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Age diversity and firm's technological innovation: The role of HRM practices

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Abstract

While numerous studies have been dedicated to the study of the relationship between employee diversity, in particular age, and firms' performance, we here focus on the link between age diversity and its two components (variety and polarization) and innovation. Moreover, as past research has found mixed results of such relationships, we here investigate the moderating impact of human resources management practices, which may mitigate or reinforce the direct links. Based on a study of more than 1300 Luxembourg firms and a longitudinal study between 2009 and 2012, our results indicate a positive association between age variety on innovation, but a negative one between polarization and innovation. The three HRM practices (information sharing, teamwork and training) have a differentiated moderating impact, highlighting positive interaction effects between information sharing and polarization, meaning that the negative relationship between age polarization and innovation can be counterbalanced by the implementation of information sharing practices. These results have important theoretical contributions as well as for managers.

Keywords: Workforce diversity, Innovation, HRM practices

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1. Introduction

A growing number of studies have analyzed the relationship between employee diversity and firms' performance. A particular attention has been paid to age. Indeed, as people work longer in most industrialized countries, age diversity in organizations has a tendency to increase. This ascertainment led researchers to look at the implications of this type of diversity for organizational performance. Recent research (De Meulenaere et al., 2016) has found that the effect of age diversity depends on the particular shape of the age distribution: positive when it is heterogeneous and varied, and negative when it is polarized. The authors underlie that such negative association could be offset by adequate HRM practices, however recognizing that no empirical study of the effectiveness of HRM practices in relation to age polarization has been conducted. Moreover, although a whole stream of research has spurred on the importance of innovation for firms' performance, studies focusing on the impact of employee diversity on innovation remain scarce (van der Vegt and Janssen, 2003; Østergaard et al., 2011; Galia and Zenou, 2012). This is rather surprising as management and innovation gurus such as Peter Drucker or Tom Peters have long advised to encourage diversity of all kinds, and especially of employees, in order to spur a variety of knowledge, skills and competences which are favorable for innovation.

Our research question can be stated as follows: "When is age diversity associated to technological innovation considering both the workforce distribution (diversity and polarization) and the moderating effect of HRM practices"? This understudied question lies on the assumption that diversity effects (positive knowledge-based synergies or negative value-based problems) will depend on (i) the particular shape of the workforce age distribution (variety vs. polarization) and (ii) one important moderator - HRM practices - that shape the organizational context in which workforce age diversity is embedded.

This paper takes is anchored in the two previously mentioned streams of research while extending them in four main ways. First, in line with Østergaard et al. (2011), who found a negative impact of age diversity on innovation, we here concentrate on innovation as a performance indicator and deepen our comprehension of the relationship between age diversity and technological innovation. Contrary to most previous studies, who use proxies for the innovation dependent variables, such as the number of patents application (Faems and Subramanian, 2013), we here use a direct measure of innovation (Østergaard et al., 2011). Moreover, also in line with Østergaard et al. (2011), since diversity in the composition of a firm's employees is supposed to contribute to a larger knowledge base, we consider the composition of the entire firm – and not only of top management teams. Indeed, innovation is

an interactive process where employees interact in groups and develop, discuss, modify, and realize new ideas. Thus, diversity in groups is likely to promote innovation behaviour (van der Vegt and Janssen, 2003) and innovative learning requires diversity in the experiences and competences of a group.

Second, following De Meulenaere et al. (2016), we concentrate on age diversity and on its two aspects, variety and polarization, which were found to have opposite impacts on labour productivity. We disentangle "age diversity" by distinguishing two age distributions: variety and polarization. Age variety—referring to the heterogeneity of ages—is expected to make knowledge differences manifest, encouraging the favorable synergies that increase firm performance. Conversely, age polarization—referring to the separation of the workforce into distinct homogeneous subgroups—is expected to elicit age-related value-based subgroups, triggering the negative outcomes of diversity that reduce organizational performance. Third, we account for the moderating effect of HRM practices on these two variables in order to see whether they may reinforce or counterbalance the direct positive or negative links. Finally, we adopt a longitudinal study allowing us to take a step further as far as methodological aspects are concerned: we are able to take into account the endogeneity of diversity, method that allows controlling for possible reverse causality between diversity and innovation.

Our study is based on a Luxembourgish linked employer-employee data which is suited to the objective of our analysis. The employer dataset refers to the employer survey of the human resource management and firm's business strategies conducted in 2013. The second database is the longitudinal administrative data from the Social Security. We took the 4 waves from 2010 to 2013 of such latter database in order to generate the longitudinal data on diversity. Based on a study of more than 1433 Luxembourg firms, our results indicate a positive association between age variety and innovation, but a negative relationship between polarization and innovation. The three HRM practices (information sharing, teamwork and competences development) have a differentiated moderating impact, highlighting positive interaction effects between information sharing and age polarization, meaning that the negative relationship between age polarization and innovation can be offset by the implementation of such information sharing practices between employees.

The remainder of the paper is structured as follows. Section 2 contains a discussion on diversity, innovation and the influence of HRM practices. 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. Theoretical framework

2.1. Age diversity and innovation

The literature on workforce diversity has identified both negative and positive effects on organizational performance (De Meulenaere et al., 2016; D'Netto et al., 2014; Kunze et al., 2011, 2013; van Dijk and van Engen, 2013). Such differentiated effects have been found regardless of the type of measures of such performance: firm's gross added value divided by the number of employees (De Meulenaere et al., 2016), productivity (Backes-Gellner and Veen, 2013; Parrotta et al., 2014a), wages and profits (Garnero et al., 2014), or the value added per employee (Grund and Westergaard-Nielsen, 2008). Indeed, various theoretical and contradictory theoretical lenses may explain these conflicting results.

On one hand, diversity has a positive effect on firm performance. Diversity groups provide superior solutions to organizational problems and increase organizational efficiency, effectiveness and profitability (Wilson and Iles, 1999). Therefore, valuing diversity may become a source of competitive advantage (Cassell, 1996). Opposed to this diversity argument, on the other hand, the organisational demography approach (Pfeffer, 1985) argues that social similarity is important for interaction and communication, which are essential for performance. A diverse workforce may thus generate communication problems, low cohesion and high turnover (Milliken and Martins, 1996; Williams and O'Reilly, 1998), and impede organizational performance (Sacco and Schmitt, 2005). Several barriers prevent the successful implementation of diversity initiatives (Wentling, 2004), related to the work environment (competing agendas, size and firm's complexity) or to the employees (who may not value diversity). These counter-effective arguments are also consistent with social categorization and social identity theories (Tajfel, 1981; Turner, 1987) and with the similarity-attraction paradigm (Byrne, 1971): diversity will instigate ingroup–outgroup distinctions and negative social processes between individuals, thereby compromising group and organizational performance.

As far as age is concerned, the same mixed results are found in the literature (see De Meulenaere et al., 2016, for a review). A review of the literature on age and work even shows an emphasis of negative predictions (Shore et al., 2009) – which can easily be understood in consideration of the numerous theoretical approaches highlighting the negative impacts of diversity. On one hand, age diversity creates a pool of complementary age-specific knowledge, which can lead to potential synergies (Horwitz and Horwitz, 2007; Williams and O'Reilly, 1998). Mixing people of various ages stimulates creativity, problem-solving capacity, decision-making quality, innovation and organizational performance. The benefits may be explained thanks to three major processes: more diverse problem-solving capacities (an increased cognitive toolbox), better incentive structures, and more effective transfer of specific know-

how and capabilities from older to younger generations (Backes-Gellner and Veen, 2013). Age-diverse workforces have different perspectives, interpretations and mental models (Richard and Shelor, 2002; Page, 2007; Cannella et al., 2008). Thus, as a team, they have a larger pool of knowledge and problem-solving comprehension. Younger employees may have high academic skills but may be socially inexperienced, whereas older cohorts may have lower academic competencies but more work experience or social skills. Age diversity is therefore supposed to enhance productivity when the work do be done requires either a high degree of creativity (Richard and Shelor, 2002; Page, 2007). In these situations, increased age diversity can lead to more group discussions and superior problem solving (Richard and Shelor, 2002). A more diverse age spectrum makes transfer of tacit knowledge between generations easier (Cremer, 1986). Therefore, growing benefits are expected with increasing age diversity, these benefits being more pronounced in companies that engage in creative tasks and innovative activities. Combining workers of different ages and different knowledge may thus increase the knowledge pool of the workforce, which may induce positive effects on problem solving and innovation.

On the other hand, age diversity may also entail differences in values, which might impede cohesion and cooperation among employees (Carton and Cummings, 2012; van Dijk and van Engen, 2013), thereby reducing organizational performance. Grund and Westergaard-Nielsen (2008) found a pyramidal or inverse U-shaped interrelation between mean age and standard deviation of age and value added per employee, respectively. Moreover, in a firm with more homogeneous age groups, career options for the younger age group may be reduced as the older group locks the career progression, which can demotivate them as it diminishes promotion-based incentives (Cremer, 1986; Gibbons and Waldman, 2006). Moreover, age-homogeneous workforces make it difficult to transfer company-specific knowledge from one generation of workers to the next. The negative effects linked to age diversity therefore result from three major problems: increased communication difficulties, value conflicts resulting in a lower degree of social integration, and increased turnover (Backes-Gellner and Veen, 2013).

Only a few studies look at the relationship between diversity (and especially age diversity) and innovation performance - and also provide mixed results. Considering that age diversity groups can generate more innovative ideas than homogeneous ones, Bantel and Jackson (1989) analyze how the composition of top management teams in the banking sector affects innovation, and find a positive relation between the educational level and the functional background, and innovation, but no impact of age diversity. In the same way, Van der Vegt and Janssen (2003), analyzing the effect of task interdependence and work group diversity on innovative behavior in a Dutch multinational financial services firm, found no direct link

between work group diversity and innovative behavior. Pitcher and Smith (2001) also found that age and functional background heterogeneity produce an inconsistent pattern of false positives and negatives with administrative innovation.

Several negative results have been identified. For Zajac et al. (1991), age similarity among members is positively related to innovation in internal corporate joint ventures in the medical sector. For Østergaard et al. (2011), there is a negative impact of age diversity on innovation. To our knowledge, one study has identified a positive impact: that of Galia and Zenou (2012), for whom age diversity shows a positive relationship with product innovation, and a negative impact on organizational innovation.

In line with such studies, and especially with De Meulenaere et al. (2016) who found that age variety as a positive effect on labour productivity while it is negative when it such age distribution is polarized, we elaborate the following hypotheses:

H1: Age variety is positively associated to technological innovation

H2: Age polarization is negatively associated to technological innovation

2.2. Managing diversity through HRM practices

Given these competing forces, it is not surprising that empirical research on the performance effects of age diversity provides inconclusive results. They "*may be traced back to researchers' neglect of possible mediators and moderators in the relationship between age diversity and outcomes in the studies on organizational demography*" (Kunze et al., 2011: 265). Such assertion leads us to analyze the possible moderating impact of HRM practices. Indeed, in addition to the full utilization of the skills and potential of all employees, managing diversity effectively can contribute to organizational success by enabling access to a changing marketplace through the organization's multicultural employees (Cox and Blake 1991; Iles 1995). Moreover, following recent research on work group diversity (including age diversity such as Boehm et al., 2014a, 2014b; Carton and Cummings, 2012; Hogg and Terry, 2000; Kunze et al., 2011), we argue that the impact of workforce age composition is likely to depend on the context in which people have to work together and, especially, on the management practices that are implemented at the firm level. Therefore, we introduce HRM practices as a key moderator.

Surprisingly, despite the recognized importance of HR diversity management, little research has empirically investigated how organizations manage diversity in the HRM domain. According to D'Netto et al. (2014) however, diversity-related problems can be solved and the potential benefits realized only through effective diversity management. The challenge for

managers of diverse groups is to adopt interventions that diminish the detrimental effects of social categorization processes without relinquishing the benefits of diversity. If designed and implemented properly, HR diversity management can support key organizational development initiatives (Agocs and Burr 1996; Liff and Wajcman 1996; Storey 1999). Effective diversity management thus requires close integration with HR practices, given that the focus of diversity management is on employees.

We here support the idea that when HR practices support the creation of a workforce that has the skills needed to turn diversity into an advantage, even in the case of age polarization, diversity is more likely to lead to positive performance outcomes (Kochan et al., 2003). Past studies concluded that using HRM toolkits in addressing inequality in recruitment, appraisal, advancement and rewards can improve inclusiveness and increase creativity in a diverse workforce (Goodman et al., 2003). The positive relationship between HR diversity management and employee work attitudes and behavior has been demonstrated, for instance by D'Netto et al. (2014), who have focused on ethnicity.

While no previous study has studied the impact of HRM practices for diversity management in the context of innovation, Backes-Gellner and Veel (2014) have found that increasing age diversity has a positive effect on company productivity if and only if a company engages in creative rather than routine tasks, i.e. only in innovative firms. Parrotta et al. (2014b) merged the Danish LEED set with information on firms' innovation ability for the years 1995–2003. Using an instrumental variable approach, they found that ethnic diversity within firms is valuable for the latter's capacity to innovate. McGuirk and Jordan (2012) found that age diversity (measured with a Blau Diversity Index) is insignificant on both process and product innovations. Yang and Konrad (2011) are the only ones, to our knowledge, to have analyzed the interactive effects of workplace diversity and employee involvement on innovation, focusing on racio-ethnic diversity (and not age) - and on organizational (and not technological) innovation.

We are the first to propose and test potentially important interplay between age diversity and HRM practices for innovation. In the case of diversity measured through variety, HRM practices may reinforce the positive relationship between age variety and technological innovation:

H3: HRM practices will have a positive moderating effect on the link between age variety and innovation performance

We also believe that the negative effect of polarization can be moderated by HRM practices since they can increase employee participation, communication and team working, thus counterbalancing the negative impact of polarization. Indeed, the demographic ideas state that similarity in time of entry and in other dimensions such as age and education will lead to increased communication frequency. Communication frequency tends to increase similarity in values and is enhanced further by similarity in attitudes and beliefs (Pfeffer, 1985). Hence, the major element for greater integration and cohesion among the group is communication frequency. Zenger and Lawrence (1989) reported that a project group's diversity on age was negatively related to the frequency of communications within the project group. We can extrapolate the reasoning by considering that HRM practices that support communication, especially between cohorts of different ages, such as between the ladders of the hierarchy (which often reflects age diversity), should palliate the negative effect of polarization (which leads to a lack of information transfer between employees of different ages):

H4: HRM practices will have a positive moderating effect on the link between age polarization and innovation performance

Our research model can be represented as follows:

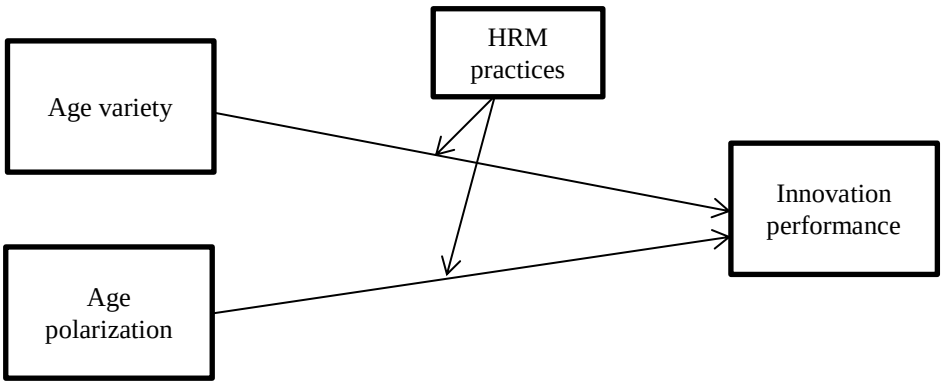

Figure 1. Research model

3. Data and variables

3.1. Data

We here use the Luxembourg case. The Luxembourg is a relevant empirical case study for three reasons. First, the Luxembourg labor market is characterized by a highly international, multicultural and multilingual working environment. Almost 70% of the Luxembourg´s workforce is composed of immigrants or cross-border workers. The country´s workforce is getting more and more diverse in terms of education, nationality, gender, age, and language. Finally, several databases for Luxembourg providing high-quality and rich information will be assembled into an integrated database.

We use the Luxembourgish linked employer-employee data which is most suited for analyzing the workforce age diversity and its impact on firm's probability to introduce innovation. The first dataset refers to the employer survey of the human resource management and business strategies during the period 2010-2012. The survey was conducted in 2013 by the Luxembourg Institute of Socio-Economic Research (LISER). It provides general information about firms (sector of activity, group belonging, number of employees, sales, geographic market), human resource management practices, technological and non-technological innovations. The database includes weights to account for non-response and survey design probabilities and to ensure representativeness. The second dataset refers to the longitudinal data register of the Social Security of Luxembourg. We took the four years from 2010 to 2013 of the latter database in order to generate the longitudinal data on diversity. The two datasets were interconnected using the common identity numbers of firms. The resulting sample consists of 1433 Luxembourg firms with at least 15 employees in the manufacturing and service sectors. We adopted a synthesis approach, which allows innovation to take place in manufacturing and in services (Gallouj and Weinstein, 1997).

Dependent variables

The first dependent variable is the propensity of innovation in product (*product innovation*), a binary variable that indicates whether the firm introduced a product innovation or not. The second, the propensity of innovation in process (*process innovation*), indicates whether a firm was a process innovator or not. The third, *technological innovation*, is measured as whether the firm has introduced either product or process innovation - or nothing (see Appendix 1 for the definition of the variables).

Independent variables

Age diversity: Different methods are used to measure age diversity. The age of the employees is represented by a natural number. Østergaard et al. (2011) measure diversity in age by the

standard deviation of age, and create a variable that indicates the average age of the employees. De Meuleneare et al. (2016) built on Harrison and Klein (2007) to calculate age variety with a Blau index of age heterogeneity. In line with Ilmakunnas and Ilmakunnas (2011), Haile (2012) and Leonard and Levine (2006), we define the diversity variables as one minus the Herfindahl concentration index, using the proportion of each group of gender, nationality, age at each workplace as established in administrative data (IGSS)[2]. Unlike traditional diversity measures such as the share of employees, this variety index allows to simultaneously capture the number of categories represented within the workplace (richness) and, at the same time, to measure how even the numbers are for the individual categories of equitability or evenness (Parrotta et al., 2014a). For each dimension (gender, nationality, age), the variety index is defined as:

$$Variety\ Index = 1 - \sum_{m=1}^{M} P_m^2$$

where P_m^2 is the proportion of employees in age (nationality, gender) group m. There are M groups in total. The index takes the minimal value 0 when all employees are equal, meaning a perfect homogeneity, and the maximal value (M-1)/M when the shares in all groups are equal, which means perfect heterogeneity. We distinguish between female and male employees (M=2), seven groups for nationality[3] (M=7 for nationality) and nine age groups[4] (M=9 for age). Appendix 1 provides the descriptive statistics for all variables.

Age polarization: Harrison and Klein (2007) suggested using the standard deviation (SD) to account for polarization. The SD is mainly sensitive to the age range observed in organizations and, therefore, obtains its highest value for firms in which age subgroups are the most distant. However, it ignores the relative sizes of the subgroups. As a polarization measure should theoretically be sensitive to both the distance between and the relative size (i.e., balance) of the subgroups, De Meuleneare et al. (2016) used Esteban and Ray (1994)'s polarization index. We will also adopt this polarization index (see De Meuleneare et al., 2016, for more details on this indicator).

Human Resources Management Practices. Similar to the literature (Böckerman et al., 2012; Cottini et al., 2011; Kwon and Rupp, 2013; White and Bryson, 2013), such HRM practices were assessed by three items scale indicating the existence of measures related to human resources management: development, teamwork and information sharing. *Development* is equal 1 if at least 25% of employees have received training days taken on working time or/and

[2] This Diversity Index is also called Blau's Index or Variety Index in the literature
[3] Luxembourgish, French, Belgium, German, Italian, Portuguese, others
[4] Less than 24 ; 25-29 ; 30-34 ; 35-39 ; 40-44 ; 45-49 ; 50-54 ; 55-59 ; over-60s

benefit from an annual appraisal or/and the firm an internal mechanism to encourage employees to develop their skills and their carrier, 0 otherwise. *Teamwork* is equal to 1 if at least 25% of the employees (not senior executives) currently work in a team where the members jointly decide how work is done or/and is currently involved in groups who meets voluntarily and regularly to identify and solve problems related to their work or/and the employees at the team level and for all positions are able to perform the tasks of the other colleagues during their absence, 0 otherwise. *Information sharing* is equal to 1 if at least one of the following statements are true for the firm: high frequency of meetings between senior management and all employees (meetings), high duration of the meetings used by the employees for expressing themselves and asking questions (changes with employees involved) and/or senior management seeking to stimulate employees' participation by Internet surveys (attitude surveys), 0 otherwise.

We also controlled for the impact of organizational innovation, equal to 1 if, between 2010 and 2012, the firm makes significant organizational changes (business practices, methods of organizing work responsibilities and decision making, external relations), 0 otherwise. Indeed, previous research cites an essential role of organizational innovation in the development of technological innovation capabilities (Camisón and Villar-López, 2014; Haned et al., 2014; Mothe et al., 2015). We also include the existence of an R&D department (binary), the implication of external experts in the innovation process (binary), firm size, job security through the share of part-time and share of permanent contract, dummies of activities sectors, the number of competitors and theshare of graduate's employees. Appendix 2 presents the correlations between variables.

Methodology

Previous studies highlighted this issue of reverse causality of workforce diversity (Garnero et al., 2014; Parrotta et al., 2014a; Ozgen et al., 2013). Indeed, any shock in innovation (or labor productivity, total factor production, wages) might induce correlated changes in the firm's workforce and in innovation (or other elements) that are not directly due to changes in the firm's workforce composition *per se*. In order to take into account for this reverse causality, we apply instrumental variables' estimations for three types of innovation, consisting of estimating simultaneously a system of two questions and relying on internal instruments to control for reverse causality. Similarly to Garnero et al. (2016) and Göbel and Zwick (2012), we used lagged levels of age polarization and age variety as internal instruments. The underlying hypothesis is that changes in actual polarization and variety can be correlated with their lagged levels while the latter cannot be directly correlated with the dependent variables (innovation).

4. Results

Table 1 presents the results of the basic model including measures of age diversity, HRM practices and standard control variables. Columns 1 to 3 show the Probit of the innovation models where measures of diversity are taken as exogenous and columns 4 to 6 show the IV estimates where age diversity is considered as endogenous. Appendix 3 gives the results of the estimates of the instrumenting equations. The F-statistic of the first stage regressions of instrumenting equations exceeds 10, indicating that weak instruments do not matter.

In Table 1, we note that results in both cases (columns 1 to 3 with exogenous diversity vs. columns 4 to 6 with endogenous diversity), are quite similar, except for some specific cases, revealing that reverse causality may partially not be problematic in our case. It appears that an increase of 1 point of age polarization reduces the probability of technological (product) innovation by 2.99 (3.43) points at the 10% (5%) level of significance, showing a negative association between age polarization and technological and product innovations - while it has no consistent impact on process innovation. This result is in line with De Meulenaere et al. (2016)' finding, which highlights a negative relationship between age polarization and labor productivity.

Turning to the age variety, results vary according to types of innovation and estimation approach. In the first three columns of Table 1, an increase of 1 point of age variety is positively associated with an increase of 0.58 (0.49) point in technological (product) innovation. We also find a positive significant impact of age variety on process innovation after controlling for potential reverse causality (column 6). Thus, it appears that a spurious correlation occurs when reverse causality is not taken into account. A possible explanation is the control for potential endogeneity of age variety and polarization (columns 4 to 6).

Moving to the impact of HRM practices on innovation, the results in models with exogenous (columns 1 to 3) and endogenous diversity (columns 4 to 6) are quite similar. The probability of introducing technological and product innovation is positively associated with information sharing while there is no evidence for process innovation. The estimated marginal effects of competence development are also strongly significant and positive for all types of innovations. We do not find any significant relationship between teamwork and innovation, whatever the model. Finally, the estimated marginal effect on all types of innovation of competencies development is positive and strongly significant at the 1% level (Table 1).

As for the other explanatory variables, we find that the presence of an R&D department or the active participation of external experts is strongly and positively associated with the

likelihood of all types of innovation. The estimated marginal effect of firm size is positive and significant, as expected. Share of part-time is shown to be negative and significant for technological and process innovation, in line with previous empirical studies (De Meulenaere et al., 2016; Batt and Colvin, 2011). Share of part-time denotes the degree of job security firms offer to the employees. A high degree de job security (low share of part-time) demonstrates that firms guarantee the employees' continuity of employment, value their contributions and experiences within the firm. This could in turn improve employees' motivation, satisfaction and involvement, thus facilitate the development of innovation.

Table 1 : Estimated effects of diversity and HRM on innovation: Probit and IV models

	Probit Model – Marginal effects			**IV Probit Model - coefficients**		
	Innovation	***Product***	***Process***	***Innovation***	***Product***	***Process***
Age polarisation	-2.997*	-3.430**	-0.970	-13.976**	-12.541**	-5.475
	(1.708)	(1.601)	(1.199)	(5.564)	(5.524)	(5.992)
Age variety	0.583**	0.499*	0.244	2.600***	2.271**	2.474**
	(0.294)	(0.273)	(0.201)	(1.002)	(1.006)	(1.129)
Teamwork	0.006	0.024	-0.010	0.022	0.072	-0.042
	(0.022)	(0.020)	(0.015)	(0.059)	(0.060)	(0.066)
Information sharing	0.073***	0.060***	-0.006	0.206***	0.178***	-0.027
	(0.022)	(0.021)	(0.016)	(0.060)	(0.061)	(0.068)
Competences development	0.109***	0.120***	0.061***	0.299***	0.361***	0.275***
	(0.024)	(0.023)	(0.017)	(0.071)	(0.073)	(0.083)
Mean age	-0.007**	-0.005*	-0.005**	-0.024***	-0.018**	-0.025***
	(0.003)	(0.003)	(0.002)	(0.008)	(0.009)	(0.010)
Organisational innovation	0.353***	0.321***	0.239***	0.943***	0.899***	0.901***
	(0.022)	(0.021)	(0.019)	(0.060)	(0.060)	(0.066)
Firm size	0.001***	0.001***	0.001**	0.001***	0.001***	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Share of part-time	-0.245**	-0.100	-0.155*	-0.646**	-0.292	-0.679*
	(0.106)	(0.100)	(0.081)	(0.292)	(0.293)	(0.349)
Share of permanent contracts	-0.162	-0.184	-0.074	-0.499	-0.570*	-0.361
	(0.118)	(0.113)	(0.089)	(0.325)	(0.331)	(0.385)
External experts	0.093***	0.081***	0.089***	0.235***	0.220***	0.332***
	(0.027)	(0.026)	(0.021)	(0.071)	(0.071)	(0.075)
R&D department	0.134***	0.138***	0.111***	0.355***	0.390***	0.438***
	(0.023)	(0.023)	(0.018)	(0.062)	(0.063)	(0.069)
Foreign owned	-0.087***	-0.049**	-0.059***	-0.254***	-0.148**	-0.273***
	(0.025)	(0.024)	(0.017)	(0.075)	(0.075)	(0.084)
Number of concurrents	-0.019	-0.007	-0.005	-0.050	-0.021	-0.024
	(0.013)	(0.013)	(0.010)	(0.037)	(0.037)	(0.042)
Share of graduate employees	-0.008	-0.015	0.006	-0.019	-0.041	0.030
	(0.013)	(0.012)	(0.009)	(0.035)	(0.035)	(0.040)
Construction	-0.108***	-0.055	-0.081***	-0.311***	-0.168	-0.399***
	(0.036)	(0.036)	(0.022)	(0.110)	(0.112)	(0.122)
S_trade	-0.017	0.017	-0.031	-0.042	0.049	-0.152
	(0.039)	(0.038)	(0.025)	(0.108)	(0.110)	(0.117)
S_accomodation	-0.118**	-0.068	-0.058**	-0.346**	-0.208	-0.296*
	(0.046)	(0.047)	(0.029)	(0.152)	(0.156)	(0.170)
S_transportation	-0.050	-0.030	0.012	-0.153	-0.094	0.047
	(0.046)	(0.044)	(0.034)	(0.132)	(0.135)	(0.142)
S_communication	0.027	0.073	-0.064**	0.079	0.215	-0.302*
	(0.056)	(0.055)	(0.027)	(0.149)	(0.150)	(0.164)
S_finance	0.044	0.087*	-0.051*	0.123	0.251*	-0.225
	(0.052)	(0.051)	(0.028)	(0.138)	(0.138)	(0.149)
S_services	-0.011	0.055	-0.100***	-0.023	0.162	-0.518***
	(0.043)	(0.043)	(0.020)	(0.119)	(0.120)	(0.133)

Constant				-1.771**	-2.115**	-2.244**
				(0.863)	(0.870)	(0.966)
Observations	1,433	1,433	1,433	1,433	1,433	1,433
Log likelihood	17154.01	15426.52	18452.65	17451.85	16851.25	17452.95
Wald chi2	425.42***	352.85***	415.58***	385.12***	371.71***	412.03***

Notes: The dependent variables in columns 2 and 3 correspond to product and process innovations. They are not exclusive so that estimation results came from a biprobit regression. Standard errors in parentheses. *, **, and *** denote significance at 10%, 5%, and 1% levels

We next explored the different mechanisms by which age diversity is associated with innovation by looking at three practices of HRM, taking into account employees' characteristics and firm heterogeneity. In the following tests, we will augment the baseline models with interaction terms between measures of age diversity and HRM (Tables 2, 3 and 4). Results for the moderating role of information sharing in the relationship between age diversity and innovation are in Table 2, which presents the IV models results with endogenous age variety and polarization[5]. We found a positive and stronger significant impact of information sharing on technological and product innovations[6], suggesting that information sharing mitigates the adverse impact of age polarization on technological and product innovations. On the contrary, the interaction terms between age variety and information sharing is not significant. As such, we have no evidence for the moderating role of information sharing in the innovation effect of age variety[7].

[5] We also ran models with exogenous age variety and polarization. For the sake of parsimony, we do not present those results here.

[6] It is appropriated to compute the marginal effect for Probit models. We have done it for the Baseline model (columns 1 to 3 of Table 1). However, as we augment the models with the interaction terms between polarization and variety (continuous variables) and HRM practices (binary variables), marginal effects of interaction terms between continuous variables and binary variables can be tricky to interpret (Richard Williams, 2016). For this reason, in Tables 2, 3 and 4, we will present only the estimates of IV models and build our comments based on the signs rather than the magnitudes of the interaction terms.

[7] We also ran several models testing other indicators of information sharing such as (1) bundle of information sharing measures regrouping meetings (high frequency of meetings between senior management and all employees), changes with employees involved (high duration of the meetings used by the employees for expressing themselves and asking questions) and attitude surveys (whether or not does senior management seek to stimulate employees' participation by Internet surveys), taking the value from 0 to 3; (2) separated indicators of information sharing such as only meetings; only changes with employees involved; only attitude surveys. We got the same results as presented in Table 3 concerning the moderating role of information sharing on innovation, showing that our results are robust. Results are available upon request.

Table 2 : IV Probit models with interaction term between information sharing and diversity

	IV Probit Model – Coefficients		
VARIABLES	***Innovation***	***Product***	***Process***
Age polarisation	-29.251***	-32.748***	-15.365*
	(8.288)	(8.531)	(9.265)
Age variety	1.140	0.777	1.690
	(1.438)	(1.456)	(1.553)
Polarisation*Infosharing	19.474**	26.448***	12.700
	(9.215)	(9.459)	(10.515)
Variety*Infosharing	2.359	2.361	1.326
	(1.801)	(1.815)	(1.996)
Teamwork	0.022	0.071	-0.043
	(0.059)	(0.060)	(0.066)
Information sharing	-2.257	-2.467	-1.457
	(1.539)	(1.553)	(1.704)
Development	0.278***	0.339***	0.265***
	(0.072)	(0.074)	(0.083)
Control variables	Yes	Yes	Yes
Observations	1,433	1,433	1,433
Log likelihood	16043.12	15125.25	15780.35
Wald chi2	396.11***	415.21***	512.01***

Notes: The dependent variables in columns 2 and 3 correspond to product and process innovations. They are not exclusive so that estimation results came from a biprobit regression. Standard errors in parentheses. *, **, and *** denote significance at 10%, 5%, and 1% levels

As regards the interplay between age diversity and teamwork, results in Table 3 show that, by augmenting the models with the interaction terms involving teamwork and diversity, the estimates IV indicate that age polarization is no longer significant. In addition, the interaction term is becoming negative and strongly significant for all types of innovation. It suggests that teamwork does even reinforce the adverse effect of age polarization on innovation. Age variety is positive significant, while the interaction term between teamwork and age variety is negative and significant for product innovation, while no evidence was found for process innovation. Therefore, rather surprisingly, while age variety is likely to enhance innovation, involving employees in teamwork seems to mitigate this positive effect[8].

[8] We also ran several models testing other indicators of teamwork such as (1) bundle of teamwork measures regrouping autonomous team work (share of employees working in a team where the members jointly decide how work is done) and quality circle (share of employees involving in groups who meet voluntary and regularly to identify and solve problems related to their work) and job rotation (share of employees able to perform the tasks of other colleagues in their absence), taking the value from 0 to 3; (2) separated indicators of teamwork such as only autonomous team work; only quality circle; only job rotation. We got the same results as presented in Table 3 concerning the moderating role of teamwork on innovation, showing that our results are robust. Results are available upon request.

Table 3 : IV Probit models with interaction term between teamwork and diversity

	IV Probit Model – Coefficients		
VARIABLES	*Innovation*	*Product*	*Process*
Age polarisation	-1.633	-3.536	14.502
	(8.633)	(8.197)	(9.920)
Age variety	3.688***	4.547***	3.740**
	(1.369)	(1.392)	(1.547)
Polarisation*Teamwork	-24.882***	-32.250***	-34.938***
	(8.706)	(8.620)	(10.317)
Variety*Teamwork	-3.765	-7.712**	-4.301
	(3.141)	(3.157)	(3.477)
Teamwork	4.258	8.202***	4.974
	(3.099)	(3.108)	(3.435)
Information sharing	0.200***	0.170***	-0.017
	(0.061)	(0.061)	(0.068)
Development	0.305***	0.364***	0.284***
	(0.072)	(0.074)	(0.083)
Control variables	Yes	Yes	Yes
Observations	1,433	1,433	1,433
Log likelihood	15143.52	15135.51	16790.75
Wald chi2	314.00***	452.51***	457.07***

Notes: The dependent variables in columns 2 and 3 correspond to product and process innovations. They are not exclusive so that estimation results came from a biprobit regression. Standard errors in parentheses. *, **, and *** denote significance at 10%, 5%, and 1% levels

No significant effect of interaction between competence development and age polarization (Table 4) was found. A similar finding occurs for the interaction between development and age variety. These results provide strong evidence that competence development, which includs upskilling, annual appraisal, abd internal mechanisms of skills' development, is not likely to moderate the effects of age diversity on innovation[9].

[9] We also ran several models testing other indicators of development such as (1) bundle of development measures regrouping training, annual appraisal and internal mechanism, taking the value from 0 to 3; (2) separated indicators of development such as only training; only annual appraisal; only internal mechanism. We got the same results as presented in Table 4 concerning the moderating role of development on innovation, showing that our results are robust. Results are upon request.

Table 4 : IV Probit models with interaction term between development and diversity

	IV Probit Model – Coefficients		
VARIABLES	*Innovation*	*Product*	*Process*
Age polarisation	-18.156	-18.319	-9.563
	(11.893)	(12.392)	(14.727)
Age variety	4.967**	3.226	6.228**
	(2.461)	(2.534)	(3.133)
Polarisation*Development	4.575	5.935	4.103
	(11.228)	(11.575)	(13.807)
Variety*Development	-2.875	-1.091	-4.298
	(2.695)	(2.766)	(3.362)
Teamwork	0.027	0.076	-0.037
	(0.059)	(0.060)	(0.067)
Information sharing	0.213***	0.184***	-0.021
	(0.061)	(0.062)	(0.069)
Development	2.576	1.110	3.762
	(2.314)	(2.377)	(2.881)
Control variables	Yes	Yes	Yes
Observations	1,433	1,433	1,433
Log likelihood	16425.01	15871.25	16124.03
Wald chi2	481.00***	381.54***	401.65***

Notes: The dependent variables in columns 2 and 3 correspond to product and process innovations. They are not exclusive so that estimation results came from a biprobit regression. Standard errors in parentheses. *, **, and *** denote significance at 10%, 5%, and 1% levels

5. Discussion

This paper provides two major results: on one hand, we support De Meuleneare et al. (2016)'s results on the effect of age diversity on labour productivity in the context of innovation. This effect depends on the shape of the age distribution and is positive when it is heterogeneous (variety) and negative when it is polarized (polarization). On the other hand, we look at the moderating effect of three major HRM practices (teamwork, upskilling and information sharing, and found that information sharing, when associated to polarization, counterbalances the negative impact of polarization on technological innovation. The interaction term is positive while the direct effect was negative.

These results provide two major contributions, which has interesting theoretical implications. First, in line with De Meulenaere et al. (2016), we concentrate on age diversity and on its two aspects, variety and polarization, and found that the effect of these two types of diversity are radically opposite, which can explain for the mixed results found in the literature on the impact of age diversity on organizational performance – whatever the measure. The diversity argument, which lies on the assumption that there are complementarities among the different kinds of human capital of young and older workers (Grund and Westergaard-Nielsen, 2008), therefore holds in terms of variety (i.e. when ages are heterogeneous), but not of

polarization (i.e. when there is a separation of the workforce into distinct homogeneous subgroups). In the latter case, it seems that the organizational demography approach (Pfeffer, 1985), which argues that social similarity is important for interaction, communication and cohesion, holds, confirming that there is no single theory of corporate age structures (Grund and Westergaard-Nielsen, 2008). Therefore, social dissimilarities between co-workers lead to dissatisfaction, less communication, and alleviated efficiency of the firm in terms of technological innovation. Hence, it is therefore not that surprising that HRM practices which emphasize communication between workers may attenuate such counterproductive effects.

Second, we account for the moderating effect of three HRM practices on these two variables to see whether they may reinforce, counterbalance or alleviate the direct positive or negative relationships. There are no interaction effects of such HRM practices for age variety (in line with De Meuleneare et al. (2016)' results), meaning that the use of such practices by firms does not reinforce the positive impact of age variety on technological innovation. On the contrary, results are interesting for age polarization. Whatever the measure for upskilling (training, development or appraisal, or a bundle of the three) or teamwork (autonomy, quality circle or job rotation), such practices do not have any moderating role.

However, HRM practices oriented towards communication transform the negative direct link into a positive relationship. This means that the HRM practices that are directly linked or focused on job efficiency do not have any positive impact, while those oriented towards an improvement of communication and cooperation counterbalance the negative effect of polarization. Such results are not that surprising. Indeed, members of diverse groups appear to communicate more formally and, perhaps, less frequently with each other than members of less diverse groups (Milliken and Martens, 1996). For another type of diversity, functional diversity, Ancona and Caldwell's (1992) study of 45 product teams indicated that diversity had a negative direct effect on innovation and team-rated performance, but it had a countervailing positive indirect effect on innovation through its association with an increased frequency of communication with those outside the project group. In the same line of idea, functional diversity in top management groups was associated with more frequent communication within the team (Glick et al., 1993).

This result can be explained by social exchange theory (Blau, 1964; Cropanzano and Mitchell, 2005), which has identified trust as an outcome of favorable social exchanges, which rest on increased communication between workers within an organization. As the innovation process involves interaction between several employees at various levels in the firm (Østergaard et al., 2011), our finding that the introduction of communication practices between

various layers in the firm counterbalances the negative effect of age polarization on technological innovation reinforces the adequacy of social exchange theory for innovation. Demographical ideas also explain the importance of communication processes as it is often considered as a sort of mediator of the link between diversity and performance: "*diversity in the composition of organizational groups affects outcomes such as turnover and performance through its impact on affective, cognitive, communication, and symbolic processes*" (Milliken and Martins, 1996: 402).

6. Conclusions, limitations, and further research

Previous studies that consider the intangible human capital dimension focus only a small group within a larger organizational setting, i.e. top-management teams. However, the diversity in the composition of TMT teams does not adequately reflect the effect of employee diversity on innovation. Indeed, the innovation process involves interaction between several employees at various levels in the firm. Therefore, in line with Østergaard et al. (2011), we here look at the broader composition of all members in the firm to analyze the effect of employee age diversity on firms' technological innovation.

Our findings are in accordance with our predictions. They show that the two aspects of diversity have opposite relationships with technological innovation, positive for variety and negative for polarization. The major result lies in the moderating effect of only one type of HRM practices: those oriented towards enhancing communication between the different age cohorts (hence, between employees and their managers). In that case, implementing communication HR management offsets the negative impact of polarization: the interactive term becomes positive. Communication allowing social integration and the feeling to be part of the same whole is therefore an essential component of HR diversity management. Such informal practices seem to have a more important impact than more formal practices such as training or upskilling practices.

Limitations of our study include some measurement problems. Although we have used the same measure as the main major studies in the field, it would be interesting to consider other types of measures for HRM practices, for instance for teamwork. Indeed, while we have adopted quantitative measures of formal work practices, teamwork could also be considered as favoring communication between team members, thus also fostering group cohesion and integration. Moreover, we could only have access to longitudinal data for HRM practices, but not for technological innovation. Future research should look at a more longitudinal study, for

instance to analyze whether persistent innovative firms (Haned et al., 2014) become more diverse or whether diverse firms become more innovative. Moreover, the size of our sample and its composition did not allow us to make distinctions between different types of industry, such as between service and manufacturing firms. Finally, in line with Østergaard et al.'s (2011) recommendations, we have looked not only at the demographic age composition, but have also considered other factors that make the human capital composition of a firm to a success: HR management. Pitcher and Smith (2001) also found that management plays a role in the effect of diversity. We here show that some HR management practices do more than just offsetting the possible negative effect of age diversity: it transforms the negative effect into a positive one. In line with such result, more studies should look at how to better integrate diverse types of employees, and not only for age diversity but also racial, gender, cultural, etc. Such research is essential in a world that tends to become diversity adverse.

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Appendix 1: Variables description and descriptive statistics

Variables	Definition	Mean	SD	Min	Max
Innovation	Equal 1 if the firm introduced new or significantly improved products or/and process during the three years 2010 to 2012, 0 otherwise	0.360	0.481	0	1
Product	Equal 1 if the firm introduced new or significantly improved goods or services during the three years 2010 to 2012, 0 otherwise	0.324	0.468	0	1
Process	Equal 1 if the firm introduced new or significantly improved production process, distribution methods, or support activity for goods or services during the three years 2010 to 2012, 0 otherwise	0.193	0.395	0	1
Diversity					
Age polarisation	Esteban and Ray index	0.006	0.007	0.012	0.088
Age variety	Blau index	0.826	0.040	0.568	0.888
Instruments					
Age polarisation in t-1	Esteban and Ray index	0.026	0.008	0.001	0.106
Age polarisation in t-2	Esteban and Ray index	0.027	0.011	0.021	0.199
Age variety in t-1	Blau index	0.824	0.045	0.410	0.892
Age variety in t-2	Blau index	0.812	0.075	0.512	0.881
Number of quits in t-1	Total number of quits	10.62	24.49	0	463
Number of hirings in t-1	Total number of hirings	10.41	22.36	0	311
Teamwork	Equal 1 if at least 25% of the employees (not senior executives) currently work in a team where the members jointly decide how work is done or/and at least 25% of employees is currently involved ion groups who meets voluntarily and regularly to identify and solve problems related to their work or/and the employees at the team level and for all positions are able to perform the tasks of the other colleagues during their absence, 0 otherwise	0.543	0.498	0	1
Information sharing	Equal to 1 if at least one of the following statements are true for the firm: (1) high frequency of meetings between senior management and all employees (meetings); high duration of the meetings used by the employees for expressing themselves and asking questions (changes with employees involved) and/or senior management seeking to stimulate employees' participation by Internet surveys (attitude surveys), 0 otherwise	0.539	0.472	0	1
Competences development	Equal 1 if at least 25% of employees has received training days taken on working time or/and at least 25% of employees benefit from an annual appraisal or/and the firm an internal mechanism to encourage employees to develop their skills and their carrier, 0 otherwise	0.664	0.498	0	1
Control variables					
Age mean	Firm's mean of age	38.89	4.133	24.65	52.31
Organisational innovation	Binary variable, equal to 1 if between 2010 and 2012, the firm make significant organizational changes such as business practices, methods of organizing work responsibilities and decision making, external relations), 0 otherwise.	0.33	0.47	0	1
Firm size	Logarithm of the number of employees	5.60	1.25	5.49	9.58
Part-time	Share of part-time in the firm	0.085	0.112	0	1
Permanent contracts	Share of permanent contracts in the firm	0.082	0.096	0	1
External experts	Equal to 1 if firm involves external experts (Universities, research institutes) in the innovation process, 0 otherwise	0.201	0.401	0	1
R&D department	Equal to 1 if there is a R&D department within the firm, 0 otherwise	0.321	0.469	0	1
Foreign owned	Equal to 1 if the firm is foreign owned, 0 otherwise	0.241	0.428	0	1

Number of concurrents	Equal to 1 if firm has less than 5 concurrents; 2 if firm has between 6 and 25 concurrents; 3 if firm has more than 25 concurrents	2.138	0.784	1	3
Manufacturing	Manufacturing sector (reference)	0.114	0.318	0	1
Construction	Construction	0.218	0.413	0	1
Trade	Trade, accommodation and food service	0.184	0.287	0	1
Accommodation	Low-tech manufacturing	0.064	0.245	0	1
Transportation	Transportation and storage	0.103	0.304	0	1
Communication	IT and communication	0.066	0.248	0	1
Finance	Finance	0.094	0.293	0	1
Others services	Others services	0.154	0.361	0	1

Appendix 2 : Correlation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Innovation (1)	1,00																	
Product (2)	0,92	1,00																
Process (3)	0,65	0,51	1,00															
Teamwork (4)	0,10	0,11	0,05	1,00														
Information sharing (5)	0,16	0,15	0,06	0,15	1,00													
Development (6)	0,25	0,25	0,16	0,22	0,29	1,00												
Mean age (7)	-0,07	-0,07	-0,04	-0,05	-0,13	-0,13	1,00											
Organazational innovation (8)	0,41	0,39	0,34	0,11	0,15	0,23	-0,06	1,00										
Firm size (9)	0,15	0,15	0,13	0,02	-0,02	0,12	0,00	0,11	1,00									
Part-time (10)	-0,04	-0,01	-0,04	0,04	-0,03	0,00	-0,08	0,02	0,05	1,00								
Permanent (11)	0,00	0,00	0,00	-0,01	-0,01	0,00	-0,25	0,05	-0,01	0,18	1,00							
External experts (12)	0,21	0,20	0,21	0,15	0,08	0,21	-0,08	0,19	0,10	0,00	0,03	1,00						
R&D (13)	0,22	0,22	0,21	0,11	0,09	0,21	-0,03	0,12	0,11	-0,05	-0,01	0,18	1,00					
Foreign owned (14)	0,04	0,05	-0,01	0,02	0,11	0,23	0,04	0,04	0,13	-0,05	0,01	0,06	0,10	1,00				
Number of concurrents (15)	-0,07	-0,05	-0,05	0,02	-0,03	-0,08	0,04	-0,03	-0,02	0,03	0,01	-0,07	-0,07	-0,03	1,00			
Graduate employees (16)	0,16	0,16	0,08	0,18	0,20	0,34	-0,09	0,14	0,07	-0,09	-0,04	0,21	0,21	0,27	-0,02	1,00		
Age polarisation (17)	-0,12	-0,12	-0,08	0,01	0,03	-0,17	-0,26	-0,11	-0,29	0,10	0,00	-0,10	-0,13	-0,27	0,02	-0,17	1,00	
Age variety (18)	-0,01	-0,01	0,00	-0,04	-0,13	-0,12	0,24	-0,06	0,10	0,06	-0,01	0,01	-0,03	-0,11	0,04	-0,26	-0,08	1,00

Appendix 3: Instrumenting regressions of the endogenous diversity

	Polarisation	***Variety***
Age variety in t-1	0.006***	0.811***
	(0.002)	(0.014)
Age variety in t-2	0.001	0.002
	(0.001)	(0.008)
Age polarisation in t-1	0.690***	-0.397***
	(0.013)	(0.082)
Age polarisation in t-2	0.118***	0.188**
	(0.014)	(0.091)
Number of quits in t-1	0.000***	0.000
	(0.000)	(0.000)
Number of hirings in t-1	-0.000***	0.000*
	(0.000)	(0.000)
Firm characteristics	Yes	Yes
Observations	1,433	1,433

Notes: Standard errors in parentheses. *, **, and *** denote significance at 10%, 5%, and 1% levels