Product Innovation and Educational Diversity in Top and Middle Management Teams

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Key words: Product innovation; diversity; middle management; top management; firm performance

JEL codes: M14; M12; O30

PRODUCT INNOVATION AND EDUCATIONAL DIVERSITY IN TOP AND MIDDLE MANAGEMENT TEAMS

ABSTRACT

The effects of diversity in management teams on firm innovation have become an important topic in strategic management. With a few exceptions, however, the literature has focused on diversity in Top Management Teams (TMTs), while the role of lower management levels, particularly in Middle Management Teams (MMTs), has usually been neglected. In this paper, we intend to fill this gap by explicitly differentiating between the effects of diversity in TMTs and MMTs. Focusing on measures of educational diversity, we compiled a linked employer-employee panel dataset for Sweden for the period 2004–2012 by matching various firm-level and individual-level datasets. We find that diversity effects differ considerably between MMTs and TMTs. TMTs diversity determines whether firms engage in innovation activities at all (strategic decision), while MMTs diversity affects the actual outcome of innovation processes (successful product innovations and their market novelty).

At present, almost all major companies have explicitly adopted non-financial goals as part of their mission. Among these non-financial goals, the promotion of diversity has become particularly important because of its alleged beneficial effects on innovation among other things. The Swedish-based vehicle manufacturer Volvo, for example, states the following on its website: "We know that diversity and inclusion are crucial to our business success as they increase innovation and employee engagement." Similarly, Apple states: "The most innovative company must also be the most diverse." The globally operating German-based retailer Lidl concurs: "We are convinced that diversity boosts our creativity and innovativeness." This general agreement among many of the largest companies worldwide may come as a surprise given the mixed results in the scientific literature on performance and innovation effects that differ in context and methodology (van Knippenberg and Schippers 2007, Meyer et al. 2014).

In an effort to explain the mixed findings, scholars have highlighted the existence of both costs and benefits associated with diversity (George and Chattopadhyay 2009). While diversity may provide a team with better access to non-redundant, task-relevant information, it may also trigger processes of social categorization, leading to disputes and, ultimately, a decline in information-sharing among team members (Williams and O'Reilley 1998, van Knippenberg et al. 2004, Roberge and van Dick 2010, Faems and Subramanian 2013). Aiming to separate the negative from the positive effects, the scholars have proposed differentiating the dimensions of diversity. In particular, some authors have argued that informational benefits are most likely to result from task-related dimensions of diversity, such as the diversity of educational backgrounds. This has nurtured the expectation of unambiguously positive performance effects for these task-related dimensions of diversity (van Knippenberg et al. 2014). Although intuitive, the existing meta-analyses have found no support for pervasive positive effects (Bowers et al. 2000, Webber and Donahue 2001, van Knippenberg and Schippers 2007, Guillaume et al. 2012). Even when narrowing performance down to the topic of innovation and knowledge processes, the results remain ambiguous, with some authors finding positive effects (Østergaard et al. 2011, Garcia Martinez et al. 2017), some finding non-linear effects (Dahlin et al. 2005), and some finding no effects at all (Faems and Subramanian 2013).

Thus, there is still some controversy about whether the informational variety perspective will lead to robust causal predictions. In this paper, we argue that the informational variety perspective can be further refined to take into account the specific organizational contexts of the team. So far, because many of the most prominent papers in the diversity literature rely on upper echelons theory, a large share of the literature has looked only at the diversity in Top

Management Teams (TMTs) (Eesley et al. 2014, Campbell and Minguez-Vera 2007, Joecks et al. 2013, Miller and del Carmen Triana 2009). We regard this strong emphasis on TMTs as potentially problematic because research has shown that also lower level managers can have strong effects on firm level performance (Wooldridge and Floyd 1990, Raes et al. 2011). Therefore, we argue that the mixed findings in the diversity literature may result from neglecting the organizational context of the team.

Building on the problem-based view of the firm (Nickerson and Zenger 2004, Felin and Zenger 2015, Baer et al. 2013), we hold that high-ranking TMTs are in charge of the strategic decisions that affect whether or not to engage in innovation activities at all, while lower-ranking Middle Management Teams (MMTs) attend to the actual *implementation* of the innovation process and thus affect its outcome. We argue that educational diversity in TMTs is more likely to affect the decision to engage in innovation activities, while educational diversity in MMTs more likely affects the outcome side of innovation. Moreover, acknowledging that innovation outcomes differ drastically in their degree of novelty, we distinguish between imitative innovation and genuine market novelties. We expect that the effects of MMTs' educational diversity is most pertinent for market novelties.

Testing our theoretical predictions with biennial linked employer-employee panel dataset for Sweden for the period 2004-2012, we believe that our contribution is important because we provide a detailed conceptualization of innovation as a process by distinguishing between the decision to engage in and the outcome of innovation. We furthermore explain how the organizational level of teams shapes the expected effects of diversity, where large parts of the diversity literature have adopted upper echelons theory and focused on the effects of diversity in TMTs or the board of directors (Campbell and Mínguez-Vera 2007, Miller and del Carmen Triana 2009, Eesley et al. 2014). Our theory suggests that focusing solely on upper echelons runs the risk of misattributing the effects of diversity, some of which are at least partly attributable to lower-level MMTs (Floyd and Wooldridge 1999, Wooldridge et al. 2008). On a practical level, our results have important implications for employing diversity as an organizational means to promote innovation. If a firm believes that its weakness relates to the initial step of engagement in innovation, e.g. if poor strategic decisions are stopping the firm from engaging in innovation, increasing diversity in the TMT might help. If, however, the firm believes that the problem relates to the outcome side, e.g. if the concern is about the efficient use of available resources to attain positive innovation outcomes, increasing diversity in the MMT might be the better option.

THEORY & HYPOTHESES

Diversity, Performance and Innovation

Despite the theoretical arguments in favor of the benefits of diversity, empirical accounts have largely yielded mixed results (van Knippenberg and Schippers 2007, Meyer et al. 2014). Most authors have explained these mixed results by arguing that, on the one hand, diversity causes social categorization processes that imply costs, while, on the other hand, it increases access to relevant diverse information (Williams and O'Reilly 1998, van Knippenberg et al. 2004, Dahlin et al. 2005). The perspective emphasizing social categorization is inspired by social identity theory, which argues that particularly salient demographic diversity attributes, such as gender or nationality, lead individuals to categorize their team members into in-group (similar) or out-group (dissimilar) members (Faems and Subramanian 2013), implying conflict and low levels of information-sharing (Jackson et al. 1995, George and Chattopadhyay 2009). In contrast, the evolutionary perspective of innovation (Nelson and Winter 1982) emphasizes that diversity implies a greater variety of information (Hambrick et al. 1996, Eesley et al. 2014). Greater informational variety allows teams to create solutions that are more valuable by combining distant, yet complementary, information sources (Fleming 2001, Yayavaram and Ahuja 2008, Tavassoli and Carbonara 2014, Dahlin et al. 2005, Bower and Hilgard 1981). Furthermore, greater informational variety may mitigate several behavioral biases by making constructive criticism more likely (Barsade et al. 2000) and by increasing the willingness to incorporate feedback (Mitchell et al. 2009). Diversity helps ensure that team members analyze a problem from different perspectives (Hambrick et al. 1996, Eesley et al. 2014) and avoids making important decisions prematurely (van Knippenberg and Schippers 2007). Shin and Zhou (2007) conclude that diversity on the whole increases the quality of decision-making and creativity in teams.

The question of how to integrate both the information variety perspective and the social categorization perspective has been the subject of considerable scholarly debate. Several authors have argued that, in particular, diversity pertaining to task-related dimensions such as education has positive effects (Harrison and Klein 2007, Talke et al. 2011, Østergaard et al. 2011, Faems and Subramanian 2013).

First, educational backgrounds are closely related to the task performed by the team (Faems and Subramanian 2013), and therefore directly affect the informational benefits. Education is an important source of knowledge and forms a cognitive framework that allows individuals to decide which information is important and what to do with it (Faems and Subramanian 2013). Because teams that are more diverse will have joint access to broader cognitive frames, they are more likely to perform better (Østergaard et al. 2011, Hambrick et al. 1996). Dahlin et al. (2005) show that an important mechanism linking diversity to performance is indeed the use of information. In addition, the effects of educational diversity on information use are likely to persist over extended periods of time. The reason is that the cognitive frameworks created by education not only determine what an individual currently knows or is able to perform. By affecting and filtering the type of information an individual perceives as useful or valid, cognitive frames develop cumulatively and are therefore self-enforcing. Accordingly, several authors have highlighted remarkable differences in competences, solution approaches, and skills between engineers and scientists, which are unlikely to vanish as individuals grow older (Allen 1977, Allen and Katz 1992, Faems and Subramanian 2013).

Second, unlike gender or nationality, task-related diversity such as educational backgrounds are more difficult to observe directly, making individuals less likely to categorize their team members as similar or dissimilar (Williams and O'Reilly 1998). Moreover, educational diversity is less likely to lead to processes of social categorization when compared to other task-related dimensions such as work experience. Work experience is often based on the variety of functions individuals perform within a firm (Dahlin et al. 2005). For example, belonging to one type of function or department as opposed to another creates an organizational categorization, into which individuals sort their co-workers (Bunderson and Sutcliffe 2002). Educational and functional diversity differ from each other due to the fact that educational diversity has less marked social categorization effects and may therefore be a better indicator of informational diversity (Williams and O'Reilly 1998).

Although intuitive, even in the case of educational diversity, the effects on innovation are mixed. Most studies in this field focus on the level of the organization in its entirety, because innovation typically relates to a firm-level outcome. Indeed, some studies have corroborated the positive effects of educational diversity on innovation (Østergaard et al. 2011, Talke et al. 2010, Garcia Martinez et al. 2017). However, there are also more critical voices arguing for a non-monotonic relationship. For example, Dahlin et al. (2005) focus on the role of educational diversity in information use in small teams of students and provide evidence of an inverted U-shape of diversity. Although embracing the notion that educational diversity promotes innovation, Faems and Subramanian (2013) and Parrotta et al. (2014) find no significant effects at organizational level.

In this paper, we propose that the mixed findings on the informational variety perspective result from an incomplete understanding of how the tasks related to innovation are distributed organizationally in the firm. The distribution of tasks has implications on the question of how educational diversity in management teams affects innovation. More specifically, we argue that some teams are more likely to influence strategic decisions and planning while other teams influence the outcome of innovation. However, since most studies choose the former (Miller and del Carmen Triana 2009) or the latter (Bantel and Jackson 1989, Talke et al. 2010, Østergaard et al. 2011) on an ad hoc basis, there is considerable imprecision in the definition of the causal mechanisms that drive the relationship between educational diversity and innovation.

The Effects of the Organizational Level on the Diversity-Innovation Relationship: A Problem-Based View

The problem-based view of a firm emphasizes that management has two important tasks in the innovation process. The first task is to formulate a concrete problem. The second is to devise processes to solve it (Nickerson and Zenger 2004, Baer et al. 2013, Felin and Zenger 2015). Thus, the problem-based view distinguishes strategic managerial tasks from operational ones. We build on this task-related distinction and argue that it reflects an organizational distinction that is prevalent in most companies.

In particular, problem formulation is a managerial task involving high-order generic decision-making that precedes and structures the ensuing decisions related to problem-solving (Lyles and Mitroff, 1980, Watson et al 1993, Baer et al. 2013). Regarding innovation, managerial decisions related to problem formulation include whether to engage in innovation at all, what resources to allocate and which broad topics to follow. Thus, the decisions related to problem formulation are strategic ones about overall planning. In contrast, the managerial tasks related to problem-solving concern the implementation of the innovation process. Such tasks pertain to the effective use of the resources made available during the problem formulation phase and include decisions on whether to start, continue or discontinue specific innovation projects, how to distribute resources between them, and how to organize the interdepartmental teams in charge of the innovation projects. These decisions thus crucially affect the outcome side of innovation.

While firms differ in the degree to which they rely on top-down mechanisms, the innovation process is often organized such that TMTs decide on the general scope of feasible/permissible activities for lower-level MMTs, which are then in charge of implementing the high-level decisions of the TMTs for ongoing innovation processes (cf. Wooldridge and Floyd 1990, Floyd and Wooldridge 1999, Wooldridge et al. 2008, Talke et al. 2011). In practice, TMTs make strategic and crucial decisions about whether to innovate at all, while MMTs take these TMTs higher-order decisions as given for their own decision-making. Since MMTs' tasks typically relate to the effective use of the resources available for innovation within the framework set by TMTs, MMTs have a considerable effect on the actual outcome of these innovation processes.

The Hypotheses

The problem-based view emphasizes that an important strategic task of TMTs is to ensure that the company remains continuously committed to innovation and that it permanently challenges established practices (Teece et al. 1997, Nickerson and Zenger 2004). On this strategic decision side, a prerequisite for innovation is the ability to detect problems whose solutions could have a positive effect for the company and opportunities that increase the company's engagement in innovation (Teece 2007). The general decision to innovate is typically a higher-order decision that tends to be located at the level of TMTs (Teece 2010). We argue that educational diversity in TMTs positively affects the ability to identify valuable problems, thereby also raising the likelihood of engaging in innovation, via several mechanisms. First, greater educational diversity implies access to broader knowledge pools, which allows TMTs to assess the conditions in their environment more accurately (Faems and Subramanian 2013, Biemann and Kearney 2010). Second, diversity has positive effects on team creativity (Shin and Zhou 2007), which can also help TMTs to perceive new applications of existing internal capabilities. Third, educational diversity can also make TMTs more capable of assessing internally available knowledge sources, allowing them to perceive valuable recombinations in situations where more homogenous teams see only unrelated knowledge sources. One argument against a monotonously positive effect of TMT diversity on innovation derives from the notion that excessive levels of diversity can introduce costs. Such costs mainly result from the additional required communication and coordination between very diverse team members. While Dahlin et al. (2005) indeed provide evidence of negative effects on various types of information use for excessive levels of team diversity, their research setting is very specific and focuses on ad hoc assembled teams of MBA students. Since the costs of diversity can often be mitigated by creating better communication routines or routines for conflict resolution within established teams, one of the reasons for the negative effect in Dahlin's and colleagues' study may be that the observed teams were newly established and therefore had little opportunity to create more efficient communication routines. Our setting is indeed different because the teams we observe usually had existed for longer periods of time. In the TMTs and the MMTs the average tenure was about 5 years. The joint tenure was 4 years for TMTs and 2 years for MMTs[1]. We therefore assume that TMTs diversity increases the firm's chances to decide to engage in innovation activities.

H1): Educational diversity in TMTs has a positive effect on the firm's likelihood to engage in innovation activities (the decision to innovate).

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[1] Average tenure was defined as the arithmetic average of the tenure periods of all members. Joint tenure was defined as the minimum of all members' tenure periods. We note that the provided figures even underestimate true average and joint tenure because occupational data is only available in our dataset from 2001 onwards. Because our last sample year is 2012, the maximum observable tenure period for each individual member is therefore 12 years.

Once the TMTs have decided to engage in innovation, the actual implementation of specific innovation projects begins. At this operational level, MMTs play a leading role that includes establishing the necessary processes, selecting specific innovation projects, deciding which projects to (dis)continue and managing the teams in charge of specific innovation projects. In addition to finding a solution to a certain problem, successful innovation also involves bringing the solution to market. Thus, MMTs make decisions related to product design, marketing, and sales. Because MMTs are more likely to understand the causal ambiguities of specific problems (King and Zeithaml 2001) and the firm's internal competences (King et al. 2001), they have a strong influence on how effectively the resources allocated to innovation are used. Accordingly, Glaser et al. (2015), Floyd and Lane (2000), and Raes et al. (2011) claim that the central importance of MMTs is their role of implementing the strategic intent of TMTs.[2] We posit that MMTs diversity positively affects the success of innovation activities by guaranteeing greater efficiency in resource utilization. We therefore assume that MMTs diversity increases the firm's chances to introduce new products successfully.

H2): Educational diversity in MMTs has a positive effect on the firm's likelihood to introduce new products (the outcome side of the innovation process).

H2 concerns the likelihood of introducing new products without differentiating the qualitative aspects of the introduced products. However, new products are very heterogeneous along many dimensions, particularly with respect to their novelty. The Oslo Manual (OECD 2005) makes a distinction between new-to-firm and new-to-market products. New-to-firm products are innovations that already exist on the market and are therefore only new to the firm introducing them. New-to-firm products are also called imitative. New-to-market products are

[2] That argument is not to say that TMTs have given up all control over the implementation of the actual innovation process. For example, TMTs may still claim the right of the final decision to release a developed product. Our argument therefore does not rule out any effect of TMT diversity. Rather, our argument posits that MMTs diversity is likely to be the decisive factor.

genuinely novel because they have no predecessor on the market. We expect educational diversity to have a different effect on purely imitative innovations and on market novelties. Recent research on the relationship between creativity and innovation shows that creativity is particularly important during the idea generation phase (Anderson et al. 2014). For imitative product development, however, the idea generation phase is less important or even absent. Instead, imitation is a process by which an existing product diffuses from the original innovating firm to its competitors, resulting in "me-too" products (Samuelsson and Davidsson 2009). Therefore, the intellectual contribution in product imitation does not solve a new technical problem or envisage a new demand but detects a market disequilibrium that the imitating firm can exploit by offering a competing product (Kirzner 1973). Since the generation of a novel technological idea or the identification of new demand is missing from the process of imitation, introducing imitative products is less reliant on creativity. Moreover, since one major contribution of educational diversity is to raise team creativity (Shin and Zhou 2007), we expect that the positive effects of diversity will be less important for new-to-firm and more important for new-to-market products. Furthermore, creativity may also frame and guide search behavior by broadening the search strategy in the sense that creative teams will actively look for solutions that are more creative rather than embark on imitative product development. Accordingly, many authors have noted that diversity reduces firms' tendencies towards incrementalism (Amara and Landry 2005, Nieto and Santamaria 2007, Garcia Martinez et al. 2017). In summary, we expect that the beneficial effect of MMTs' diversity (cf. H2) is particularly strong with regard to novel innovations without a predecessor in the market.

H3): The effect of educational diversity in MMTs is stronger for new-to-market innovation than for new-to-firm innovation.

In Figure 1, we present a summary of the conceptual model and the hypotheses.

[Insert Figure 1 about here]

METHODS

Data

Dataset. The dataset used in this paper results from merging three different data sources, all maintained by the Swedish Statistical Office (SCB). These sources are (i) the Community Innovation Survey (CIS), (ii) a matched population employer-employee dataset at the individual level (LISA), and (iii) a population dataset of registered firms in Sweden. The CIS dataset provides information about the data related to innovation for this study. The dataset is based on a harmonized survey conducted every two years by all EU member states. The CIS questionnaire is based on the Oslo Manual co-developed by the OECD and the EU Commission over a 25-year period (OECD 2005, 3rd revision). The Oslo Manual includes rigorous guidelines for measuring central phenomena related to innovation processes in firms. The reliability, validity, and interpretability of the survey were established by extensive pre-testing and piloting prior to its implementation in different European countries (Laursen and Salter 2006, Peters and Rammer 2013). Over the years, the survey has become increasingly popular with empirical studies in the fields of both management and economics (Crépon, Duguet, and Mairesse 1998, Laursen and Salter 2006, Cassiman and Veugelers 2006, Lööf and Heshmati 2006, Grimpe and Kaiser 2010, Tavassoli and Karlsson 2015, Schubert et al. 2017).

We matched five consecutive waves of the Swedish CIS in 2004, 2006, 2008, 2010, and 2012. In all five waves, there is information concerning the introduction of product innovations and whether such product innovations are new- to-firm (i.e. imitative) or new-to-market. The survey covers a sample of firms with 10 or more employees in a variety of industrial sectors including manufacturing, construction, and services (NACE codes 10–73, see Table 2 for more details). Firms with 10–249 employees are stratified by random sampling, covering 33% of the population[3]. Firms with 250 or more employees are fully covered. Although firms below 250 employees are not fully covered, firms are selected such that the sample reflects the population in terms of size, sectoral composition, and region of origin. Participation is mandatory, and firms that do not complete the questionnaire must pay a fine. For this reason, the overall response rate is usually high and ranges between 63% and 86% over the five waves. Considering the sampling procedure and high response rates, the CIS sample is unlikely to differ greatly from the population of firms with 10 or more employees, although some bias remains towards an oversampling of innovative firms. We merged these firms with the LISA dataset that includes a wide variety of information on the characteristics of all employees (including management teams) in the firms. Doing so allowed us to use the information on employees' educational backgrounds to construct our main diversity measures (which we will elaborate below). Finally, we merged the linked LISA dataset with registered firm characteristics data (e.g. the number of employees, physical capital, export intensity, and industrial sector affiliation) to obtain various firm-level control variables. Our final panel dataset consists of 486 firms (1,873 observations). We will present the description of all variables in Appendix A2.

Identification of the management teams. Our dataset matches every individual within a firm to his/her specific occupation code, which is based on the International Standard Classification of Occupations ISCO-88 (ILO, 2012). We used this occupation code to identify the management-level teams within any given firm as follows: First, we identified employees with the occupation code ISCO 1210 (i.e. executive directors and chief executives) as members of the TMT within any given firm. This occupation code refers to individuals who "*formulate and review the policies, and plan, direct, coordinate and evaluate the overall activities, of*

[3] The coverage of random sampling ranges from 27% to 42% depending on the survey year, with an average of 33%. The method is based on stratified independent random sampling with Neyman allocation. The stratification depends on size range and industrial sector of firms based on NACE rev.2.

enterprises or organizations with the support of other managers [i.e. middle managers, insertion by the authors] *usually within guidelines established by a board of directors or a governing body to whom they are answerable for the operations undertaken and results*" (ILO 2012, p. 90). Members of the TMT can therefore be considered identical to the top executive level of a firm. The board is not identifiable using ISCO.

Hierarchically below the TMT is situated the MMT, which we identified using the occupation codes ISCO 122X and 123X. These codes represent middle-level managers who are responsible for the implementation of various functions within a given organization, such as production and operations managers, research and development managers, supply and distribution managers, finance and administrative managers, and personnel and industrial relations managers (Table A1 in the Appendix).

On a conceptual level, the ISCO-88 classification thus makes it possible to distinguish between TMT managers, who are primarily involved in tasks related to high-level planning, coordination, and monitoring, and MMT managers, who implement the higher-level strategic intent with respect to the different functions in a firm.

Definitions of the Main Variables

The dependent variables. We first created a variable that captures the decision of a firm whether or not to engage in innovation at all (*Innovation engagement*). This is a dichotomous variable that is equal to 1, if a firm engages in any of the following five categories of innovation-related activities (expenditures): internal R&D, external R&D, the acquisition of machinery as a measure of embodied technological change, the acquisition of other external knowledge, or investment in the market introduction of the innovation. This variable reflects the strategic choice to engage in innovation (cf. H1) and goes beyond mere R&D investments. Therefore, it incorporates a wide range of investment inputs into the innovation process. This broader view of innovation engagement complies well with the Oslo Manual (OECD, 2005) that emphasizes the need to go beyond the measurement of R&D as the central investment and engagement activity, since this reflects only one part of all investments and is not necessarily the most important one either (Smith, 2005).

On the outcome side of the innovation process (cf. H2), we focus on actually implemented product innovations and use a binary variable that takes the value of 1 if a firm successfully introduces at least one product innovation in a given period of time (*Product innovation*). A product innovation, in line with the Oslo Manual guideline, is defined as the successful market introduction of a new or significantly improved service or good with respect to its capabilities, user-friendliness, components, or subsystems. This variable is a direct measure of innovation output, as opposed to an intermediate measure such as patents used by Faems and Subramanian (2013), among others. While intermediate measures are suitable to capture “invention” (however, not necessarily the market implementation of that invention), product innovation, as a direct measure of innovation outcome, explicitly considers the introduction of a new product to the market, which is in line with the Schumpeterian definition of innovation (Kleinknecht et al., 2002). We further differentiate the product innovations introduced by firms based on their degree of novelty by distinguishing between new-to-firm innovations and new-to-market product innovations (cf. H3). A new-to-firm innovation refers to a purely imitational product innovation, while a new-to-market innovation is an innovation for which there was no comparable previous solution available on the market. The latter therefore has a higher degree of novelty (Laursen and Salter, 2006; Klingebiel and Rammer, 2014).

Educational diversity. Two commonly used indicators of variety are the Blau Index and Teachman's Entropy Index. Both indicators share similar mathematical properties. Harrison and Klein (2007) therefore propose them as alternative measures. However, there are some slight differences between them. In the applied literature, the Blau Index seems to be more popular because its functional form is simple. Entropy measures are rooted in information processing and communication theory, which argues that the value of an information set increases with each signal but, for repeated signals, the additional value is subject to diminishing returns (Shannon 1948, Frenken 2007). Therefore, while the Blau Index assumes a sort of constant returns to diversity, Teachman's Entropy Index assumes diminishing returns.

With respect to the dimension of educational diversity, the most common definition seems to be the diversity of educational backgrounds measured by subject (Dahlin et al., 2005; Hutzschenreuter & Horstkotte, 2013, Faems and Subramanian 2013). Diversity of educational backgrounds is strongly associated with a variety of the knowledge pool as well as creative thinking and innovation (Bower and Hilgard, 1981; Dahlin et al., 2005), which particularly shapes top executives' "professional knowledge, skills, and abilities" (Hutzschenreuter & Horstkotte, 2013: 709). Allen (1977) and Allen and Katz (1992), for example, show marked differences between engineers and (natural) scientists. The former often rely on experiential knowledge, craftsmanship, and learning-by-doing, while the latter tend to resort to formalized analytical and theory-driven methods (Moodysson et al. 2008, Asheim and Gertler 2005). The groupings of educational background used in this paper are based on the official International Standard Classification of Education (ISCED97), which is also implemented in the Swedish education nomenclature (SUN2000)[4]. Each individual (i.e. a member of a TMT or MMT) has a one-digit education field that can take one of the following nine values: $j=1$ (general education), $j=2$ (pedagogy and teaching), $j=3$ (social science, law, business, and administration), $j=4$ (natural science, mathematics, and computer science), $j=5$ (technology and manufacturing), $j=6$ (agriculture, forestry, and animal care), $j=7$ (health, medical care, and

[4] Because of the official nature of ISCED/SUN classifications, we have relatively limited possibilities to depart from them. The only option would be to disaggregate the subjects on a more fine-grained level than the nine broad categories we currently have. However, this did not seem to be an attractive option, because we argue that the benefits of educational diversity result from providing novel perspectives. Subdividing engineering, for example, into nanoscience, chemical engineering, and bio-engineering does not seem to be very useful because these categories would overlap to a large degree. We therefore believe that adhering to the most aggregated categories as provided by ISCED/SUN is the best option. Additionally, adopting the official definitions seems the recommended option because any custom-made groupings would raise additional concerns and questions.

social care), *j=8* (services), and *j=9* (other). Moreover, for people with multiple educational degrees, the SCB chooses the highest degree (e.g. a master over a bachelor). If multiple degrees are on one level, the SCB records the most recent degree based on the date of graduation.

Since educational backgrounds are measured as a categorical variable defined based on a set of predefined classes of backgrounds, we can formulate the measure of educational diversity of TMT in firm *i* in year *t* based on the Teachman's Entropy and Blau Indexes in equations (1.1) and (1.2), respectively, as follows:

$$Diversity\_TMT\_Education^{E}{}_{i,t} = \sum_{j=1}^{J} TMTEDU_{i,t,j} \, ln \, (\frac{1}{TMTEDU_{i,t,j}}) \quad (1.1)$$

$$Diversity\_TMT\_Education^{B}{}_{i,t} = 1 - \sum_{j=1}^{J} TMTEDU_{i,t,j}^{2} \quad (1.2)$$

where $TMTEDU_{i,t,j}$ is the share of the TMT with educational background *j* of the total TMT managers in firm *i* in year *t*. We identified the TMT managers in any given firm *i* in year *t* as described in the *identification of management teams* section.

Theoretically, both diversity measures have a minimum value of 0 if all the TMT managers in firm *i* have exactly the same educational background *j.* The maximum values for $Diversity\_TMT\_Education^{E}{}_{i,t}$ is 1.73 and for $Diversity\_TMT\_Education^{B}{}_{i,t}$ is 0.89, which are reached when there is an equal distribution of TMT managers over all nine educational backgrounds *j*. Similar to equations (1.1) and (1.2), we can construct the measure of educational diversity of MMT in firm *i* in year *t* as follows:

$$Diversity\_MMT\_Education^{E}{}_{i,t} = \sum_{j=1}^{J} MMTEDU_{i,t,j} \, ln \, (\frac{1}{MMTEDU_{i,t,j}}) \quad (2.1)$$

$$Diversity\_MMT\_Education^{B}{}_{i,t} = 1 - \sum_{j=1}^{J} MMTEDU_{i,t,j}^{2} \quad (2.2)$$

where $Diversity\_MMT\_Education^{E}{}_{i,t}$ and $Diversity\_MMT\_Education^{B}{}_{i,t}$ are the entropy and Blau indexes for the MMT educational diversity of firm *i* in year *t*.

Other diversity-related measures as controls. Apart from educational diversity, we included another two dimensions of non-task-related diversity to at least partly control for processes of social categorization using the same formulae as those above. Non-task-related diversity refers to more salient dimensions because they are immediately observable and also because individuals are trained to associate themselves with or disassociate themselves from them (George and Chattopadhyay 2009). This ultimately may result in separation and social categorization. More specifically, we used national diversity (Herring, 2009) and gender diversity (Francoeur et al. 2008, Campbell and Mínguez-Vera 2007) of TMT and MMT members. Gender diversity and national diversity are, though not ideal, reasonably good proxies of the degree of importance of social categorization processes, primarily if having a different gender or a different nationality is strongly associated with differences in beliefs, values, or norms.

An alternative to conceptualize the costs related to the social categorization of diversity involves "fault lines", which measure the extent to which hypothetical dividing lines (e.g. gender) create homogeneous subgroups (Meyer et al. 2014). Because of the potential problems of weighing costs merely by using gender and national diversity, we also consider measures drawing from the fault lines approach (cf. Robustness Checks).

Empirical Methodology

The dependent variables in H1 and H2 (dichotomous variables for the innovation engagement of firms and the product innovation outcome, respectively) suggest the use of probit models. We used ordered probit models to test H3[5]. We restricted the sample to firms that have at least

[5] The dependent variable in H3 can take a value of no product innovation introduced, merely New-to-Firm innovations, and New-to-Market innovations. Since New-to-Market innovations are, by definition, also new to the firm, the dependent variable is ordered along the dimension of market novelty. Because this ordering is somewhat implicit and theory driven, we also ran our models using a non-ordered multinomial logit but did not observe any important differences in the results.

one employee classified as belonging to the TMT and one employee belonging to the MMT[6]. We further dropped the top 5% of observations with an excessive TMT or MMT size as outliers in the robustness check of the results (cf. *Robustness Checks*). All models consider the panel nature of the data by computing standard errors based on clustering cross-sectional observations.

Apart from the two diversity measures used as control variables as described above, we included the following additional control variables: First, to control for the size of the management teams within firms, we included the share of TMT members (*TMT_Share*) and MMT members (*MMT_Share*) to the total number of employees in any given firm. Second, to control for size of the firm, we included the total turnover of the firm in a given period (*Turnover*). Third, to control for employee diversity (members of the organization who are not TMT or MMT members) and, hence, a possible "bottom-up" process influencing the innovation, we included educational diversity in total employment (*Diversity_Employee*) using Teachman's Entropy and Blau Indexes. Fourth, to capture the capital intensity of firms, we included a variable that measures the sum of investments (value in million Swedish krona) in buildings and machines (*Physical capital*). Fifth, a variable for the productivity of the firm, which we measure by total turnover divided by the total number of employees in any given firm in a given period of time (*Productivity*). Sixth, following the learning-by-exporting literature (Grossman and Helpman 1991), we included a variable that captures firms' international links measured by export intensity (*Export*). Seventh, we included another diversity measure that captures the specialization vs. generalization composition of teams. Here, the group category *j* takes the value of 1 if the educational background of a team member is specifically reported as general education and the value of 2 in all other cases (specialized education categories based on ISCED97 as described above). This aspect is important to control for since a diverse team

[6] We also analyzed the results when excluding firms, which never had at least two members in each team (see robustness results).

in terms of including both specialist and generalist members presumably performs better in complex activities such as those related to innovation. Eighth, since our *Diversity_MMT_Education* measure may simply be an artifact of organizational departmentalization following a greater division of labor, we included a variable that measures the number of different departments (functions) in a firm per employee (*Department*). Finally, to account for general sector differences, we used sector dummies corresponding to the one-digit categories in the NACE industrial classification. We also included general year dummies to control for any unobserved time-specific effects over the period of study, 2004-2012. The precise definitions of all the variables are presented in Appendix A2.

RESULTS

Descriptive Results

Table 1 illustrates the number of firms as well as the average, minimum, and maximum size of the TMTs and MMTs in our sample. The table also shows the breakdown of this sample into small vs. large firms, high-tech vs. low-tech enterprises, and manufacturing vs. service industries. Considering the sum of all firms, the average TMT has 4.33 members, and the average MMT has 29.20 members. Analyzing the firms based on size shows that, as expected, small firms (≤249 employees) have fewer members and large firms (>249 employees) have more members in their TMTs and MMTs. Sorting the firms based on their industrial sector and level of technology reveals no clear pattern of differences in terms of the size of their TMTs and MMTs.

[Insert Table 1 about here]

The descriptive results for the main variables in our analysis are presented in Table 2. With regard to the strategic decision about innovation, the table shows that 65% of firms engage in innovation activities (i.e. *Innovation engagement*), which is somewhat higher than the EU average of 49% taken from the official Eurostat statistics. The relatively high share of innovative firms typically reported by the CIS primarily results from the focus on firms with 10 or more employees and the broader definition of innovation engagement activities, which goes significantly beyond focusing purely on R&D, as noted earlier.

With regard to the innovation outcome side (*Product innovation*), the table shows that 55% of firms are not introducing any innovation (0), 23% are introducing new-to-firm innovations (1), and 22% are introducing new-to-market innovations (2).

As for the descriptive statistics, it is also worth noting that the average diversity among MMTs is approximately three times higher than that among TMTs. Also, the majority of firms are from manufacturing and construction (approximately 76%), while the rest are from service industries.

[Insert Table 2 about here]

Table 3 reports the correlation coefficient matrix. In general, the results show relatively modest correlations between the variables, implying that the subsequent regression analysis should show minor multi-collinearity issues. This implies an absence of bias against the subsequent regression analysis results.

[Insert Table 3 about here]

Main Results

We present the results of our main empirical estimations in Tables 4, 5a, and 5b, which report the average marginal effects so that these coefficients are directly interpretable in terms of magnitude. Moreover, although the correlation matrix did not indicate any severe multi-collinearity problems, we introduce our main explanatory variables in the regression models sequentially to mitigate any remaining multi-collinearity issues between *Diversity_TMT_Education* and *Diversity_MMT_Education*.

[Insert Table 4 about here]

Hypothesis 1 suggests that TMTs educational diversity positively influences the strategic decision to engage in innovation activities. Our results generally corroborate this in Table 4. More precisely, the estimations indicate that greater diversity among TMTs (*Diversity_TMT_Education*) positively and significantly increases the probability of engaging in innovation activities, regardless of whether we measure diversity by Teachman's Entropy Index (columns 4.1 and 4.3) or the Blau Index (columns 4.4 and 4.6). A one-unit increase[7] in the educational diversity of a given TMT leads to an increase in the probability of engaging in innovation activities of 12 to 19 percentage points, *ceteris paribus* (depending on whether the entropy or the Blau Index is used). In addition, in line with our reasoning, MMT diversity is not significant in any of the regressions. Thus, we find support for Hypothesis 1.

Hypothesis 2 suggests MMT educational diversity has a positive effect on the introduction of product innovations. This should therefore affect the outcome side of the innovation process. We present the results of the regression analyses in Table 5a (columns 5a.1, 5a.4, and 5a.7 for the Entropy Index) and in Table 5b (columns 5b.1, 5b.4, and 5b.7 for the Blau Index). Tables 5a and 5b show that greater MMT diversity clearly leads to a higher probability that firms will successfully introduce product innovations, again, regardless of whether we measure diversity using the entropy index or the Blau Index. A one-unit increase in the educational diversity of a MMT in any given firm is associated with a 39 to 67 percentage point increase (depending on whether the Entropy or Blau index is used) in the probability of successfully introducing product innovations, *ceteris paribus*. On the other hand, TMT diversity is not significant in any of the regressions; that is in line with our reasoning. This suggests a differential effect of TMTs

[7] There are various ways to illustrate such a "one-unit increase" in practice. For example, considering the entropy measure of diversity, imagine a firm with two TMT members who are both in one educational category, e.g. social science (j=1 and *Diversity_TMT_Education* = 0). A one-unit increase in the diversity measure occurs if this firm adds six more TMT members, each pair of which belongs to a new educational category, i.e. adding three new educational categories, e.g. natural science, technology, and health (j=4 and *Diversity_TMT_Education* =1).

and MMTs on the decision to engage versus the outcome side of innovation. Thus, Hypothesis 2 is supported.

Hypothesis 3 suggests splitting product innovations (see H2) into new-to-firm innovations and new-to-market innovations. We argued that the positive effects of diversity stem largely from increasing creativity, which should be more important for new-to-market innovations. We show the results in Table 5a (columns 5a.2, 5a.3, 5a.5, 5a.6, 5a.8, and 5a.9 for the entropy index) and in Table 5b (columns 5b.2, 5b.3, 5b.5, 5b.6, 5b.8, and 5b.9 for the Blau index).

[Insert Table 5a about here]

[Insert Table 5b about here]

Tables 5a and 5b show that MMT diversity has a strongly significant effect on new-to-market innovations but does not have a significant effect on new-to-firm product innovations. Thus, while MMT diversity has a generally positive effect on product innovation outcome (H2), this only seems to be true for product innovations with a greater degree of novelty. A one-unit increase in the educational diversity of a MMT in any given firm is associated with a 13 to 23 percentage points increase (depending on whether the entropy or Blau Index is used) in the probability of successfully introducing new-to-market product innovations, *ceteris paribus*. As above, Tables 5a and 5b show that, TMT diversity has no influence on the actual success of product innovations, neither for imitative nor for more novel product innovations. Thus, Hypothesis 3 is supported.

Robustness Checks

To support our findings further, we performed extensive sets of tests by using Blau Indexes adjusted to team size, continuous measures of innovation inputs and alternative ways to incorporate diversity costs. We also consider delimitation of our theory by taking firm size as a moderating factor and investigate potential endogeneity biases due to simultaneity. We look at the definition of MMT, and restrictions to the size of the TMTs and MMTs. Due to space limitations we refrain from presenting the tables here. They are available from the authors upon request.

Blau Index adjusted to team size. Recent methodological advances suggest that a Blau Index adjusted to team size may account for measurement artifacts induced by different team sizes (Harrison and Klein 2007, Biemann and Kearney, 2010). In particular, if the number of categories is larger than the number of group members, some categories remain empty, even if all group members are assigned to different categories. Therefore, the theoretical maximum of the diversity index cannot be reached for a given number of categories. To adjust for this issue, we used measures proposed by Biemann and Kearney (2010) and re-estimated Tables 4, 5a, and 5b. The main results remained the same.

Continuous innovation engagement measures. Table 2 shows that a large share of the sample firms is innovation-active (65%). While this figure only slightly exceeds the official Swedish statistics provided by Eurostat, where about 50% of the sample firms are innovation-active, an issue may be that this measure sets a relatively low threshold and therefore does not sufficiently discriminate with respect to the typically skewed distribution of 'expenditure' measures for innovation. We therefore re-ran our models of Table 4 with the innovation expenditures as a share of turnover (innovation expenditure intensity) as the dependent variable. On average, the innovation-intensity was 3.5%. The distribution however has a long right tail (skewness: 22.8)[8], with many firms having no or a very low innovation expenditure intensity and some firms having a very high intensity (95th percentile: 10.1%; 99th percentile: 56.0%). When using the continuous measure, overall we corroborate the results in Table 4 qualitatively, although some of the diversity measures were only significant at the 10% level.

[8] Zero indicates a symmetric distribution.

Alternative ways to incorporate the costs of diversity. We have highlighted that the costs of diversity are largely related to processes of social categorization. We followed the approach of including gender and national diversity as controls, as they are presumably more closely linked to processes of social categorization. Since we obtained slightly negative (however, non-significant) effects, doubts remain about the quality of these measures to account for social categorization processes. Team fault lines are an alternative construct that are closely related to the costs resulting from social categorization[9]. Indeed, there is considerable meta-analytical support for the negative effects of fault lines on team performance (Thatcher and Patel 2012). At present, fault lines are measured using ordering, variance-based, regression-based, or clustering methods (Meyer et al. 2011). In our case, we derived a simplified version measuring the degree to which gender and nationality divide the MMT and the TMT into subgroups. Gender is already a binary indicator, and we dichotomized nationality into Swedish and foreign. Doing so allowed us to measure the extent to which females and foreigners are unequally distributed across the different educational categories (*j*) in the team. Focusing on the TMTs and gender, for instance, the formula is as follows:

$$FAULT\_STRENGTH\_TMT^{GEN}{}_{i,t} = \frac{1}{J}\sum_{j=1}^{J}(SHARE\_FEM\_TMT_j - SHARE\_FEM\_TMT)^2$$

where $SHARE\_FEM\_TMT_j$ is the share of females in the team in educational category j, $SHARE\_FEM\_TMT$ is the total share of females, and *J* is the number of teams with non-empty educational categories. This measure increases if females are spread unequally across educational categories and therefore captures the idea of subgroup diversity inherent in fault

[9] Fault lines are hypothetical dividing lines that split teams into homogenous subgroups (Lau and Murnighan 1998, Meyer et al. 2014) and show how multiple measures of diversity align. For example, consider a MMT split into two engineers and two economists, where two of the members are female and two are male. There would be no strong fault line if there were one female and one male engineer and the same for the economists. There would be a fault line, however, if gender fully predicted the educational background. There is agreement that such fault lines are strongly related to social categorization because they increase the likelihood that team members consider themselves as belonging to different social subgroups (Meyer et al. 2011).

lines. We defined a comparable measure for the share of foreigners and the same measures for the MMT, resulting in four fault line measures.

We re-ran the regressions of Tables 4, 5a, and 5b using these four measures to replace the four gender and national diversity measures for MMTs and TMTs. The results with respect to the educational diversity measures remained largely unchanged. The fault line effects were largely non-significant, but, when they were significant, negative, as was expected.

Apart from social categorization as the source of diversity costs, too much diversity in the educational backgrounds of team members may also cause potential costs. The reason is that too much educational diversity can create a cognitive distance between team members, leading to inefficient communication (Dahlin et al., 2005). Although we believe that the relatively long joint tenure periods in our setting may reduce the importance of communication costs, a more explicit strategy is to consider a curvilinear relationship between diversity and innovation. We implemented this strategy by including quadratic terms in our regression models in Tables 4, 5a, and 5b. Including the linear term and the quadratic term for education diversity separately in the regression yields the same results as before. However, including both the original term and quadratic term together in the same regression erased all the results completely. From a technical perspective, this can be explained by the fact that both the original term and the quadratic term recover the same linear relationship between diversity and innovation. This implies that the relationship between diversity and innovation is adequately captured by a positive monotonic relationship as shown in Tables 4, 5a, and 5b.

Delimitations of the theory. H1–H3 describe how the organizational level of the teams affects the decision to engage in innovation and the outcome of innovation. Because our dataset includes firms that differ substantially in terms of size, we analyze whether H1–H3 hold true for all firms irrespective of size so far. In this way, we treated the hypothesized effects as unconditionally true. However, it is unlikely that the results hold true irrespective of any specific context.

Because our dataset includes firms of all sizes, it is interesting to analyze inasmuch as the size of the firm influences the results in H1–H3. Another reason for focusing on this variable is that size may have considerable influence on how firms learn and innovate. Dutta and Crossan (2005) for example argue that learning takes place in two differentiated processes. In the first process, firms primarily learn from knowledge held by diverse employees. To make individual level knowledge available to the firm, knowledge must be agreed upon and integrated in the team. In a second process, this body of knowledge is institutionalized and stored in stable organizational routines. Grillitsch and Schubert (2018) build on this understanding and argue that especially younger and smaller firms tend to rely more on the knowledge of individual employees because of the absence of developed organizational routines, while larger and older firms rely more on organizational routines. In consequence, the effects of educational diversity in teams may be stronger in smaller firms.

In order to allow the effects in H1–H3 to differ by firm size, we considered size (measured by the number of employees) as a moderating factor in the management team's diversity innovation relationship. Relying on the Entropy Index (the Blau Index leads to comparable results), we therefore re-ran Tables 4 and 5 by including firm size as a moderating factor. We present visual representations of the marginal effects instead of the coefficients of the interaction variable, because it is difficult to infer the shape of the interaction effect in non-linear models such as our probit models from the interaction coefficient. The visual representation can be found in Figure 2.

[Insert Figure 2 about here]

Our results show that the marginal effects are downward sloping across the size of the firm for both MMT and TMT diversity and for both the decision to innovate as well as actual innovation outcomes. Thus, our results suggest that team diversity has more influence in smaller firms. These results put our arguments in H1–H3 into perspective in at least two respects. First, the moderating effect of firm size shows that our theory is subject to contingency factors. We cannot explore all of them in this paper due to the limited scope. However, further studies could help to analyze important contingencies in detail. Second, the fact that our arguments in H1–H3 are robust even for very small firms is an important evidence for the strength of our theory.

Direction of causality. Our hypotheses implicitly treat the diversity measures as exogenously determined, which is a strong assumption because diversity in management teams can also arise from previous strategic decisions with regard to engaging in innovation-related activities or to the actual innovation outcome. For instance, an organization with a better innovation performance (or greater engagement in innovation-related activities) may attract managers with more diversified educational backgrounds, resulting potentially in simultaneity bias. We used a two-stage least squares (2SLS) approach to correct for potential endogeneity bias. Although we did not have access to natural experiments, one way to construct variables containing exogenous sources of variation is to use variables at higher levels of aggregation. First, we used the regional averages of the diversity measures, which are measured by the average value of both TMT and MMT diversity across the 72 Swedish local labor market regions. We assume that a regional average measure of diversity is related to the diversity of management teams, but it does not affect innovation other than through the indirect effect on the firms' actual team diversity. Second, we used sector averages of diversity measures (instead of the regional average) as instruments. Third, we used the total number of managers in the firm, which we expect to be related to the diversity of management teams but not necessarily to the firms' innovation engagement or outcomes. Finally, we used the diversity measure of the number of inter-regional inflow migration of TMT and MMT to the region in which a given firm is located.

Formal tests showed that our results did not suffer from the problems of weak instruments. The results confirmed the main conclusions of Tables 4, 5a, and 5b.

Other robustness checks. Finally, we performed three additional robustness checks. One criticism of our MMT diversity measure may be that not all functions in a firm are equally relevant for innovation. We therefore computed a restricted version of the *Diversity_MMT_Education* variable that comprised only functions that we assumed to be more innovation-related. We decided to incorporate R&D, sales, advertising, and supply chain management, while we dropped the other categories contained in Table A1 (e.g. finance managers). The second criticism of our sample could be the excessive number of TMT and MMT members in some firms. We re-ran all the regressions with a restricted sample, in which we excluded the top 5% of firms with large numbers of TMT and MMT members. This reduced the average TMT and MMT members to 1.92 and 13.48, respectively. Our results were not affected by these robustness checks. Finally, another issue may be that our teams could consist of only one member. In this case, our diversity measures take, by definition, the minimum value of zero. Because our theoretical perspective is based on informational variety, this definition makes intuitive sense. In particular, informational variety is theoretically identical in a team that consists of only one member with a specific education, and in a larger team in which all members have the same educational background. A counter-argument may be that teams of only one member can only increase diversity by growing, implying that diversity in one-member teams becomes meaningless. We have therefore excluded firms that had never had more than one member in their TMTs and MMTs during the observation period. Our results were not affected by this sample restriction.

DISCUSSION AND CONCLUSION

Analyzing diversity in management teams has been a core topic in strategic management for a long time. The respective literature has considerably expanded our understanding of the relationship between innovation and diversity. In particular, research has progressed with respect to the conceptualization of diversity, pointing to the crucial distinction between processes of social categorization representing costs, and (information) variety representing benefits. Despite improved knowledge of the mechanisms related to diversity, however, less is known about the mechanisms related to different aspects of the innovation process within firms. In this paper, we argued that introducing a distinction between the strategic decision whether to innovate or not and actual innovation outcome implicitly introduces the organizational level of the management team as an important influencing factor.

Basing our arguments on the problem-based view (Nickerson and Zenger 2004, Baer et al. 2013), our framework predicted that TMTs' diversity affects the firms' decisions of whether to engage in innovation activities at all, while MMTs' diversity affects the actual outcome of the innovation processes. This central claim is important in several respects.

In particular, ignoring the organizational level may lead to a theoretical misattribution of diversity effects to certain management teams. To date, most studies analyzing the relationship between diversity and innovation have done so at various levels, typically borrowing highly generic arguments without ensuring that they apply to the specific team under consideration. Some researchers have abstained from identifying teams at all (Østergaard et al. 2011) and measured diversity among all employees. While using all employees delivers a broad measure of diversity, it becomes difficult to use arguments based on team processes to support the reasoning, particularly when the company is large. Other authors have used diversity in R&D teams (Faems and Subramian 2013). However, the most common approach has been to address diversity in teams by referring to an elite of particularly powerful managers, typically referred to as upper echelons (Hambrick and Mason 1984, Hambrick 2007). Works building on the upper echelons theory have explicitly associated the effects of diversity with TMTs (Eesley et al. 2014, Campbell and Minguez-Vera 2007, Joecks et al. 2013, Miller and del Carmen Triana 2009). Our results suggest that focusing solely on the role of TMTs may be overrated, particularly if other levels are not included at least as a control. Upper echelons theory may attribute effects to TMT diversity even in cases where the real source of the effects is diversity in lower-level MMTs. This implies an overestimation of the influence of TMTs compared to that of lower ranks (Wooldridge and Floyd 1990, Raes et al. 2011).

We provided evidence that the organizational distribution of tasks between TMTs and MMTs implies that the TMTs primarily plan innovation activities and therefore affect the strategic decision whether to engage in innovation activities or not, while MMTs implement the actual innovation process and therefore affect its outcome. In this respect, our paper has commonalities with a paper published by Ndofor et al. (2015), who argue that TMT diversity has different effects on the resource-action link (in our case, whether to engage in innovation activities) and the resource-performance link (outcome of the innovation processes). However, we go beyond this notion by including multiple management levels that influence how diversity affects innovation engagement and outcome and thereby acknowledge that TMTs and MMTs have different effects on the resource-action and the resource-performance link. In particular, we show that educational diversity in MMTs is especially important for the resource-performance link, because it contributes to improve the actual innovation outcome. These effects turned out to be stronger for market novelties than purely imitative innovation.

Furthermore, the explicit inclusion of the organizational distribution of tasks not only allows us to gain a better understanding of how MMTs and TMTs differ and in what respect they complement each other from a conceptual perspective. We also argued that not including such an explicit differentiation may lead to poorly specified empirical models and this can partially explain the inability of the diversity literature to find robust causal effects on firm performance (Meyer et al. 2014, Bowers et al. 2000, Webber and Donnahue 2001, van Knippenberg and Schippers 2007, Faems and Subramanian 2013). Although we are unable to assert that our results are context-independent, our extensive robustness checks showed that they are at least very robust with respect to alternative methodological choices including different diversity indicators, the consideration of endogeneity issues, and conceptual choices on how to control for the costs of diversity.

Finally, we indicate some limitations of our work that could point the way to future research. In particular, while we have argued for the importance of including multiple organizational levels when analyzing the effects of diversity, we have not explicitly examined how these levels interact. In this context, a large part of the upper echelons theory has analyzed how diversity is linked to social processes at the intragroup level and has highlighted the importance of trust, debate, and conflict (Simons et al. 1999, Smith et al. 2005). There is strong evidence that such social processes mediate the ways in which diversity plays out at the intragroup level (Ensley et al. 2002, Olson et al. 2007). Simultaneously, trust, debate, and conflict most likely play a decisive role in how diversity shapes the interaction of TMTs and MMTs and how this interaction influences both the costs and benefits of diversity. It would therefore be highly relevant to expand the perspective propagated in this paper by research on the role of social processes moderating the effects of diversity. In addition, our initial analysis of firm size as a moderating factor showed that moderation effects are likely to be pertinent to our theory. Thus, our main hypotheses should not be understood as universal. These require further refinement in order to develop our proposed theory to include the organizational level of the team.

In summary, we believe that our study contributes to the literature by extending the informational variety perspective on diversity to include the organizational level of the teams. Our work is therefore an approach that explicitly takes into account that management teams do not exist in isolation but are embedded in the organizational framework of a firm. It is therefore important to take into account the specific tasks and responsibilities a certain team has when analyzing the role of team diversity for organizational performance.

REFERENCES

Allen, T. J.1977. Managing the flow of technology: technology transfer and the dissemination of technological information within the R&D organization, Massachusetts Institute of Technology, Cambridge, MA

Allen, T. J., & Katz, R. 1992. Age, education and the technical ladder. IEEE transactions on engineering management, 39(3), 237-245.

Amara, N., R. Landry. 2005. Sources of information as determinants of novelty of innovation in manufacturing firms: evidence from the 1999 statistics Canada innovation survey Technovation, 25: 245–259

Anderson, N., Potočnik, K., & Zhou, J. 2014. Innovation and creativity in organizations: A state-of-the-science review, prospective commentary, and guiding framework. Journal of Management, 40(5), 1297-1333.

Asheim, B., & Gertler, M. S.2005. The geography of innovation: regional innovation systems. The Oxford handbook of innovation, 291-317.

Baer, M., Dirks, K. T., & Nickerson, J. A. (2013). Microfoundations of strategic problem formulation. Strategic Management Journal, 34(2), 197-214.

Bantel, K., Jackson, S., 1989. Top management and innovations in banking: does the composition of the top team make a difference? Strategic Management Journal 10, 107–124.

Barsade, S. G., Ward, A. J., Turner, J. D., & Sonnenfeld, J. A. 2000. To your heart's content: A model of affective diversity in top management teams. Administrative Science Quarterly, 45(4), 802-836.

Becker, M.C., 2004. Organizational routines: A review of the literature. Industrial and Corporate Change 13 (4), 643–678.

Biemann, T., & Kearney, E. (2010). Size does matter: How varying group sizes in a sample affect the most common measures of group diversity. Organizational research methods, 13(3), 582-599.

Bower, G., Hilgard, E. 1981. Theories of learning. Englewood Cliffs, NJ: Prentice-Hall.

Bowers, C. A., Pharmer, J. A., & Salas, E. 2000. When member homogeneity is needed in work teams: A meta-analysis. Small group research, 31(3), 305-327.

Campbell, K, Mínguez-Vera, A. 2007. Gender Diversity in the Boardroom and Firm Financial Performance, Journal of Business Ethics, 83, 435-451

Cassiman, B., & Veugelers, R. 2006. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. Management science, 52(1), 68-82.

Crépon, B., Duguet, E., & Mairesse, J. 1998. Research, Innovation and Productivity: An Econometric Analysis at the Firm Level. Economics of Innovation and new Technology, 7(2): 115-158.

Dahlin, K. B., Weingart, L. R., & Hinds, P. J. 2005. Team diversity and information use. Academy of Management Journal, 48(6): 1107-1123.

De Cabo, Ruth Mateos, Ricardo Gimeno, and María J. Nieto. 2012. Gender diversity on European banks' boards of directors. Journal of Business Ethics, 109(2): 145-162.

Dutta, D.K., Crossan, M.M., 2005. The nature of entrepreneurial opportunities: Understanding the process using the 4I organizational learning framework. Entrepreneurship Theory and Practice 29 (4), 425–449.

Easley, C. E., Hsu, D. H., & Roberts, E. B. 2014. The contingent effects of top management teams on venture performance: Aligning founding team composition with innovation strategy and commercialization environment. Strategic Management Journal, 35(12), 1798-1817.

EIGE. 2016. Advancing gender equality in political decision-making, Good practices. https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&

uact=8&ved=0ahUKEwjEsLrcjoHYAhWCVZQKHVcvAtwQFggyMAE&url=http%3A%2F%2Feige.europa.eu%2Fsites%2Fdefault%2Ffiles%2Fdocuments%2Fmh0415104enn_0.pdf&usg=AOvVaw0eiuZG4rGaqIUWn71jO434

Ensley, M.D., Pearson, A.W., Amason, A.C. 2002. Understanding the dynamics of new venture top management teams: cohesion, conflict, and new venture performance, Journal of Business Venturing, 17: 365-386.

Faems, D., & Subramanian, A. M. 2013. R&D manpower and technological performance: The impact of demographic and task-related diversity. Research Policy, 42(9), 1624-1633.

Felin, T., & Zenger, T. R. 2015. Crossroads—Strategy, Problems, and a Theory for the Firm. Organization Science, 27(1), 222-231.

Fleming, L. 2001. Recombinant Uncertainty in Technological Search. Management Science 47: 117–132.

Floyd, S. W., & Wooldridge, B. 1999. Knowledge creation and social networks in corporate entrepreneurship: The renewal of organizational capability. Entrepreneurship Theory and Practice, Spring: 123-143.

Floyd, S. W., & Lane, P. J. 2000. Strategizing throughout the organization: Managing role conflict in strategic renewal. Academy of Management Review, 25: 154-177.

Francoeur, C; Labelle, R; & Sinclair-Desgagne, B. 2008. Gender Diversity in Corporate Governance and Top Management, Journal of Business Ethics, 81

Frenken, K. 2007. "Entropy Statistics and Information Theory." In Elgar Companion to Neo-Schumpeterian Economics, by Horst Hanusch and Andreas Pyka, 544-555. Edward Elgar.

Garcia Martinez, M., Zouaghi, F., & Garcia Marco, T. 2017. Diversity is strategy: the effect of R&D team diversity on innovative performance. R&D Management, 47(2), 311-329.

Garcia-Vega, M. 2006. Does technological diversification promote innovation?: An empirical analysis for European firms. Research Policy, *35*(2), 230-246.

George, E., & Chattopadhyay, P. 2009. "Group composition and decision making". In The Oxford Handbook of Organizational Decision Making.

Glaser, L., Fourné, S. L., & Elfring, T. 2015. Achieving strategic renewal: The multi-level influences of top and middle managers' boundary-spanning. Small Business Economics, 45: 305-327.

Grillitsch, M., Schubert, T. 2018. Integration of new skills and growth in start-up firms, paper presented at the DRUID summer conference 2018.

Grimpe, C., & Kaiser, U.2010. Balancing internal and external knowledge acquisition: the gains and pains from R&D outsourcing. Journal of management studies, 47(8), 1483-1509.

Grossman, G. M. & Helpman, E., 1991. Innovation and growth in the global economy. Cambridge: MIT Press.

Guillaume, Y. R., Brodbeck, F. C., & Riketta, M. 2012. Surface-and deep-level dissimilarity effects on social integration and individual effectiveness related outcomes in work groups: A meta-analytic integration. *Journal of Occupational and Organizational Psychology*, *85*(1), 80-115.

Hambrick DC. 2007. Upper echelons theory: an update. Academy of Management Review 32(2): 334–343.

Hambrick, D. C., & Mason, P. A. 1984. Upper echelons: The organization as a reflection of its top managers. Academy of management review, 9(2), 193-206.

Hambrick, D. C., Cho, T. S., & Chen, M. J. 1996. The influence of top management team heterogeneity on firms' competitive moves. Administrative science quarterly, 659-684.

Harrison, D. A., & Klein, K. J. 2007. What's the difference? Diversity constructs as separation, variety, or disparity in organizations. Academy of management review, 32(4), 1199-1228.

Herring, C. 2009. Does Diversity Pay?: Race, Gender, and the Business Case for Diversity, American Sociological Review, 74: 208-224.

Hutzschenreuter, T., & Horstkotte, J. (2013). Performance effects of top management team demographic faultlines in the process of product diversification. Strategic Management Journal, 34(6), 704-726.

ILO (2012), International Standard Classification of Occupations: Structure, group definitions and correspondence tables, *International Labor Office*, Geneva

Jackson, S. E., May, K. E., & Whitney, K. 1995. Understanding the dynamics of diversity in decision-making teams. Team effectiveness and decision making in organizations, 204, 261.

Joecks, J., Pull, K., & Vetter, K. 2013. Gender diversity in the boardroom and firm performance: What exactly constitutes a "critical mass?". *Journal of business ethics*, *118*(1), 61-72.

King, A. W., & Zeithaml, C. P. 2001. Competencies and the causal ambiguity paradox. Strategic Management Journal, 22: 75-99.

King, A.W., Fowler, S.W., Zeithaml, C.P. 2001. Managing organizational competencies for competitive advantage: The middle-management edge, *Academy of Management Perspectives*, 15: 95-106.

Kirzner, I. 1973. Competition and Entrepreneurship, University of Chicago Press.

Kleinknecht, A., Van Montfort, K., & Brouwer, E. 2002. The Non-Trivial Choice between Innovation Indicators. *Economics of Innovation and New Technology*, 11(2), 109-121.

Klingebiel, R., & Rammer, C. 2014. Resource allocation strategy for innovation portfolio management. Strategic Management Journal, 35(2), 246-268.

Lau, D. C., & Murnighan, J. K. 1998. Demographic diversity and faultlines: The compositional dynamics of organizational groups. Academy of Management Review, 23(2), 325-340.

Laursen, K., Salter, A., 2006. Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. Strategic Management Journal 27: 131–150.

Li, C.-R. 2013. How Top Management Team Diversity Fosters Organizational Ambidexterity: The Role of Social Capital among Top Executives. Journal of Organizational Change Management 26: 874–896

Li C.R., Liu, Y.Y., Lin, C.J., Ma, H.J. 2016. Top management team diversity, ambidextrous innovation and the mediating effect of top team decision-making processes, Industry and Innovation, DOI:10.1080/13662716.2016.1144503.

Lyles MA, Mitroff II. 1980. Organizational problem formulation: an empirical study. Administrative Science Quarterly 25: 102–119.

Lööf, H., & Heshmati, A.2006. On the relationship between innovation and performance: A sensitivity analysis. *Economics of Innovation and New Technology*, 15(4-5), 317-34

Meyer, B., Glenz, A., Antino, M., Rico, R., & González-Romá, V. 2014. Faultlines and subgroups: A meta-review and measurement guide. *Small Group Research*, *45*(6), 633-670.

Meyer, B., Shemla, M., & Schermuly, C. C. 2011. Social category salience moderates the effect of diversity faultlines on information elaboration. *Small Group Research*, *42*(3), 257-282.

Miller, T., del Carmen Triana, M. 2009. Demographic Diversity in the Boardroom: Mediators of the Board Diversity–Firm Performance Relationship, *Journal of Management Studies*, 46: 755-786

Mitchell, R., Nicholas, S., & Boyle, B. 2009. The role of openness to cognitive diversity and group processes in knowledge creation. Small Group Research.

Moodysson, J., Coenen, L., & Asheim, B. 2008. Explaining spatial patterns of innovation: analytical and synthetic modes of knowledge creation in the Medicon Valley life-science cluster. Environment and Planning A, 40(5), 1040-1056.

Nelson, R. R., & Winter, S.G. 1982. An evolutionary theory of economic change, 929-964.

Ndofor, H. A., Sirmon, D. G., & He, X. 2015. Utilizing the firm's resources: How TMT heterogeneity and resulting faultlines affect TMT tasks. Strategic Management Journal, 36(11), 1656-1674.

Nickerson, J. A., & Zenger, T. R. 2004. A knowledge-based theory of the firm—The problem-solving perspective. Organization science, 15(6), 617-632.

Nieto, M.J., Santamaria, L. 2007. The importance of diverse collaborative networks for the novelty of product innovation, Technovation, 27: 367-377.

OECD, 2005. *Oslo Manual: guidelines for collecting and interpreting innovation data.* Paris: OECD and Eurostat.

OECD, 2017, Gross domestic spending on R&D (indicator). doi: 10.1787/d8b068b4-en (Accessed on 11 December 2017)

Olson, B.J., Parayitam, S., Bao, Y. 2007. Strategic decision making: The effects of cognitive diversity, conflict, and trust on decision outcomes, *Journal of Management*.

Østergaard, C. R., B. Timmermans, and K. Kristinsson. 2011. Does a Different View Create Something New? The Effect of Employee Diversity on Innovation. Research Policy 40 (7): 500–509.

Parrotta, P., Pozzoli, D., & Pytlikova, M. 2014. The nexus between labor diversity and firm's innovation. Journal of Population Economics, 27(2), 303-364.

Peters, B. and Rammer, C. 2013, Innovation Panel Surveys in Germany, in: Gault, F. (ed.), *Handbook of Innovation Indicators and Measurement, Edward Elgar*, Cheltenham, 135–177.

Raes, A., Heijltjes, M., Glunk, U., & Roe, R. 2011. The interface of top management team and middle managers: A process model. Academy of Management Review, 36: 102-126.

Roberge, M. É., & Van Dick, R. 2010. Recognizing the benefits of diversity: When and how does diversity increase group performance?. Human Resource Management Review, 20(4), 295-308.

Samuelsson, Mikael, & Davidsson, Per. 2009. Does venture opportunity variation matter? Investigating systematic process differences between innovative and imitative new ventures. Small Business Economics 33(2): 229-255.

Schubert, T., Baier, E., Rammer, C. 2017. Firm Capabilities, Technological Dynamism and the Internationalisation of Innovation – a Behavioural Approach, Journal of International Business Studies, https://doi.org/10.1057/s41267-017-0101

Shannon, Claude E. 1948. A Mathematical Theory of Communication. Bell System Technical Journal 27 (3): 379–423.

Shin, S. J. and Zhou, J. 2007. When is educational specialization heterogeneity related to creativity in research and development teams? Transformational leadership as a moderator'. Journal of Applied Psychology, 92: 1709–1721.

Smith, Wendy K. and Tushman, Michael L. 2005. Managing strategic contradictions: A top management model for managing innovation streams. Organization Science, 16: 522-536.

Smith, K. 2005. Measuring innovation. In J. Fagerberg, D. C. Mowery, & R. R. Nelson, *The Oxford handbook of innovation* (pp. 148-179). Oxford: Oxford University Press.

Talke, K., Salomo, S., & Kock, A. 2011. Top management team diversity and strategic innovation orientation: The relationship and consequences for innovativeness and performance. Journal of Product Innovation Management, 28(6): 819-832.

Tavassoli S.; Carbonara N. 2014. The Role of Knowledge Variety and Intensity on the Regional Innovation, Small Business Economics 43(2): 493-509.

Tavassoli S., Karlsson C. 2015. Persistence of Various Types of Innovation Analyzed and Explained, Research Policy 44(10), 1887-1901.

Teece, D. J. 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. Strategic management journal, 28(13), 1319-1350.

Teece, D. J. 2010. Technological innovation and the theory of the firm: the role of enterprise-level knowledge, complementarities, and (dynamic) capabilities. Handbook of the Economics of Innovation, 1, 679-730.

Teece, D. J., Pisano, G., & Shuen, A. 1997. Dynamic capabilities and strategic management. Strategic management journal, 509-533.

Thatcher, S. M., & Patel, P. C. 2012. Group faultlines: A review, integration, and guide to future research. *Journal of Management*, *38*(4), 969-1009.

Van Knippenberg, D., De Dreu, C. K., & Homan, A. C. 2004. Work group diversity and group performance: an integrative model and research agenda. Journal of applied psychology, 89(6), 1008.

Van Knippenberg, D., & Schippers, M. C. 2007. Work group diversity. Annu. Rev. Psychol., 58, 515-541.

Watson WE, Kumar K, Michaelsen LK. 1993. Cultural diversity's impact on interaction process and performance: comparing homogenous and diverse task groups. Academy of Management Journal 36: 590–602.

Webber, S. S., & Donahue, L. M. 2001. Impact of highly and less job-related diversity on work group cohesion and performance: A meta-analysis. Journal of management, 27(2), 141-162.

Williams, K.Y., C.A. O'Reilly. 1998. Demography and diversity in organizations: a review of 40 years of research B.M. Staw, L.L. Cummings (Eds.), Research in Organizational Behavior, vol. 20, JAI Press, Greenwich, CT. (1998), pp. 77–140

Wooldridge, B., Schmidt, T., Floyd, S.W. 2008. The Middle Management Perspective on Strategy Process: Contributions, Synthesis, and Future Research, Journal of Management, 34: 1190-1221.

Wooldridge, B., & Floyd, S. W. 1990. The strategy process, middle management involvement, and organizational performance. Strategic management journal, 11(3), 231-241.

Yayavaram, S., and G. Ahuja. 2008. Decomposability in Knowledge Structures and Its Impact on the Usefulness of Inventions and Knowledge-Base Malleability. Administrative Science Quarterly 53: 333–362.

Figure 1
Conceptual model

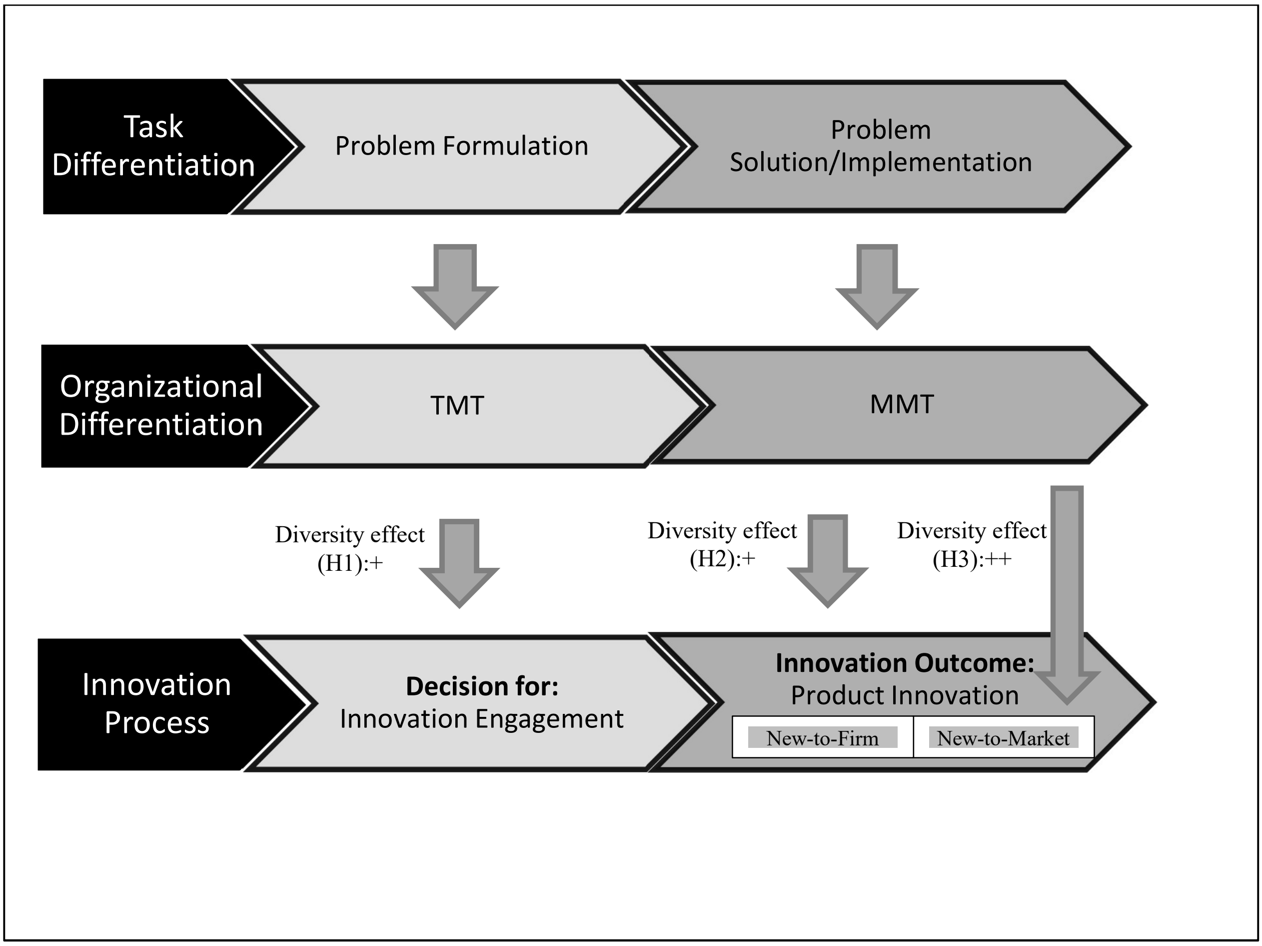


Table 1
Descriptive statistics for the size of TMTs and MMTs across various types of firms

	No. of firms	Mean	Min.	Max.
ALL FIRMS				
TMT	486	4.33	1	331
MMT	486	29.20	1	1686
SMALL FIRMS				
TMT	327	1.54	1	12
MMT	327	5.55	1	36
LARGE FIRMS				
TMT	182	8.64	1	331
MMT	182	65.74	1	1686
HTM FIRMS				
TMT	132	5.81	1	331
MMT	132	57.08	1	1686
LTM FIRMS				
TMT	245	3.38	1	193
MMT	245	15.23	1	294
HTS FIRMS				
TMT	68	4.35	1	58
MMT	68	17.89	1	178
LTS FIRMS				
TMT	41	5.05	1	66
MMT	41	39.49	1	301

Notes: SMALL FIRMS: firms with fewer than 250 employees, LARGE FIRMS: firms with 250 and more employees, HTM FIRMS: firms in high-tech manufacturing sectors, LTM FIRMS: firms in low-tech manufacturing sectors, HTS FIRMS: firms in high-tech service sectors, LTS FIRMS: firms in low-tech service sectors

Table 2
Descriptive statistics

VARIABLES*	Observations	Mean	Std. dev.	Min.	Max.
Innovation engagement	1873	0.65	0.47	0	1
Product innovation**	1873	0.68	0.82	0	2
Diversity_TMT_Education	1873	0.25	0.39	0	1.73
Diversity_MMT_Education	1873	0.80	0.45	0	1.91
Diversity_TMT_Gender	1873	0.08	0.20	0	0.70
Diversity_TMT_Nationality	1873	0.02	0.11	0	1.04
Diversity_TMT_Generalist	1873	0.07	0.19	0	0.73
Diversity_MMT_Gender	1873	0.34	0.26	0	0.69
Diversity_MMT_Nationality	1873	0.06	0.14	0	1.04
Diversity_MMT_Generalist	1873	0.23	0.25	0	0.71
TMT_Share	1873	0.03	0.05	5.91×10^{-4}	1
MMT_Share	1873	0.09	0.10	6.55×10^{-4}	1
Diversity_Employee	1873	1.31	0.28	0	1.93
Export	1873	0.27	0.34	0	1
Physical capital	1873	17.09	3.21	0	23.95
Productivity	1873	14.63	0.80	9.94	18.45
Turnover	1873	1.83	7.51	9.98×10^{-4}	111.97
Employee	1873	509.30	1600.54	10	19456
Department	1873	0.04	0.05	0	0.4
Industry Sectors***					
1. Manufacturing: food preparation, clothes, etc.	1873	0.18	0.39	0	1
2. Manufacturing: chemical, pharmaceutical, etc.	1873	0.40	0.49	0	1
3. Manufacturing: transportation vehicles	1873	0.17	0.38	0	1
4. Construction	1873	0.06	0.24	0	1
5. Service: Transportation, storage	1873	0.08	0.27	0	1
6. Service: Information, communication	1873	0.02	0.15	0	1
7. Service: Knowledge-intensive business services	1873	0.06	0.25	0	1

Notes: * The diversity variables are reported based on the entropy index. The diversity measures based on Blau and Blau-adjusted indexes have similar values.
** This is the dependent variable, which is categorical. Breaking it down into its categories, 55% of the sample are not introducing innovations (0), 23% are introducing new-to-firm innovations (1), and 22% are introducing new-to-market innovations (2).
*** Here we only report 1-digit industry classification (ranging from 1 to 7), which we used in our regression analysis as sectoral control dummies. Please refer to the Standard Industry Code Classification (NACE version 2) for detailed components of industries up to 5-digit classification.

Table 3
Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
(1) Innovation engagement	1																		
(2) Product innovation	0.58	1																	
(3) Diversity_TMT_Education	0.07	0.05	1																
(4) Diversity_MMT_Education	0.12	0.15	0.27	1															
(5) Diversity_TMT_Gender	0.03	0.02	0.54	0.19	1														
(6) Diversity_TMT_Nationality	0.07	0.08	0.25	0.14	0.16	1													
(7) Diversity_TMT_Generalist	-0.02	-0.04	0.62	0.13	0.34	0.08	1												
(8) Diversity_Mmt_Gender	0.08	0.09	0.12	0.51	0.16	0.05	0.03	1											
(9) Diversity_MMT_Nationality	0.05	0.07	0.06	0.2	0.06	0.11	0	0.17	1										
(10) Diversity_MMT_Generalist	-0.02	0.01	0.12	0.54	0.07	0.03	0.13	0.14	0.06	1									
(11) Diversity_Employee	0.02	0.05	0.15	0.33	0.13	0.08	0.12	0.2	0.11	0.25	1								
(12) Export	0.3	0.28	-0.06	0.11	-0.05	0.05	-0.08	0.07	0.12	-0.04	-0.03	1							
(13) Physical capital	0.14	0.1	0.2	0.34	0.09	0.15	0.07	0.11	0.1	0.1	0.12	0.13	1						
(14) Productivity	0.05	-0.01	0.12	0.2	0.08	0.11	-0.01	0.11	0.05	0.04	0.01	0.11	0.28	1					
(15) Employee	0.12	0.17	0.31	0.2	0.2	0.26	0.08	0.12	0.14	0.07	0.06	0.08	0.29	0.08	1				
(16) Turnover	0.1	0.15	0.24	0.17	0.15	0.28	0.04	0.12	0.14	0.04	0.05	0.09	0.26	0.22	0.92	1			
(17) Department	-0.07	-0.04	-0.2	-0.16	-0.12	-0.14	-0.09	-0.01	-0.14	-0.13	-0.16	0.06	-0.35	-0.02	-0.23	-0.18	1		
(18) TMT_Share	-0.11	-0.1	0.12	-0.25	0.08	-0.06	0.13	-0.15	-0.14	-0.15	-0.23	-0.07	-0.29	-0.06	-0.14	-0.11	0.56	1	
(19) MMT_Share	-0.03	0.01	-0.03	0.08	-0.02	-0.06	-0.03	0.1	-0.03	0	-0.19	0.05	-0.17	0.03	-0.09	-0.06	0.69	0.66	1

Table 4

TMT and MMT diversity and innovation engagement of firms

	Diversity: Entropy Index			Diversity: Blau Index		
VARIABLES	(4.1) Innovation Engagement	(4.2) Innovation Engagement	(4.3) Innovation Engagement	(4.4) Innovation Engagement	(4.5) Innovation Engagement	(4.6) Innovation Engagement
Diversity_TMT_Education	0.132***		0.127***	0.202***		0.191***
	(0.045)		(0.046)	(0.070)		(0.070)
Diversity_MMT_Education		0.053	0.022		0.070	0.019
		(0.041)	(0.042)		(0.072)	(0.075)
Diversity_TMT_Gender	-0.008		-0.011	0.000		-0.000
	(0.073)		(0.073)	(0.103)		(0.101)
Diversity_TMT_Nationality	0.054		0.052	-0.182		-0.184
	(0.101)		(0.100)	(0.130)		(0.128)
Diversity_TMT_Generalist	-0.133*		-0.119	-0.159		-0.140
	(0.080)		(0.080)	(0.105)		(0.103)
TMT_Share	-0.472*		-0.635*	-0.541*		-0.677*
	(0.281)		(0.373)	(0.281)		(0.365)
Diversity_MMT_Gender		0.025	0.020		-0.058	-0.048
		(0.058)	(0.058)		(0.045)	(0.045)
Diversity_MMT_Nationality		-0.067	-0.071		-0.092	-0.053
		(0.094)	(0.094)		(0.139)	(0.137)
Diversity_MMT_Generalist		-0.066	-0.054		-0.137	-0.122
		(0.065)	(0.064)		(0.090)	(0.089)
MMT_Share		0.037	0.197		0.020	0.190
		(0.208)	(0.209)		(0.206)	(0.203)
Diversity_Employee	0.077	0.083	0.074	0.066	0.115	0.103
	(0.053)	(0.054)	(0.055)	(0.116)	(0.121)	(0.121)
Export	0.363***	0.355***	0.355***	0.368***	0.354***	0.355***
	(0.047)	(0.047)	(0.047)	(0.046)	(0.047)	(0.047)
Physical capital	0.007	0.007	0.006	0.008	0.007	0.006
	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)
Productivity	-0.013	-0.011	-0.013	-0.013	-0.016	-0.017
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Turnover	0.021**	0.023**	0.020**	0.023**	0.026***	0.023**
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Department	0.061	-0.391	-0.198	0.003	-0.414	-0.238
	(0.333)	(0.399)	(0.376)	(0.339)	(0.406)	(0.382)
Pseudo R^2	0.142	0.139	0.144	0.142	0.138	0.145
No. of firms	486	486	486	486	486	486
Observations	1,873	1,873	1,873	1,873	1,873	1,873

Notes: The table reports the estimated Average Marginal Effects (AME) of probit models with clustered standard errors over 486 firms in parentheses. ***, ** and * indicate significance on a 1%, 5% and 10% level. The dependent variable in all models is whether firms engage in innovation activities or not (0/1). Columns (4.1) to (4.3) use the Entropy measure to operationalize all diversity variables; and columns (4.4) to (4.6) use Blau's index measure to operationalize all diversity variables. All models include a set of sector and time dummies. The results are based on the balanced panel of five waves of CIS with t=2004, 2006, 2008, 2010, 2012.

Table 5a

TMT and MMT diversity and innovation performance of firms: using the entropy (Teachman) index for measuring diversity variables

VARIABLES	(5a.1) Product Innovation	(5a.2) New-to-Firm	(5a.3) New-to-Market	(5a.4) Product Innovation	(5a.5) New-to-Firm	(5a.6) New-to-Market	(5a.7) Product Innovation	(5a.8) New-to-Firm	(5a.9) New–to-Market
Diversity_TMT_Education	0.179	-0.001	0.062				0.094	-0.000	0.032
	(0.133)	(0.002)	(0.046)				(0.137)	(0.001)	(0.047)
Diversity_MMT_Education				0.408***	-0.002	0.140***	0.393***	-0.002	0.135***
				(0.130)	(0.005)	(0.044)	(0.136)	(0.005)	(0.046)
Diversity_TMT_Gender	0.001	-0.000	0.000				-0.071	0.000	-0.024
	(0.223)	(0.001)	(0.077)				(0.221)	(0.001)	(0.076)
Diversity_TMT_Nationality	-0.004	0.000	-0.001				-0.026	0.000	-0.009
	(0.371)	(0.002)	(0.128)				(0.370)	(0.002)	(0.127)
Diversity_TMT_Generalist	-0.379	0.002	-0.131				-0.352	0.002	-0.120
	(0.249)	(0.005)	(0.086)				(0.247)	(0.005)	(0.084)
TMT_Share	-2.033	0.010	-0.703				-1.342	0.007	-0.459
	(1.310)	(0.027)	(0.454)				(1.416)	(0.018)	(0.485)
Diversity_MMT_Gender				0.034	-0.000	0.012	-0.002	0.000	-0.001
				(0.172)	(0.001)	(0.059)	(0.176)	(0.001)	(0.060)
Diversity_MMT_Nationality				0.105	-0.001	0.036	0.101	-0.001	0.035
				(0.266)	(0.002)	(0.091)	(0.263)	(0.002)	(0.090)
Diversity_MMT_Generalist				-0.233	0.001	-0.080	-0.232	0.001	-0.079
				(0.199)	(0.003)	(0.068)	(0.197)	(0.003)	(0.068)
MMT_Share				1.048	-0.005	0.359	1.205*	-0.006	0.412*
				(0.677)	(0.013)	(0.232)	(0.704)	(0.015)	(0.241)
Diversity_Employee	0.285	-0.001	0.098	0.150	-0.001	0.051	0.155	-0.001	0.053
	(0.183)	(0.004)	(0.063)	(0.184)	(0.002)	(0.063)	(0.186)	(0.002)	(0.064)
Export	0.305**	-0.002	0.106**	0.264**	-0.001	0.090**	0.235*	-0.001	0.080*
	(0.123)	(0.004)	(0.042)	(0.124)	(0.003)	(0.042)	(0.125)	(0.003)	(0.042)
Physical capital	0.003	-0.000	0.001	-0.013	0.000	-0.005	-0.015	0.000	-0.005
	(0.016)	(0.000)	(0.005)	(0.016)	(0.000)	(0.006)	(0.017)	(0.000)	(0.006)
Productivity	-0.139**	0.001	-0.048**	-0.169***	0.001	-0.058***	-0.169***	0.001	-0.058***
	(0.060)	(0.002)	(0.021)	(0.060)	(0.002)	(0.021)	(0.060)	(0.002)	(0.021)
Turnover	0.016***	-0.000	0.005***	0.016***	-0.000	0.005***	0.016***	-0.000	0.005***
	(0.004)	(0.000)	(0.001)	(0.003)	(0.000)	(0.001)	(0.004)	(0.000)	(0.001)
Department	1.688*	-0.008	0.583*	-1.166	0.006	-0.400	-0.733	0.004	-0.251
	(0.998)	(0.022)	(0.345)	(1.359)	(0.016)	(0.466)	(1.374)	(0.011)	(0.470)
Pseudo R^2	0.037	0.037	0.037	0.043	0.043	0.043	0.045	0.045	0.045
No. of firms	414	414	414	414	414	414	414	414	414
Observations	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233

Notes: The table reports the estimated Average Marginal Effects (AME) of ordered probit models with clustered standard errors over 414 firms in parentheses. ***, ** and * indicate significance on a 1%, 5% and 10% level. The base model (not reported in the table) is "no innovation", where firms indicate there was no introduction of product innovation. Diversity measures are based on Entropy indexes (equations 1.1 and 2.1). The results are based on the balanced panel of five waves of CIS with t=2004, 2006, 2008, 2010, 2012. Using a Multinomial Logit model as an alternative estimator reveals similar results (available upon request).

Table 5b

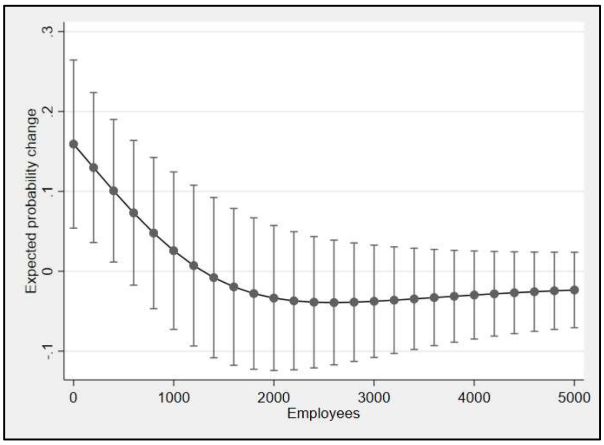
TMT and MMT diversity and innovation performance of firms: using the Blau index for measuring diversity variables

VARIABLES	(5b.1) Product Innovation	(5b.2) New–to-Firm	(5b.3) New-to-Market	(5b.4) Product Innovation	(5b.5) New-to-Firm	(5b.6) New-to-Market	(5b.7) Product Innovation	(5b.8) New-to-Firm	(5b.9) New-to-Market
Diversity_TMT_Education	0.296	-0.001	0.103				0.172	-0.001	0.059
	(0.203)	(0.004)	(0.070)				(0.206)	(0.002)	(0.071)
Diversity_MMT_Education				0.728***	-0.003	0.249***	0.673***	-0.003	0.230***
				(0.223)	(0.009)	(0.076)	(0.232)	(0.008)	(0.079)
Diversity_TMT_Gender	-0.015	0.000	-0.005				-0.113	0.001	-0.039
	(0.311)	(0.002)	(0.108)				(0.307)	(0.002)	(0.105)
Diversity_TMT_Nationality	0.002	-0.000	0.001				0.030	-0.000	0.010
	(0.333)	(0.002)	(0.115)				(0.346)	(0.002)	(0.118)
Diversity_TMT_Generalist	-0.393	0.002	-0.136				-0.376	0.002	-0.129
	(0.308)	(0.005)	(0.107)				(0.315)	(0.005)	(0.108)
TMT_Share	-2.355*	0.012	-0.815*				-1.418	0.007	-0.485
	(1.249)	(0.031)	(0.433)				(1.376)	(0.019)	(0.471)
Diversity_MMT_Gender				-0.147	0.001	-0.050	-0.133	0.001	-0.045
				(0.148)	(0.002)	(0.051)	(0.151)	(0.002)	(0.052)
Diversity_MMT_Nationality				-0.335	0.002	-0.115	-0.330	0.002	-0.113
				(0.363)	(0.004)	(0.124)	(0.360)	(0.004)	(0.123)
Diversity_MMT_Generalist				-0.331	0.002	-0.113	-0.317	0.002	-0.108
				(0.283)	(0.004)	(0.097)	(0.282)	(0.004)	(0.096)
MMT_Share				1.245*	-0.006	0.427*	1.372**	-0.007	0.469**
				(0.672)	(0.016)	(0.230)	(0.691)	(0.017)	(0.236)
Diversity_Employee	0.468	-0.002	0.162	0.294	-0.001	0.101	0.293	-0.001	0.100
	(0.406)	(0.006)	(0.140)	(0.414)	(0.004)	(0.142)	(0.416)	(0.004)	(0.142)
Export	0.305**	-0.001	0.106**	0.267**	-0.001	0.092**	0.245**	-0.001	0.084**
	(0.122)	(0.004)	(0.042)	(0.123)	(0.003)	(0.042)	(0.124)	(0.003)	(0.042)
Physical capital	0.003	-0.000	0.001	-0.013	0.000	-0.004	-0.015	0.000	-0.005
	(0.016)	(0.000)	(0.005)	(0.017)	(0.000)	(0.006)	(0.018)	(0.000)	(0.006)
Productivity	-0.142**	0.001	-0.049**	-0.173***	0.001	-0.059***	-0.174***	0.001	-0.059***
	(0.061)	(0.002)	(0.021)	(0.060)	(0.002)	(0.021)	(0.060)	(0.002)	(0.021)
Turnover	0.016***	-0.000	0.006***	0.018***	-0.000	0.006***	0.017***	-0.000	0.006***
	(0.004)	(0.000)	(0.001)	(0.004)	(0.000)	(0.001)	(0.004)	(0.000)	(0.001)
Department	1.676*	-0.008	0.580*	-1.772	0.008	-0.607	-1.229	0.006	-0.420
	(0.996)	(0.022)	(0.345)	(1.359)	(0.023)	(0.466)	(1.371)	(0.017)	(0.468)
Pseudo R^2	0.036	0.036	0.036	0.044	0.044	0.044	0.045	0.045	0.045
No. of firms	414	414	414	414	414	414	414	414	414
Observations	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233	1,233

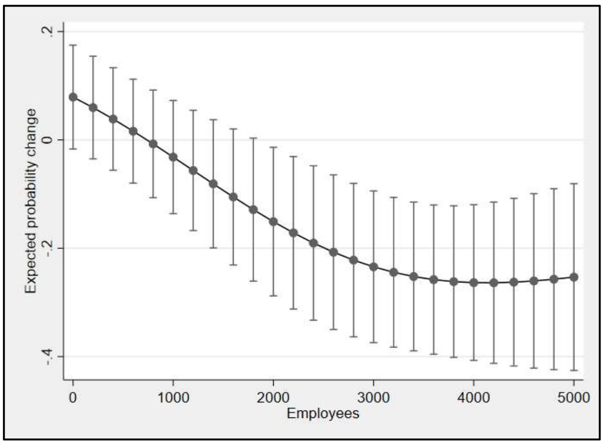
Notes: The table reports Average Marginal Effects (AME) of ordered probit models with clustered standard errors over 414 firms in parentheses. ***, ** and * indicate significance on a 1%, 5% and 10% level. The base model (not reported in the table) is "no innovation", where firms indicate no introduction of product innovation. Diversity measures are based on Blau indexes (equations 2.1 and 2.2). The results are based on the balanced panel of five waves of CIS with t=2004, 2006, 2008, 2010, 2012. Using the Multinomial Logit model as an alternative estimator reveals similar results (available upon request).

Figure 2

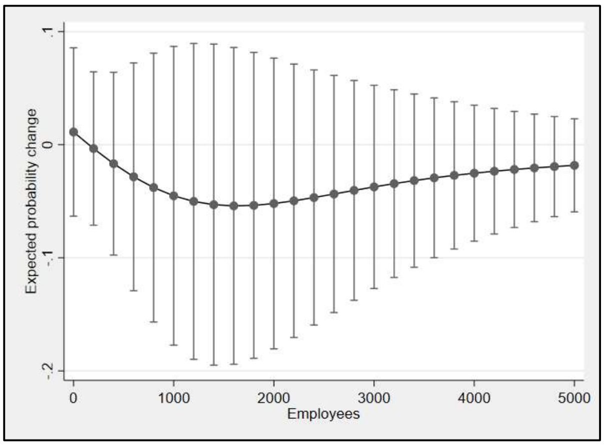
Firm size as a moderating factor on the management team's diversity-innovation relationship



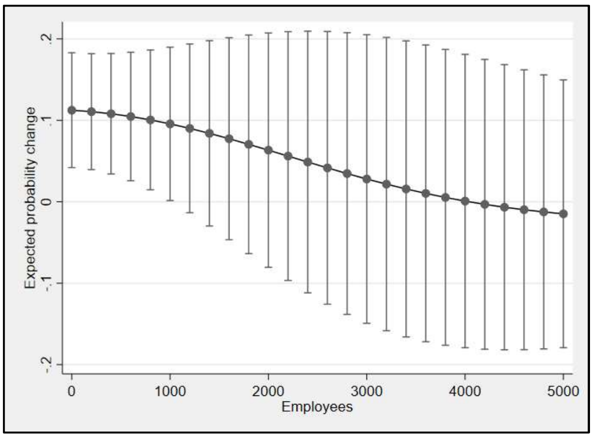
2a: Expected probability change of the effect of TMT diversity on *Innovation engagement* across firm size (number of employees)



2b: Expected probability change of the effect of TMT diversity on *Product innovation* across firm size



2c: Expected probability change of the effect of MMT diversity on *Innovation engagement* across firm size



2d: Expected probability change of the effect of MMT diversity on *Product innovation* across firm size

Appendix A1

Definition of TMT and MMT based on the International Classification of Occupations ISCO-88COM

ISCO88COM Code	Corporate Managers (Code 12)	TMT or MMT
121	**Directors and chief executives**	TMT
1210	Directors and chief executives	”
122	**Production and operations managers**	MMT
1221	Production and operations managers in agriculture, hunting, forestry, and fishing	”
1222	Production and operations managers in manufacturing	”
1223	Production and operations managers in construction	”
1224	Production and operations managers in wholesale and retail trade	”
1225	Production and operations managers in restaurants and hotels	”
1226	Production and operations managers in transport, storage, and communications	”
1227	Production and operations managers in business services enterprises	”
1228	Production and operations managers in personal care, cleaning and related services	”
1229	Production and operations managers not elsewhere classified	”
123	Other specialist managers	
1231	**Finance and administration managers**	MMT
1232	**Personnel and industrial relations managers**	MMT
1233	**Sales and marketing managers**	MMT
1234	**Advertising and public relations managers**	MMT
1235	**Supply and distribution managers**	MMT
1236	**Computing services managers**	MMT
1237	**Research and development managers**	MMT
1239	**Other specialist managers not elsewhere classified**	MMT

Notes: Refer to the section ‘*Identification of the management teams*’ in the text for further explanation.

Appendix A2

Variable definitions

Variables	Definitions
$Innovation\ engagement_{i,t}$	Takes value 1 if firm *i* in year *t* engages in at least one of the following five innovation-related activities (expenditures), and 0 otherwise: investment in internal R&D, investment in external R&D, investment in acquisition of machinery, investment in other external knowledge, or investment in market introduction of innovation
$Product\ innovation_{i,t}$	Takes value 0 if firm *i* in year *t* did not introduce any product innovation* (no innovation) Takes value 1 if firm *i* in year *t* successfully introduces at least one new-to-firm product innovation Takes value 2 if firm *i* in year *t* successfully introduces at least one new-to-market product innovation
$Diversity\_TMT\_Education_{i,t}$	The educational diversity of TMT in firm *i* in year *t*. See equations (1.1) and (1.2) for formulas based on entropy and Blau indexes, respectively.
$Diversity\_MMT\_Education_{i,t}$	The educational diversity of MMT in firm *i* in year *t*. See equations (2.1) and (2.2) for formulas based on entropy and Blau indexes, respectively.
$Diversity\_TMT\_Gender_{i,t}$	The gender diversity of TMT in firm *i* in year *t*. The formulas are based on the equations (1.1) and (1.2) for entropy and Blau indexes, respectively.
$Diversity\_TMT\_Nationality_{i,t}$	The national diversity of TMT in firm *i* in year *t*. The formulas are based on the equations (1.1) and (1.2) for entropy and Blau indexes, respectively. The individual registry data categorizes individuals in the following nationality groups: Sweden, Nordic countries (without Sweden), Europe (without Nordic countries), Africa, North America, South America, Asia, and other.
$Diversity\_TMT\_Generalist_{i,t}$	The generalist-specialist diversity of TMT in firm *i* in year *t*. The formulas are based on the equations (1.1) and (1.2) for entropy and Blau indexes, respectively.
$Diversity\_MMT\_Gender_{i,t}$	The gender diversity of MMT in firm *i* in year *t*. The formulas are based on the equations (1.1) and (1.2) for entropy and Blau indexes, respectively.
$Diversity\_MMT\_Nationality_{i,t}$	The national diversity of MMT in firm *i* in year *t*. The formulas are based on the equations (1.1) and (1.2) for entropy and Blau indexes, respectively. The individual registry data categorizes individuals in the following nationality groups: Sweden, Nordic countries (without Sweden), Europe (without Nordic countries), Africa, North America, South America, Asia, and other.
$Diversity\_MMT\_Generalist_{i,t}$	The generalist-specialist diversity of MMT in firm *i* in year *t*. The formulas are based on the equations (1.1) and (1.2) for entropy and Blau indexes, respectively.
$TMT\_Share_{i,t}$	The number of TMT members divided by the number of total employees in firm *i* in year *t*
$MMT\_Share_{i,t}$	The number of MMT members divided by the number of total employees in firm *i* in year *t*
$Diversity\_Employee_{i,t}$	An entropy measure that captures the diversity of employees (excluding TMT and MMT) in firm *i* in year *t*. See equations (1.1) and (1.2) for formulas based on entropy and Blau indexes, respectively.
$Productivity_{i,t}$	Labor productivity, measured as the amount of total turnover per employees in firm *i* in year *t* (log)
$Turnover_{i,t}$	A measure of firm size, proxied by the amount of total turnover (in BSEK) in firm *i* in year *t*
$Physical\ capital_{i,t}$	Physical capital, measured as amount of investment expenditures (in MSEK) in buildings and machines at year's end for firm *i* in year *t* (log)
$Export\ _{i,t}$	Exports (value in SEK) divided by the total turnover in firm *i* in year *t*
$Department_{i,t}$	The number of departments per employee in firm *i* in year *t* as the measure for the maximum number of different types of MMTs in firm *i* in year *t*
$Sector\ dummies_{i}$	Sector-specific component captured by seven industry dummies in 1-digit NACE code (see Table 2)
Time dummies	Time-specific component captured by five year dummies

* A product innovation is defined as the market introduction of a new or significantly improved good or service with respect to its capabilities, user friendliness, components, or sub-systems (OECD, 2005).