturing	CIS Surveys as provided by Statistics Sweden
R&D unit size	Total number of female employees in the R&D unit + Total number of male employees in the R&D unit	R&D Surveys

Engagement in extramural R&D	During the last three years, did your enterprise purchase: … External R&D Creative work to increase the stock of knowledge for developing new and improved products and processes (include software development performed by other enterprises (including other enterprises or subsidiaries within your group) or by public or private research organizations 0-No 1-Yes	CIS Surveys

Table 2a: Descriptive Statistics – R&D 2005, CIS 2006 and CIS 2008

	M	SD	R&D employee productivity	Subsidiary or stand alone	R&D unit size	Engagement in extramural R&D	Investment in R&D	Type	Gender diversity	Gender Diversity SQ
R&D employee productivity	1.62	2.32		-.17**	-.71***	-.24***	-.53***	.05	-.23***	.48***
Subsidiary or stand alone	.87	.33	-.01		.18**	.14**	.21**	.15**	-.10	-.11*
R&D unit size	3.22	1.50	-.70***	.11		.24***	.70***	.03	.07	-.36***
Engagement in extramural R&D	.53	.50	-.26***	.03	.32***		.24**	.17**	.05	-.19**
Investment in R&D	6.94	2.05	-.43***	.01	.74***	.25**		.09	.11	-.31***
Industry type	.72	.45	-.07	.20**	.05	.13*	.07		-.15*	.01
Gender diversity	.00	.98	-.22**	-.03	.09	.08	.03	-.10		-.49***
Gender Diversity SQ	.95	.98	.53***	-.12	-.42***	-.14*	-.29**	-.08	-.44***	
M			1.47	.89	3.34	.58	7.11	.73	-.03	.89
SD			2.17	.31	1.47	.49	1.97	.45	.95	.99

Figures on the lower diagonal and vertical M and SD represent variables from the surveys R&D 2005 and CIS 2006. Figures on the upper diagonal and horizontal M and SD represent variables from the surveys R&D 2005 and CIS 2008.

*p <.05, **p <.01, ***p <.001 (one-tailed)

Table 2b: Descriptive Statistics – R&D 2007, CIS 2008 and CIS 2010

	M	SD	R&D employee productivity	Subsidiary or stand alone	R&D unit size	Engagement in extramural R&D	Investment in R&D	Type	Gender diversity	Gender Diversity SQ
R&D employee productivity	1.15	1.44		.06	-.75***	.01	-.49***	.11	.00	.30***
Subsidiary or stand alone	0.90	0.29	-.16**		.03	.13**	.03	.18***	-.03	-.09
R&D unit size	3.44	1.36	-.74***	.14*		.20**	.62***	.01	-.09	-.20***
Engagement in extramural R&D	0.63	0.48	-.10	.11*	.17**		.07	.26**	.02	-.10
Investment in R&D	7.23	1.83	-.49***	.21**	.66***	.09		.10	.01	-.15**
Type	0.72	0.45	.09	.22***	.02	.25***	.13		-.18**	.11*
Gender diversity	-0.08	0.99	.09	-.11	-.13*	-.05	.03	-.22***		-.54
Gender Diversity SQ	0.98	1.11	.21**	-.08	-.14*	-.02	-.23**	.06	-.51***	
M			.65	.68	3.51	.65	7.31	.68	-.06	1.00
SD			.48	.47	1.39	.48	1.81	.47	1.00	1.14

Figures on the lower diagonal and vertical M and SD represent variables from the surveys R&D 2007 and CIS 2008. Figures on the upper diagonal and horizontal M and SD represent variables from the surveys R&D 2007 and CIS 2010.

*p <.05, **p <.01, ***p <.001 (one-tailed)

Table 2c: Descriptive Statistics – R&D 2009 and CIS 2010

	M	SD	R&D employee productivity	Subsidiary or stand alone	R&D unit size	Engagement in extramural R&D	Investment in R&D	Type	Gender diversity
R&D employee productivity	2.22	3.37							
Subsidiary or stand alone	.89	.32	-.02						
R&D unit size	3.03	1.61	-.72***	.09*					
Engagement in extramural R&D	.66	.47	-.10*	.08*	.16**				
Investment in R&D	-	-	-	-	-	-			
Type	.71	.45	.11*	.15***	-.09*	.15***	-		
Gender diversity	-.01	.98	-.37**	.00	.30***	.12*	-	-.14**	
Gender Diversity SQ	.95	.83	.51**	-.02	-.50***	-.16**	-	.00	-.41***

Figures represent variables from the surveys R&D 2009 and CIS 2010. Investment in R&D is not available in the obtained dataset.

**p* <.05, ***p* <.01, ****p* <.001 (one-tailed)

Table 3a: Hierarchical Regression Analyses – R&D gender diversity (2005) predicting employee productivity in 2006 and 2008

	Gender diversity (2005) predicting R&D employee productivity 2006			Gender diversity (2005) predicting R&D employee productivity 2008		
Variables						
	Beta (Model 1)	Beta (Model 2)	Beta (Model 3)	Beta (Model 1)	Beta (Model 2)	Beta (Model 3)
Controls						
Firm type (2006, 2008)	.09	.09	.11	-.05	-.07	-.05
R&D unit size (2005)	-.85***	-.83***	-.05	-.65***	-.65***	-.59***
Involvement in extramural R&D (2006, 2008)	-.04	-.03	-.73***	-.09	-.08	-.06
Investment in R&D (2005)	.21†	.20†	.20*	-.05	-.03	-.02
Industry type	-.06	-.07	.01	.09	.07	.07
Gender diversity (2005)		-.15*	-.04		-.18**	-.08
Gender diversity^2			.27**			.20**
R^2	.52	.54	.58	.52	.55	.58
Adjusted R^2	.49	.51	.55	.50	.53	.55
F	19.49***	17.61***	18.08***	29.07***	27.07***	25.57***
Change in R^2		.02	.05		.03	.03
Change in F		4.50*	10.20**		8.71**	8.03**

*p <.05, **p <.01, ***p <.001 (two-tailed)

Table 3b: Hierarchical Regression Analyses – R&D gender diversity (2007) predicting employee productivity in 2008 and 2010

	Gender diversity (2007) predicting R&D employee productivity 2008			Gender diversity (2007) predicting R&D employee productivity 2010		
Variables						
	Beta (Model 1)	Beta (Model 2)	Beta (Model 3)	Beta (Model 1)	Beta (Model 2)	Beta (Model 3)
Controls						
Firm type (2008, 2010)	-.09	-.08	-.07	.05	.05	.07
R&D unit size (2007)	-.71***	-.71***	-.69***	-.75***	-.76***	-.71***
Involvement in extramural R&D (2008, 2010)	.00	-.01	-.01	.13*	.14*	.14*
Investment in R&D (2007)	-.02	-.03	-.02	-.04	-.03	-.03
Industry type	.13*	.13*	.14*	.07	.06	.05
Gender diversity (2007)		.02	.09		-.06	.05
Gender diversity^2			.14†			.20**
R^2	.56	.56	.58	.59	.59	.62
Adjusted R^2	.54	.54	.55	.57	.57	.59
F	32.62***	27.00***	24.21***	22.81***	28.29***	26.62***
Change in R^2		.00	.01		.00	.02
Change in F		.07	3.83†		.88	7.36**

†p <.10, *p <.05, **p <.01, ***p <.001 (two-tailed)

Table 3c: Hierarchical Regression Analyses – R&D 2009 gender diversity predicting employee productivity in 2010

	Gender diversity (2009) predicting R&D employee productivity 2010		
Variables			
	Beta (Model 1)	Beta (Model 2)	Beta (Model 3)
Controls			
Firm type (2010)	.04	.04	.03
R&D unit size (2009)	-.72***	-.67***	-.61***
Involvement in extramural R&D (2010)	.00	.02	.03
Investment in R&D (2009)[a]	-	-	-
Industry type	.04	.02	.03
Gender diversity (2009)		-.16***	-.11**
Gender diversity^2			.16***
R^2	.52	.54	.56
Adjusted R^2	.51	.54	.55
F	88.54***	77.31***	69.05
Change in R^2		.02	.02
Change in *F*		16.11***	13.25***

[a] Data not available.

*p <.05, **p <.01, ***p <.001 (two-tailed)

Figure 1: Gender diversity (2005) and Innovation-specific employee productivity (2006)

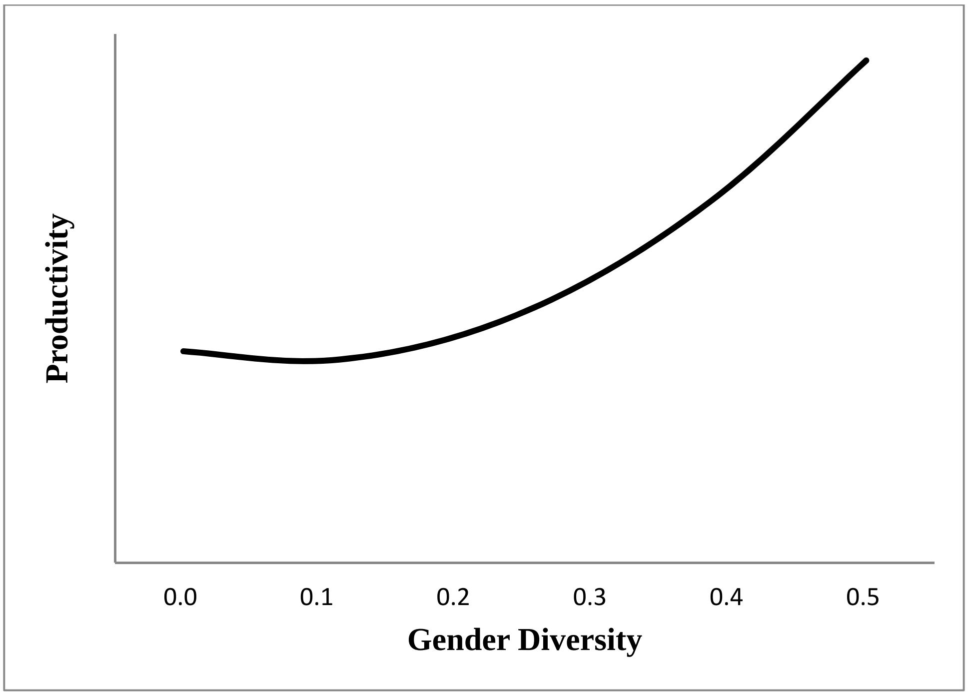

Figure 2: Gender diversity (2005) and Innovation-specific employee productivity (2008)

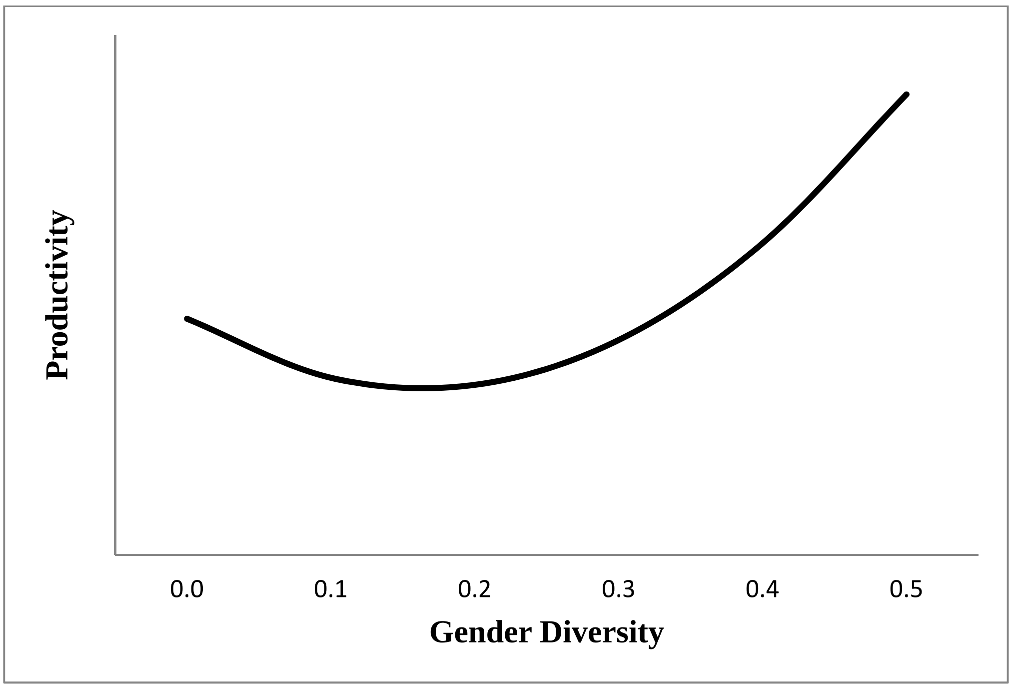

Figure 3: Gender diversity (2007) and Innovation-specific employee productivity (2008)

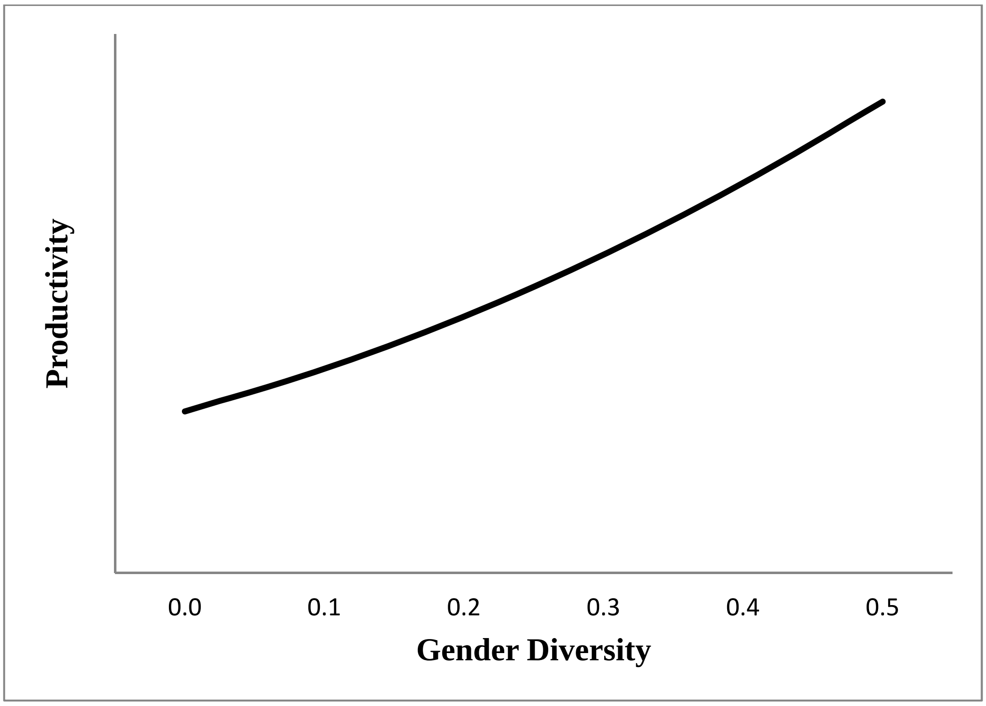

Figure 4: Gender diversity (2007) and Innovation-specific employee productivity (2010)

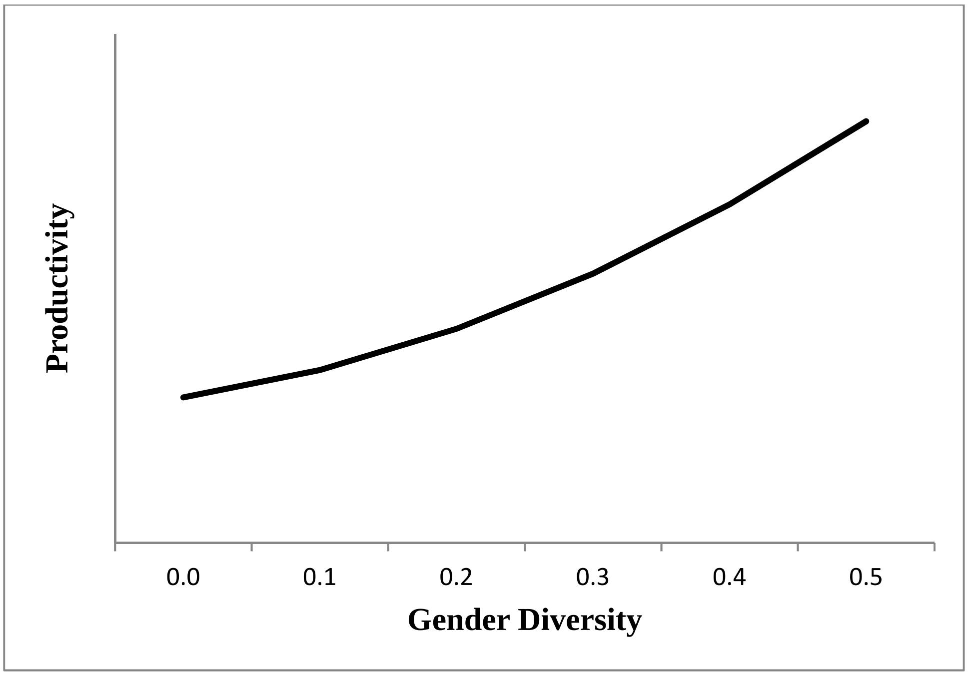

Figure 5: Gender diversity (2009) and Innovation-specific employee productivity (2010)