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Beyond Technological Diversification: The Impact of Employee Diversity on Innovation

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Abstract:
This paper investigates the effect of employee diversity in terms of gender, age, ethnicity and education on the firm's likelihood of introducing an innovation. The analysis draws on data from a recent innovation survey. This data is merged with a linked employer-employee dataset that allow us to identify the employee composition of each firm. We test the hypothesis that employee diversity is associated with better innovative performance. The econometric analysis reveals positive, negative and non-significant effects of the different employee characteristics on the likelihood of introducing an innovation.

Keywords: Diversity, Innovation, Education, Gender, Cultural Background

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1 Introduction

The notion of diversity plays an important role in a wide range of scientific disciplines (Stirling, 2007). Studies have suggested that there is a positive relationship between diversity in the firm's knowledge base and their innovative capabilities. Firms that are technologically diverse are more innovative and survive longer (Breschi et al., 2003; Suzuki and Kodama, 2004; Garcia-Vega, 2006). Firms with a variety of knowledge, experience and skills among their employees may benefit from complementarities that can foster development in other fields (Dosi, 1982; Quintana-García and Benavides-Velasco, 2008), have a broader organisational routines and search activities (Nelson and Winter, 1982; Dosi, 1988), have a higher absorptive capacity that allow the firm to exploit external knowledge (Cohen and Levinthal, 1990; Zahra and George, 2002), and are better to exploit internal knowledge through interaction and learning (Lundvall, 1992; Woodman et al., 1993; van der Vegt and Janssen, 2003). These theories suggest that employee diversity has a positive effect on innovation.

The relation between diversity in the composition of the workforce and firm performance was addressed in Penrose's work from 1959 where she states that: "It is the heterogeneity of the productive services available or potentially available from its resources that gives each firm its unique character" (Penrose, 1959, p. 75). An important element of these resources is a firms' human capital resources (Penrose, 1959; Barney, 1991). Human capital resources have a cognitive dimension, such as vocational training and experience; and a demographic dimension, such as gender, age and cultural background, which affect the application and combination of existing knowledge and the communication and interaction between employees.

Employee diversity is often considered to be positive since it might create a broader search space and make the firm more open towards new ideas and more creative. Ideally, diversity should increase a firm's knowledge base and increase the interaction between different types of competences and knowledge. As the cultural, educational and ethnic background among employees becomes more diverse so does the knowledge base of the firm. This creates possibilities for new combinations of knowledge (Schumpeter, 1934). However, increasing employee diversity strengthens the need for interaction and communication within the firm and might lead to conflict and distrust.

A growing literature is analysing the relation between diversity among top management teams and the performance of firms. The characteristics of the top managers appear to influence growth, productivity and revenues, since it influence their decisions, strategy, and responsiveness to change (Murray, 1989; Wiersema and Bantel, 1992; Pitcher and Smith, 2001). However, the studies focusing on the effect of diversity and innovation are scarce (Bantel and Jackson, 1989; O'Reilly and Flatt, 1989; Zajac et al., 1991; van der Vegt and Janssen, 2003). This paper takes its point of departure in these studies but extends this work in multiple ways. First, we include all the employees within the firm because the composition of the top management team does not necessarily reflect the composition of the larger pool of human capital in the firm (Laursen et al., 2005). This approach is supported by the notion that innovation is an interactive process that often involves communication and interaction among employees in a firm and draws on their different qualities from all levels of the organisation (Lundvall, 1985, 1992). Second, the analysis is based on a large-scale innovation-based survey that directly addresses innovation and not innovation proxies. The contributions of this paper are substantive. First of all by using an employer-

employee database. This enables us to look at all the employees in the firm and to extend the analysis to a larger sample and more industries compared to previous studies. In addition, a major contribution is made to the scarce literature on human capital diversity and innovation thereby arguing to move beyond the much more studied technological dimension of diversity.

The empirical analysis is based on two types of datasets: The first is a questionnaire based innovation survey (DISKO4) collected in 2006 focusing on organisational and technical change in more than 1,600 Danish manufacturing and service firms in the period from 2003 to 2005. This database is merged with register data from the Integrated Database for Labour Market Research (IDA) that contains detailed information on all Danish firms and all individuals on the labour market. Therefore it is possible to link employee diversity in terms of gender, age, education, and ethnicity with the innovative behaviour of these firms. The analysis shows that employee diversity has an effect on the innovative performance of firms. We find that employee diversity with respect to gender and education has a significant positive effect on firms' likelihood to innovate, while diversity in age has a significant negative effect. The remainder of the paper is structured as follows. Section 2 contains a discussion on diversity and innovation. Section 3 describes the data. Section 4 presents the results of the logistic regressions analysis and Section 5 discusses the results. Section 6 presents the conclusions and suggestions for further research.

2 Diversity and Innovation

Studies in evolutionary economics often consider diversity, in tangible and intangible resources, within firms to be positively related to performance. Firms with a diverse knowledge base that covers a wide range of technologies have better organisational problem solving routines and broader search activities (Nelson and Winter, 1982; Dosi, 1988). Technologically diverse firms are also found to be more innovative and survive longer (Breschi et al., 2003; Suzuki and Kodama, 2004; Garcia-Vega, 2006). Technological diversity creates cross-fertilization and spillovers between related knowledge bases which positively affects the firms innovative competences. When firms broaden their technological base by adding new technologies, they also widen their search for complementarities and novel combinations (Quintana-García and Benavides-Velasco, 2008). Diversity in a firms knowledge base also increases the firms ability to exploit knowledge from external sources (Cohen and Levinthal, 1990; Zahra and George, 2002). The firms absorptive capacity depends on the diversity in knowledge in the firm. Knowledge diversity improves the basis for learning and enables firms to make new combinations (Cohen and Levinthal, 1990). Firms with diversity in the skills, knowledge and experiences among their employees also increase the possibilities for new combinations of internal knowledge through interaction and learning (Lundvall, 1992; Woodman et al., 1993; Wenger, 2000; van der Vegt and Janssen, 2003). Different points of views, educational backgrounds and experiences facilitate the exploratory competence of a firm through better problem solving and generation of new ideas (Quintana-García and Benavides-Velasco, 2008).

However, in the knowledge-based economy a firm relies less on their tangible and more on their intangible resources (Teece et al., 1997). As a result the firm's knowledge base, in the form of human capital, becomes even more important in explaining its performance. This human capital is affected by diversity in the composition of employees and their interaction (Laursen et al., 2005). Thus, employee diversity is

a key variable for understanding the knowledge base of the firm. Employee diversity is often measured by individuals' demographic attributes that are used as a proxy for different attitudes, knowledge bases and cognitive models (Williams and O'Reilly, 1998; Harrison and Klein, 2007). Individual employees' knowledge structures are also affected by group membership, social interactions and organisation of the firm (Walsh, 1995).

Many of the previous studies on the relation between diversity and firm performance have focused on the effect of diversity in the top management teams (TMT). The upper-echelon framework analyses factors that affect the executive leadership's strategy formation and subsequently organisational behaviour and performance. Finkelstein and Hambrick (1990) argues that functional background and demographic characteristics influence the managers' interpretation of problems and the length of tenure is related to strategic inertia. However, they also found that the characteristics of the management team as a whole had greater predictive power for firm performance than the characteristic of the top manager. Laursen et al. (2005) takes a broader perspective and analyses the composition of all the engineers in Danish engineering consulting firms to see how employee diversity affects firm performance. They argue that firm performance is not only related to levels of human resources, but also to the composition of these resources. They also argue that too little and too much diversity can have a negative effect, which implies an inverted curve linear relationship between diversity and performance. They discover that combining fundamentally different skills lead to a competitive advantage, however, they unexpectedly find some support for a curve linear relationship between diversity and performance, i.e. a low level of diversity and a high level of diversity is positive for performance.

In their review of 40 years of research on demography and diversity in organisations Williams and O'Reilly (1998) finds that diversity has both direct and indirect effects on processes and performance of groups. However, some results point towards a positive effect of diversity, while others stress the negative effect of an increase in diversity, thus diversity has potentially two opposite effects. Recent literature reviews find similar results (see e.g. Horwitz (2005); Harrison and Klein (2007); Horwitz and Horwitz (2007)). Many field studies find no or a negative effect on performance of some dimensions of diversity, while studies in controlled settings often find a positive effect. Williams and O'Reilly (1998) argues that the difficulties of finding significant positive effects of diversity might stem from differences in defining performance indicators and the lack of separating the creativity (invention) phase from the implementation (innovation) phase. Employee diversity might improve the creative process, but impede the innovation phase. However, while this might be likely for smaller groups, overall employee diversity can make the organisation more flexible and adaptive in the implementation phase.

Innovation often depends on groups of individuals in the organisation. It is in the context of a complex social system in an organisation, where the different types of individual knowledge come into play to generate new knowledge or ideas (Woodman et al., 1993). Therefore the composition of individuals within the firm is an important factor for understanding innovation, since diversity in the composition of a firm's employees contributes to diversity in the knowledge base. As a result, it is not sufficient to analyse diversity in TMT but consider the composition of the entire firm. Innovation is an interactive process, where employees interact in groups and develop, discuss, modify and realise new ideas. Thus, diversity in groups is likely to promote innovation behaviour (van der Vegt and Janssen, 2003). Wenger

(2000) argues that innovative learning requires diversity in the experiences and competences of a group. The interplay between diverse competences and experiences generates learning. However, if they are too disconnected then only a little learning occurs (Wenger, 2000).

Theories on decision making in groups suggest that the quality and consensus of group decisions improve in more diverse groups, but it takes longer time to reach an agreement. To make good decisions when facing uncertain and complex problems it often requires some degree of cognitive conflict and expression of different viewpoints to avoid premature consensus (Priem et al., 1995). However, diversity is negative if it creates a socio-emotional conflict between individual employees since this type of conflict is not related to a fact-based problem solving process and draws important resources away from the task at hand (Priem et al., 1995; Pelled et al., 1999).

Only a few studies look at the relationship between diversity and innovation performance. Bantel and Jackson (1989) analyses how the composition of TMT in the finance sector affects innovation. They define innovation as the number of products, programs and services that firms had adopted or developed. They find a positive relation between educational level, functional background and innovation. Zajac et al. (1991) finds that age similarity among members is positively related to innovation in internal corporate joint ventures in the medical sector. Van der Vegt and Janssen (2003) applies a broader perspective and analyses the effect of task interdependence and work group diversity on innovative behaviour in a Dutch multinational financial services firm. They find no direct link between work group diversity and innovative behaviour when they control for size and organisation of work. Pitcher and Smith (2001) finds that diversity in TMT is positive for innovation, but it has some limits if managers receive orders from the firm headquarters.

Williams and O'Reilly (1998) and Horwitz (2005) suggest that diversity has an effect on performance, although some researchers have found negative effects and others positive effects of diversity. The positive effects relate to openness, creativity, learning, flexibility, broader search space, better problem solving, and new combinations of knowledge. Diversity can also increase the firm's absorptive capacity (Cohen and Levinthal, 1990). The costs of diversity are related to lack of economies of scale in the knowledge production, distrust, conflict and dissatisfaction. Diversity also leads to increased transaction costs, since interaction and communication between different knowledge bases and groups might be difficult. Social identity theory predicts that diversity in groups often results in competitive behaviour and conflict. Therefore, diverse work groups experience less cooperation and internal communication than homogeneous work groups (Joshi and Jackson, 2003). However, Joshi and Bantel argue that diversity improves the work groups external relationships and allow them to acquire knowledge through cooperation with employees from other work groups, while the homogeneous work groups will focus on internal cooperation. Thus, diversity has a positive side and a negative side. However, in their discussion of why they do not find any negative effects of diversity Bantel and Jackson (1989) argue that: "This may be because the dysfunctional effects of heterogeneity occur only when extremely high levels of diversity exist, and such extreme diversity is less likely among members of top management teams" (Bantel and Jackson, 1989, p. 118). However, work organisation, and organisational recruitment policies are working against potential negative effects of diversity. When firms hire new employees they try to select people with a profile that fits the needs of the firm in terms of skills, experience, values, and norms. In addition,

there is self-selection among the applicants that reduces the disparity between employees. Through these selection processes firms avoid extreme levels of diversity that might cause negative effects.

Interaction between diverse knowledge bases in a firm is necessary to experience an effect of the diversity. Innovation is an interactive process and diversity among those who interact promotes the innovation process, since diversity affects the way knowledge is generated and applied in the innovation process. Therefore employee diversity should generally have a positive effect on innovation, but high levels of diversity might create conflict, information overload and slow down the innovation process. Thus, there is a trade-off between diversity and the commonality of knowledge across individuals (Cohen and Levinthal, 1990; Wenger, 2000).

Hypothesis 1: Employee diversity has a positive effect on the likelihood that firms innovate.

Hypothesis 2: The effect of employee diversity on the likelihood that firms innovate decreases for high levels of diversity.

The characteristics of employees differ along a wide range of dimensions and their attitudes, values, cognitive models and knowledge bases are generated through complex processes. To measure the extent of diversity among employees it is necessary to look at measurable characteristics that have influenced their experience, cognitive model, identity and knowledge base. The characteristics can be divided into ascribed and achieved characteristics(Ruef et al., 2003). The ascribed characteristics are demographic attributes, such as gender, age, ethnicity and nationality, while the achieved characteristics are educational background, functional background and work experience.

Milliken and Martins (1996) and Harrison and Klein (2007) argue that diversity in ascribed characteristics, such as ethnic background, nationality, gender, and age can have negative affective consequences for the firm. Members of the minority group can experience less job satisfaction, lack of commitment, problems with identity, perceived discrimination, etc. However, some of the problems disappear when the minority group grows (Milliken and Martins, 1996). In addition, Milliken and Martins (1996) finds that the cognitive consequences are a broader range of perspectives, increased number of ideas and better innovative performance. Horwitz (2005) argues that cognitive diversity is positively related to firm performance, but diversity in achieved characteristics has a stronger positive relationship with performance than ascribed characteristics. Kilduff et al. (2000) analyses the demographic component of TMT diversity by gender, age and race. They find that these characteristics give a more accurate reflection of how much a team differs in attitude, values and norms. Pelled et al. (1999) argues that diversity in age reduces harmful emotional conflict since similarity in age enables comparisons of careers that can lead to rivalry. Zajac et al. (1991) finds a negative effect of diversity in age on service innovation performance. They argue that differences in perspectives on a wide range of issues and differences in training between young and old create disagreement that lowers innovative performance. Bantel and Jackson (1989) finds a negative effect of average age on innovative performance. Gender and age clearly affect the individual's experiences and views of the world e.g. different generations experience different political, economical and technological trends that influence their attitude, perspectives and ideas. Diversity in gender is about balance between the two genders and can be expected to have a positive effect on innovative perfor-

mance. Age diversity should have a positive effect, but a high average age could lower the innovative performance.

Hypothesis 1a: Gender diversity has a positive effect on the likelihood that firms innovate.

Hypothesis 1b: Age diversity has a positive effect on the likelihood that firms innovate.

Ethnicity can be used as a proxy for cultural background and diversity in ethnicity can be expected to be positive for innovative performance, since it broadens the viewpoints and perspectives in the firm. A high degree of diversity in ethnicity might be negative for innovation since it can create conflict and cliques (Dahlin et al., 2005).

Hypothesis 1c: Diversity in ethnicity has a positive effect on the likelihood that firms innovate

Achieved characteristics, such as skills and education of employees, are an important part of the firms' human capital. Firms employing employees with a highly education are more likely to be innovative and the average level of and diversity in employees education constitutes an important part of the firms' absorptive capacity (Cohen and Levinthal, 1990; Wenger, 2000; Lundvall, 2002). Murray (1989) analyses how diversity in the TMT influence firm performance. He uses age, tenure, occupational background and educational background based on different educational levels (i.e. graduates, undergraduates, doctorates) in several disciplines (e.g. liberal arts, engineering, science, business, law, etc.). Murray finds a positive effect of educational diversity on firm performance. The educational background is an important part of the employee's knowledge base and it also influences the working methods. The employee has a professional identity rooted in education. This professional identity affects the employees decision making and views on how to identify and solve problems (Joshi and Jackson, 2003). Dahlin et al. (2005) argues that educational diversity will enhance the information use, while too much diversity will reduce the ability to diffuse the information between employees. Educational diversity is expected to have a positive effect on the innovative performance of firms, but a very high degree of diversity might have a negative effect since it increase coordination and communication costs.

Hypothesis 1d: Educational diversity has a positive effect on the likelihood that firms innovate.

3 Data and Sample

The quantitative analysis is based on innovation survey data from the DISKO4 [1] questionnaire survey on organisations, employees and research and development strategies in Danish firms. The DISKO (Danish Innovation System: Comparative analyses of challenges, strength and bottlenecks) innovation survey was sent to a stratified sample of Danish firms with more than 20 employees in 2006. The survey population includes all firms that participated in the previous DISKO survey, all firms with more than 100 fulltime employees in the selected industries and a sample of firms with less than 50 employees and

[1] The DISKO4 survey on organisations, employees, and research and development strategies in Danish firms was conducted by Statistics Denmark in 2006 on behalf of four research groups (IKE, CARMA, CCWS, and CIP) from Aalborg University. Over time four DISKO surveys have been conducted: DISKO1 in 1996, DISKO2 in 2001, DISKO3 in 2004, and DISKO4 in 2006. For a more thorough explanation of the DISKO research see http://www.business.aau.dk/ike/data.html

50-99 employees to make the sample representative to the population of Danish firms. The questionnaire was sent to the management of 4136 companies, 1775 answers were received, which gives a response rate of 42.9 percent.

To obtain detailed background information on the firms in the innovation survey the sample was merged with data from the IDA dataset (Integrated Database for Labour Market Research). IDA is a linked employer-employee database maintained by Statistics Denmark and it contains information on individuals and firms retrieved from government registers from 1980 and onwards. All the required individual and firm level data needed to create the diversity measures are available in this database. The survey refers to the period 2003-2005 and therefore the data is merged with IDA data for November 2002. This provides information on the composition of the firm at the start of the survey period.[2] We exclude those firms that did not answer whether they innovated and firms without background information, which reduce the sample to 1648 firms. Table 1 provides an overview on the number of firms based on size and industry that are present in the sample.

Table 1 around here

This study has certain limitations. Whenever the firm has multiple plants, in our sample 42.26 percent of the firms have more than one plant and 10.34 percent of the firms have more than 5 plants, the information from the DISKO survey is merged with the characteristics of the largest plant in the firm. The questionnaire was sent to the head office of each firm and it is not possible to identify this specific workplace in the database. Another limitation is that it is not possible to identify the persons who interact with each other or who are involved in the specific innovation process. We only identify employee diversity at the start of the survey period. Changes in employment are not taken into consideration.

3.1 Diversity Measures

In this paper employee diversity is defined as the distribution of differences among the members of the firm with respect to a common attribute. Diversity is thus treated as a unit-level compositional construct (Harrison and Klein, 2007). These differences are measured based on three dimensions, i.e. variety, balance, disparity (Stirling, 2001; Harrison and Klein, 2007). Variety relates to the number of categories of a certain attribute that are present in the firm where a high number of categories results in a high level of diversity. Balance is based on the shares of the specific categories where a more equal distribution of the categories gives a higher degree of diversity. The last dimension of diversity is disparity. This dimension refers to the distance between the outer boundaries of the categories within one characteristic. (Harrison and Klein, 2007) makes a distinction between separation and disparity where the first relates to horizontal differences, e.g. difference in position, opinion, education, and the latter on vertical differences, e.g. status and pay.

In this analysis two different measures are used. For the categorical variables we use a Shannon-Weaver entropy index, a method often used to measure diversity in organisational teams, to indicate the degree of diversity in the firm. Entropy is defined as:

[2]The questionnaire was only sent to those firms that had 20 employees or more in 2006. Since we use information on the sampled firms in the year 2002 some of the firms have less than 20 employees.

$$\sum_{i=1}^{n} p_i(\ln \frac{1}{p_i}) = (p_1(\ln \frac{1}{p_1}) + p_2(\ln \frac{1}{p_2}) + \ldots + p_n(\ln \frac{1}{p_n}) \quad (1)$$

This entropy index is a dual concept measure that includes the variety and balance of the categories (Junge, 1994; Stirling, 2007; Harrison and Sin, 2006). However, the entropy index is more sensitive to an increase in variety than an increase in balance (Peet, 1974). Diversity in age is measured by the coefficient of variation to include disparity in age. This measure is often used to calculate diversity for non-negative variables, such as age, tenure and wage (Harrison and Sin, 2006). The coefficient of variation is defined as:

$$CV = \frac{\sigma}{\bar{x}} = \frac{\sqrt{\frac{[\sum(x_i - \bar{x})^2]}{n}}}{\bar{x}} \quad (2)$$

3.2 Variables

3.2.1 Independent Variables

The characteristics that form the basis for our diversity measures are gender, age, ethnicity, and education. These are, with the exception of age, all categorical variables. For *gender* the categories are straightforward, but besides the entropy index a second set of variables is constructed. To determine the effect of a specific gender composition on the likelihood to innovate we create five compositional groups based on the share of the most represented gender: Group 1: 90-100 percent of the same gender, Group 2: 80-90 percent of the same gender, Group 3: 70-80 percent of the same gender, Group 4: 60-70 percent of the same gender and Group 5: 50-60 percent of the same gender.

To measure ethnicity we use the individual' s country of origin divided into six different groups: Danish, Nordic, EU15 and Swiss, other Europeans, other western countries, and the rest of the world.[3] Diversity in ethnicity is measured by calculating the entropy value of these categories.

The diversity in employees' *education* focus on the diversity among employees with a higher education, i.e. bachelor degree or higher. We focus on these education levels since preliminary studies of the data revealed a positive effect of having at least one highly educated employee in the firm on the likelihood of introducing an innovation. These individuals are divided into sixteen different higher education categories making a distinction between Bachelor's, Master's and Ph.D. degrees in social sciences, humanities, food and health science, engineering, and natural sciences. There is also a category for persons that are educated as high-school teachers and officers in the army, navy and air force. In addition to the entropy index a dummy variable on the presence of at least one highly educated employee is added as well as a variable that indicates the share of highly educated employees in the firm.

[3]The citizens in the different ethnicity groups are: **Danish**: Danish, Greenlandic, Faeroe; **Nordic**: Norwegian, Swedish, Finnish, Icelandic. **EU15 and Swiss**: All EU15 citizens excluding the ones mentioned above and including citizens from Liechtenstein, Monaco, Andorra, San Marino, and Switzerland. **Other Europeans**: All European citizens excluding the ones mentioned above. **Other Western Countries**: United States, Canada, Australia, New Zealand, Japan. **Other World**: Citizens not included elsewhere.

The *age* of the employees is represented by a natural number. Therefore diversity is measured by the coefficient of variation i.e. the standard deviation divided by the mean. However, this measure has a limitation since the same variety in age becomes less important for groups with a higher average age.

Another issue related to diversity is how open firms are to diversity. The openness of firms toward diversity is measured by a dummy variable with the name diversity policy. This variable is derived from the questionnaire and indicates whether or not the firm has an active approach in hiring older and/or foreign employees.

3.2.2 Dependent and Control Variables

The dependent variable in the analysis is whether or not the firm introduced an innovation during the period 2003-2005. Innovation is defined as the introduction of a new product or service, excluding minor improvements on already existing products and services.

Besides the variables listed above we also add the usual predictors of innovation starting with the variable *organisational change*. This variable indicates whether or not the firm has undergone important organisational changes during the period 2003-2005. Earlier DISKO studies show that organisational change is important for innovation (Lundvall, 2002). We also control for diversity in collaboration with external partners. Based on the questionnaire we create dummy variables for *high intensity collaboration* with customers, supplies and knowledge institutes. The last two variables control for *industry* and *size*. The sample is divided into eight industries: Manufacturing, Construction, Wholesale & Retail, Hotels & Restaurants, Transport, Financial Services, Business Services, and Culture & Sports. The firms are placed in three groups based on their size: less than 50 employees, between 50 and 100 employees, and firms with more than 100 employees.

3.3 Analyses

The above-mentioned variables are used in a logistics regressions where the first set of logistic regression models the effect of diversity on the likelihood to innovate, see Table 6. The independent variables in *Model 1* are: gender entropy (Hypothesis 1a), coefficient of variation for age (Hypothesis 1b) and ethnicity entropy (Hypothesis 1c). For education we only tested if the presence of a highly educated worker (Hypothesis 1d) has effect on the firm's likelihood to innovate. Dummy variables for industry and size were included as control variables.

Model 2 extends the previous model with additional explanatory variables to test the robustness of the model. The variables added are dummy variables on organisational change, the presence of a diversity policy and whether or not the firm has collaborated with customers, suppliers and/or knowledge institutes. In addition, the education measure is changed into a share of highly educated in the firm.

The last model in this set, *Model 3*, makes a distinction between the different gender distributions. Since gender entropy is based on two categories it is replaced by the gender group variable to analyse the effect of different distributions of men and women in the firm. Variables for the presence of highly educated employees and the diversity among these are added to measure the effect of education diversity. Both variables are added because the entropy index can be *zero* when there is no or only one type of highly

educated groups present in the firm.

Table 7 presents the last logistic regression model. *Model 4* adds the squared values of the diversity variables for gender, age, ethnicity and education to test for curvilinear effects (Hypothesis 2).

3.4 Descriptive statistics

Table 2 shows the distribution of firms that innovated during the period 2003-2005 based on the size of the firm. The average firm in the sample consists of 107 employees, where the smallest firm has two and the largest 4041 employees. The table indicates that larger firms have a higher tendency of being innovative compared to smaller firms.

Table 2 around here

Table 3 shows the share of innovative firms by industry. In Manufacturing, Wholesale & Retail, Financial Services, Business Service, and Culture & Sports the shares of innovative firms are higher than non-innovators. However, the sample only has a small number of firms active in Culture & Sports. The industry that has the relative lowest number of innovating firms is Construction. In this industry 73.3 percent answered that they did not make any innovations during the period 2003-2005.

Table 3 around here

In Table 4 we present the descriptive statistics of the variables that are used in the analyses. More than 55 percent of the firms in the sample introduced at least one innovation in the period from 2003 to 2005. A total of 65 percent of the firms also indicated that they have been through a process of organisational change. The interpretation of the entropy variables is a bit more complicated because of the construction of this variable. The number of categories will determine the potential highest entropy value for each variable. The correlation matrix in Table 4 indicates that there is significant correlation between the different variables.[4]

Table 4 around here

Table 5 presents the distribution of the different gender groups in the sample. As the table already indicates the distribution is almost equally divided over the entire sample.

Table 5 around here

[4] A test for multicollinearity using the Variance Inflation Factor method reveals no multicollinearity.

4 Results

The effects of employee diversity on innovation is analysed using four different models. Table 6 shows the result of the first three models. *Model 1* presents the basic model only including only the standard control variables for industry and size. The model reveals a strong positive and significant effect on the entropy measure for gender, indicating that being diverse in gender composition contributes positively to the likelihood of introducing an innovation. There are only a weak significant negative effects from on the average age on the likelihood to innovate. The disparity measure of age, however, shows a significant negative effect on the likelihood of introducing an innovation. Diversity in age thus affects the likelihood of innovation negatively. Having at least one highly educated employee present in the firm shows a positive and significant effect on innovation. The entropy value for ethnicity shows no significant effect.

Table 6 around here

Model 2 includes additional control variables on organisational change, diversity policy, and collaboration with customers, suppliers and/or knowledge institutes. Organisational change has, as expected, a significant and positive effect on the likelihood of innovation. This likelihood is more than two times as high compared to firm that not had implemented any form of organisational change. Collaboration with customers also shows a significant and positive effect on the likelihood of introducing an innovation. While there is no significant effect on collaboration with suppliers and knowledge institutes. This model also introduces the diversity policy variable indicating openness towards diversity, which shows a significant and positive effect. The diversity measures for gender, age, and ethnicity show similar effects as presented in *Model 1*. The variable indicating the presence of a highly educated has been replaced with the share of highly educated employees in order to determine the level-effect of a higher share in the firm. Somewhat surprisingly there seems to be no significant effect on the share of highly educated on the likelihood to innovate.

The purpose of *Model 3* is, first of all, to look deeper into the positive effect of diversity in gender. Including the *Gender Group* variable in the analysis indicates that there is only a significant and positive effect on Gender Group 5, which is 50-60 percent of the same gender. The odds ratio show that the likelihood of introducing an innovation is 76 percent higher in this group compared to a firm that is dominated by one gender. In this model the entropy variable indicating the diversity among the highly educated employees is added. In order to control for the effect of not having any highly educated in the firm we include the education dummy variable as presented in *Model 1*. The model shows that having at least one highly educated employee is positive. Whenever the highly educated employees are diverse in their educational background there is an additional positive and significant effect on the likelihood to innovate. Other researchers have proposed to test for the role of related variety similar to Boschma et al. (2009). Tests have shown no related variety effect based on this measure.

Table 7 tests for curvilinear relationship between diversity and innovation using the same variable as those presented in *Model 3*. Due to a high degree of multicollinearity the variables are standardized by subtracting the mean and divide by the standard deviation. Model 4 shows no curvilinear effect on the diversity measures. The outcomes are somewhat surprising in the case of education. However, it

should be taken into consideration that this diversity is only measured on the highly educated part of the employees in the firm and as Table 4 indicates 73 percent of the firms in the sample have at least one highly educated employee and the average share is 9 percent.

Table 7 around here

Besides curvilinearity we can also identify another important component of the diversity issue. Since all the diversity measures have been standardized it is possible to identify which type of diversity has the strongest effect by looking at the beta coefficient estimates. As expected diversity in education has the strongest effect on the likelihood of innovation, followed by gender. The negative effect of age is also considerable.

5 Effects of Employee Diversity on Innovation

This study of 1648 Danish firms shows that employee diversity based on the characteristics of all employees has an effect on the firms' likelihood to innovate. Thus it appears that not only diversity in terms of technologies or in the top management team, but also on the level of employees matters for firms' innovative performance. Obviously not all employees are involved in the innovation process, but as Lundvall (1992) and Woodman et al. (1993) argues this process often involves interaction between several groups in the organisation. Therefore it can be beneficial to look at the broader composition of employees in the firm. The hypotheses state that the effect of employee diversity on innovation is positive, but decreasing for high levels of diversity. The first hypothesis has been broken down to four sub hypotheses, each addressing a specific employee characteristic.

Hypothesis 1a, on a positive effect of gender diversity on the likelihood of innovation, is supported. Therefore an increase in gender balance is positive for the innovative performance of firms. The results for gender groups indicate that the most balanced firms (50-60% of same gender) are almost twice as likely to innovate compared to the most concentrated firms (90-100% of same gender). Thus, a balanced gender distribution has a strong effect on the likelihood to innovate. This is in line with the arguments of Milliken and Martins (1996) on the benefits of having a strong minority group. Other studies of diversity among top management teams on performance often find no significant effect of gender diversity. However, these studies measure the impact of diversity on other performance measures. Ordinary measures like productivity growth and effectiveness might not be influenced by a different composition in gender. These measures are not necessarily correlated with being innovative. In addition, the need of being creative as a group benefits more from being diverse, also being diverse in gender composition. The analysis shows that gender diversity is one of the variables that has the strongest effect on the likelihood to innovate. This impact of gender diversity is somewhat overlooked in the innovation literature.

Hypothesis 1b is rejected since there is a clear negative effect of diversity in age on the likelihood of innovation. Although this result is unexpected, this finding is in line with Zajac et al. (1991) who argue that diversity in age causes disagreements that lead to lower innovative performance. The negative effect is also very strong compared to the other variables in the analyses. The impact of average age on the

likelihood that the firm innovates is negative in the first model, which finds support in the arguments presented by Bantel and Jackson (1989). However, in the other models there are no significant effect of average age on the likelihood of innovation.

The effect of diversity in ethnicity is not significant in the regressions, which means that *Hypothesis 1c* will be rejected. The argued positive effect of a diverse cultural heritage (Dahlin et al., 2005) cannot be identified from the analysis. The missing effect might be explained by the high share of Danes among the employees and subsequently on average very low entropy values. Alternatively, the effect is highly dependent on the type of work; for example a higher share of foreigners might take routine type work with low entry barriers in low innovative industries or in highly innovative firms that are sourcing very specialised employees regardless of ethnicity.

The hypothesis stating a positive effect of educational diversity, *Hypothesis 1d*, will be confirmed because the regressions show a positive effect of diversity in education among the employees with a higher education on the likelihood of introducing an innovation. There are two types of dynamics that influence this likelihood: The presence of different education groups or more balance between the education groups. There might be a bias in the education diversity measure, since it measures diversity within the highly educated group. Employing highly educated employees is positive for innovation performance, more education categories increase this likelihood. Different educational backgrounds not only provide the firm with different knowledge and work methods but also increases the absorptive capacity and strengthen the firm's innovative capability (Cohen and Levinthal, 1990; Zahra and George, 2002).

An interesting result that can be found in the regression analysis and which is not explicitly hypothesised is the effect of diversity policy. Diversity policy has a positive effect on the likelihood to be innovative. Actively working on hiring foreigners and/or older people can be used as a proxy for a firm with an open culture towards diversity. A diverse composition of a firm should be accompanied with a culture that accepts this diversity. The organisational culture appears to be an important factor in the success of diversity. Only a few studies have already touched upon this issue, e.g. Dwyer et al. (2003).

Hypothesis 2 for a curvilinear relationship between diversity and innovation is not supported by the results of the analysis. There is no indication that a curvilinear relationship exists in the diversity measures except for ethnicity where there is a weak significant negative effect by squared ethnicity entropy on innovation. There are several reasons why the curvilinear effect may not show up. A general explanation is that high degrees of diversity are avoided through organisational recruitment processes and self selection. In the particular case of education, a possible explanation might be that diversity is measured on a small proportion of the employees in a firm, i.e. only on the highly educated. A curvilinear effect might show up when including the diversity of all the employees with a degree below the bachelor's level. In the case of gender the curvilinear effect is not present since the dominance of one gender does not promote innovation (Milliken and Martins, 1996). This is found in the regressions where Gender Group 5 has the largest and only effect on the likelihood of innovation.

6 Conclusion

Previous studies linking a diverse knowledge base to a firm's innovative capability have predominantly focused on the technological dimension of diversity, which overlooks the importance of intangible assets in the firm (Teece et al., 1997). The few studies that consider the more intangible human capital dimension focus only a small group within a larger organisational setting, i.e. top-management teams. However, the diversity in the composition of these teams might be a poor proxy for the effect of employee diversity on innovation, since the innovation process involves interaction between several employees at various levels in the firm (Lundvall, 1985, 1992; Laursen et al., 2005). Therefore it is necessary to look at the broader composition of skills and knowledge in the firm and to analyse the effect of employee diversity on the innovative performance of firms.

Based on 1648 Danish firms in service and manufacturing we found that employee diversity in terms of gender, age and education has an effect on the likelihood that firms innovate when controlling for other factors such as size, industry, organisational change and diversity in external cooperation. Firms with more balanced gender composition are more likely to innovate compared to firms with high concentration in one gender. Firms with a higher share of employees with a higher education and diversity in the types of educations have a higher likelihood of innovating. Diversity in age appears to be negative, although average age has no significant effect. We find no significant effect of diversity in ethnicity. The regression with the standardized variables indicates that educational diversity is most positive for innovation followed by gender diversity. This study has certain limitations since it based on a cross-sectional analysis of 1648 Danish firms and we are not able to identify who are involved in the innovations processes and the specific structures of the particular firms.

The results in this paper clearly indicate that diversity aspects in terms of human capital cannot be ignored in relation to a firm's innovative capabilities. It is encouraging to notice that the demographic attributes in our study show the same impact on innovation as earlier studies that try to link diversity to innovation, e.g. the positive effect of education diversity (Bantel and Jackson, 1989) and the negative effect of age diversity (Zajac et al., 1991), even though the latter is not in line with our original expectations. This is encouraging because studies focusing on other performance indicators often find inconsistent results regarding diversity where similar attributes appears to be positive, negative, or non-significant. It is difficult to relate our study to studies that do not focus on innovation since one type of diversity composition might have a different impact on various types of performance measures. Creativity, which is at the center of every innovative process, calls for a different interaction style compared to the interaction that enhance a firm's effectiveness.

As already indicated, the studies linking employee diversity and innovation are scarce. We suggest that future studies look not only at the demographic composition, but also consider other factors that make the human capital composition of a firm to a success. As the analysis indicates firms that are more conscious of diversity have a higher likelihood to innovate. Pitcher and Smith (2001) also finds that management plays a role in the effect of diversity. This opens up discussions on management cultures in the firm in line with Dwyer et al. (2003) and how firms can manage diversity and use other strategies to broaden the cognitive scope of the firm, e.g. through collaboration. In addition, future research should look at longitudinal analysis, and analyse if persistent innovative firms become more diverse or

diverse firms become more innovative. It could also be fruitful to address particular industries based on their knowledge base and work organisation, since the effect of diversity might vary between industries based on doing-using-interaction modes compared to more science based industries. Similarly diversity is likely to be less important in jobs with a high degree of routines compared to jobs characterised by interaction and problem solving. Future studies should also address the effect of organisational modes and innovation strategies.

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Table 1: Distribution of firms based on size and industry

Industry	Less then 50 employees	50-99 employees	100 or more employees
Manufacturing	193	191	193
Construction	118	51	29
Wholesale & Retail	226	101	49
Hotels & Restaurants	13	18	6
Transport	58	34	32
Financial Services	14	20	35
Business Services	121	52	66
Culture & Sports	9	11	8

N=1648

Source: Based on data from Statistics Denmark

Table 2: Innovation and Size

Innovation	Less than 50 employees		50-99 employees		100 or more employees	
No	412	54.8%	197	41.2%	130	31.1%
Yes	340	45.2%	281	58.8%	288	68.9%
Total	752		478		418	
N=1648						

Source: Based on data from Statistics Denmark

Table 3: Innovation and Industry

Innovations	Manufacturing		Construction		Wholesale& Retail		Hotels & Restaurants		Transport		Financial Services		Business Services		Culture & Sports	
No	220	38.1%	145	73.2%	181	48.1%	20	54.1%	69	55.7%	9	13.0%	84	35.2%	11	39.3%
Yes	357	61.9%	53	26.8%	195	51.9%	17	46.0%	55	44.4%	60	87.0%	155	64.9%	17	60.7%
Total	577		198		376		37		124		69		239		28	

N=1648

Source: Based on data from Statistics Denmark

Table 4: Descriptive Statistics and Pearson Correlation Coefficients, N=1648

Variable	$\bar{x}$	σ	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11	12
1 Innovation	0.55	0.50	0.00	1.00												
2 Size	1.80	0.82	1.00	3.00	**0.20**											
3 Org.Change	0.65	0.48	0.00	1.00	**0.27**	**0.23**										
4 Div.Policy	0.19	0.39	0.00	1.00	**0.09**	**0.12**	**0.06**									
Collaboration																
5 Customer	0.70	0.46	0.00	1.00	**0.13**	0.04	**0.09**	0.04	1.00							
6 Supplier	0.59	0.49	0.00	1.00	**0.08**	-0.02	**0.05**	0.03	**0.50**							
7 Know. Inst.	0.13	0.33	0.00	1.00	0.03	**0.08**	**0.06**	0.04	**0.12**	**0.08**						
Gender																
8 Entropy	0.50	0.19	0.00	0.69	**0.24**	**0.22**	**0.19**	0.04	0.05	**0.05**	-0.03					
Age																
9 Coefficent of Variation	0.29	0.07	0.08	0.62	**-0.14**	**-0.07**	**-0.13**	0.00	-0.02	**0.07**	-0.04	**-0.07**				
Higher Education																
10 At least one	0.73	0.44	0.00	1.00	**0.22**	**0.40**	**0.19**	**0.05**	0.04	-0.03	**0.10**	**0.25**	**-0.23**			
11 Share	0.09	0.13	0.00	1.00	**0.14**	**0.15**	**0.14**	0.04	0.02	**-0.09**	**0.19**	**0.25**	**-0.30**	**0.42**		
12 Entropy	0.51	0.60	0.00	2.30	**0.27**	**0.58**	**0.25**	**0.11**	0.01	**-0.05**	**0.07**	**0.35**	**-0.26**	**0.52**	**0.51**	
Ethnicity																
13 Entropy	0.20	0.21	0.00	1.20	**0.09**	**0.22**	**0.07**	**0.13**	0.02	0.00	-0.02	**0.19**	-0.02	**0.18**	**0.13**	**0.30**

Source: Based on data from Statistics Denmark
Note: Correlation estimates in bold indicate significance at 5% level

Table 5: Descriptive statistics for Gender Group

	Frequencies	Percent	Cumulative Frequency	Cumulative Percent
Gender group 1	345	20.93	345	20.93
Gender group 2	318	19.30	663	40.23
Gender group 3	276	16.75	939	56.98
Gender group 4	348	21.12	1287	78.09
Gender group 5	361	21.91	1648	100.00

Source: Based on data from Statistics Denmark

Table 6: Summary of the regression analyses

Variable	Model 1 Estimates		S.E.	Odds	Marg. Effects	Model 2 Estimates		S.E.	Odds	Marg. Effects	Model 3 Estimates		S.E.	Odds	Marg. Effects
(Intercept)	1.105		0.711			0.711		0.737			0.836		0.729		
Culture & Sports	0.061		0.357	0.898	0.015	0.160		0.366	0.923	0.040	0.067		0.374	0.865	0.017
Business Services	0.108		0.156	0.940	0.027	0.045		0.180	0.826	0.011	0.016		0.165	0.822	0.004
Financial Services	1.284	***	0.333	3.050	0.318	1.222	***	0.336	2.679	0.302	1.178	***	0.338	2.627	0.291
Transport	-0.204		0.197	0.689	-0.050	-0.273		0.201	0.601	-0.068	-0.177		0.205	0.678	-0.044
Hotels & Restaurants	-0.616	*	0.332	0.456	-0.152	-0.570		0.346	0.447	-0.141	-0.490		0.348	0.495	-0.121
Wholesale & Retail	-0.030		0.131	0.819	-0.007	-0.044		0.136	0.756	-0.011	-0.039		0.139	0.778	-0.010
Construction	-0.772	***	0.188	0.390	-0.191	-0.773	***	0.196	0.365	-0.191	-0.768	***	0.199	0.375	-0.190
Manufacturing	*Benchmark*					*Benchmark*					*Benchmark*				
100 or more Employees	0.207	**	0.090	1.596	0.051	0.150	*	0.092	1.491	0.037	-0.026		0.106	1.057	0.006
50-99 Employees	0.054		0.080	1.370	0.013	0.099		0.082	1.417	0.024	0.108		0.084	1.208	0.027
20-49 Employees	*Benchmark*					*Benchmark*					*Benchmark*				
Organisational Change						0.420	***	0.058	2.315	0.104	0.405	***	0.059	2.249	0.100
Diversity Policy						0.445	***	0.147	1.561	0.110	0.436	***	0.148	1.547	0.108
Collaboration															
Customers						0.361	***	0.137	1.435	0.089	0.367	***	0.138	1.444	0.091
Suppliers						0.178		0.130	1.195	0.044	0.199		0.132	1.220	0.049
Knowledge Institutes						0.091		0.177	1.095	0.023	0.071		0.176	1.073	0.018
Gender															
Entropy	1.332	***	0.340	3.750	0.329	1.204	***	0.350	3.332	0.298					
Group 5											0.237	**	0.116	1.660	0.059
Group 4											0.148		0.111	1.518	0.037
Group 3											-0.014		0.118	1.292	-0.003
Group 2											-0.100		0.111	1.185	-0.025
Group 1	*Benchmark*					*Benchmark*					*Benchmark*				
Age															
Mean	-0.023	*	0.013	0.978	0.006	-0.019		0.014	0.982	-0.005	-0.021		0.014	0.980	-0.005
Coefficient of Variation	-3.377	***	0.951	0.034	-0.835	-3.300	***	0.981	0.037	-0.816	-2.677	***	0.991	0.069	-0.662
High Educated															
At least one	0.480	***	0.138	1.617	0.119						0.322	**	0.151	1.380	0.080
Share						0.537		0.558	1.711	0.133					
Entropy											0.364	***	0.135	1.438	0.036
Ethnicity															
Entropy	0.122		0.275	1.130	0.030	0.096		0.278	1.100	0.024	-0.053		0.283	0.948	-0.013
N	1648					1648					1648				
Max Rescaled R2	0.17					0.22					0.23				
Likelihood Ratio	217.566***					295.265**					311.631***				

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

Table 7: Testing for Curvilinearity

Variable	Model 4 Estimates		S.E.	Odds	Marg. Effects
Intercept	-0.533	**	0.228		
Culture & Sports	0.058		0.374	0.858	0.014
Business Services	0.005		0.166	0.814	0.001
Financial Services	1.195	***	0.339	2.675	0.295
Transport	-0.162		0.206	0.689	-0.048
Hotels & Restaurants	-0.501		0.368	0.487	-1.258
Wholesale & Retail	-0.052		0.140	0.769	-0.013
Construction	-0.746	***	0.200	0.384	-0.184
Manufacturing	*Benchmark*				
100 or more Employees	-0.027		0.106	1.052	-0.007
50-99 Employees	0.106		0.084	1.202	0.026
20-49 Employees	*Benchmark*				
Organisational Change	0.404	***	0.059	2.245	0.100
Diversity Policy	0.438	***	0.147	1.549	0.108
Collaboration					
Customers	0.365	***	0.139	1.440	0.090
Suppliers	0.196		0.132	1.216	0.048
Knowledge Institutes	0.075		0.176	1.078	0.019
Gender					
Entropy	0.228	***	0.084	1.256	0.056
Entropy^2	0.047		0.059	1.048	0.012
Age					
Mean	-0.104	**	0.069	0.902	-0.256
Mean^2	0.001		0.039	0.999	0.000
C.O.V.	-0.191	**	0.072	0.826	-0.047
C.O.V.^{2}	0.018		0.035	1.018	0.004
High Educated					
At least one	0.290	**	0.158	1.336	0.072
Entropy	0.266	***	0.099	1.304	0.066
Entropy^2	-0.062		0.072	0.940	-0.015
Ethnicity					
Entropy	0.008		0.083	1.008	0.002
Entropy^2	-0.011		0.035	0.990	-0.003
N	1648				
Max Rescaled R2	0.23				
Likelihood Ratio	310.909***				

*** Significant at the 1% level
** Significant at the 5% level
*Significant at the 10% level