The Impact of Aging and Age Diversity on Company Performance

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Keywords: Diversity, Aging, Demographic Change, Performance

[1] The authors are part of a joint project of the German Academy of Sciences Leopoldina and the German Academy of Sciences and Engineering acatech. It is also funded by the Jacobs Foundation Zurich.

Abstract:

We examine how the age structure of a company's workforce affects company performance. Although, *individual* age-productivity effects have been analyzed frequently, *organizational* productivity effects, which are more than the sum of individual productivities, have not. Doing so, we not only address the effect of changes in *average age* but also of changes in *age diversity* on organizational performance. By introducing a simple economic model, we are able to study the effects of workforce heterogeneity on company performance. The model provides a formal structure, i.e. cost and benefit curves, to analyze how changes in age diversity may affect organizational performance. We then combine this economic model with theoretical insights and empirical results on aging and diversity from multiple and very diverse disciplines. Our hypotheses are tested with a linked employer employee dataset consisting of more than 18.000 German firms and 2 million employees.

We find that organizational productivity does not necessarily decline with average workforce age, particularly if changes in age diversity and type of tasks are controlled for. Also, an increase in age diversity can have substantial positive productivity effects, particularly in innovative and creative companies. With demographic changes at hand, these results are of economic importance for organizational performance.

1. Introduction

In view of the foreseeable demographic changes and the resulting changes in the age structure of the working population, the question arises as to what effects an aging working population will have on the productivity of firms. Companies will be confronted with an aging workforce, on the one hand, and with changes in age composition, on the other hand. Thus, they will have to make greater use of the skills of an increasing number of increasingly older employees who, in turn, will have to be productively employed amidst a decreasing number of young, and in some instances very young, employees. Today, in contrast, many companies have no, or very few, older workers on their payrolls. This means that the average age of employed workers will increase in the foreseeable future, as will the variance in workers age, or age diversity. This paper addresses both the productivity effects of changes in average age as well as in age diversity, however, our primary focus is on the effect of age diversity on firm performance.

Although there is a rather large number of studies on age-related productivity changes with regard to *individual* productivity, the question of how aging and age diversity in an *organization* affects *organizational* productivity has largely been overlooked and few theoretical frameworks have been provided to deal with structure of this problem. Studies on age heterogeneity at top management levels (Somech, Desivilya, Lidogoster 2009; Charness, Villeval 2007; Hamilton, Nickerson, Owan 2004; Jehn, Bezrukova 2004; Pitcher, Smith 2001; Williams, O'Reilly III 1998) represent the main exceptions here, but the applicability of these findings to the rest of the workforce is limited. Therefore, we propose a new type of theoretical analysis that borrows from economic theory to study the structural effects of workforce heterogeneity on company performance on the one hand side, and from a very diverse literature on aging and diversity to bring life to the structure and derive empirically testable hypotheses. We argue that changes in age diversity exert a systematic effect on firm

performance and that the nature of this relationship depends on the nature of the tasks involved and on the business area in which an organization is active. Our hypotheses are empirically tested in section 3, with the aid of the so-called LIAB, which is a representative linked employer-employee data set for Germany based on more than 18,000 companies and more than 2 million employees over a ten year period.

2. Workforce composition and firm performance: Theoretical framework and empirical implications

The starting point of our theoretical framework is the assumption, widely supported by medical, psychological and economic research, that old and young employees possess different skills and abilities (Johnson 2005; Skirbekk 2005; Staudinger 2006). The competencies and capabilities of old and young employees vary depending on their occupational field and activity. It generally can be assumed that depending on the type of task, individual productivity declines with age and this process starts sooner or later and progresses more or less quickly. However, this age-related change in the individual productivity of each and every individual is only one aspect of productivity-relevant effects of aging, since in organizations individuals work alongside other individuals. Thus, the resulting organizational productivity is typically more than the sum of individual outputs; this, according to economic theory, is one reason for the very existence of companies (Williamson, 1975). But regarding age heterogeneity of the workforce, organizational studies produced unequivocal evidence on how the joint interaction of workers within an organization may influence performance outcomes. The effect can be positive, for example, when employees are involved in the transfer of knowledge and experience. But it can also be negative when employees are hindered in their duties when working together (Cleveland, Lim 2007; Williams, O'Reilly III 1998; Lawrence 1996). Since we aim at identifying the circumstances under which the

positive or the negative effects may dominate, we introduce a theoretical framework which we derive from Lazear (1999), whose theoretical model makes a simplifying distinction between costs and benefits of cultural diversity. We apply this model to age diversity in organizations and argue that there are *organizational costs* of age diversity, on the one hand, and *organizational benefits* of age diversity, on the other. An illustration of how these two factors are assumed to interrelate is given in Figure 1.

Figure 1 about here: Costs and benefits of age diversity and overall productivity

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In Figure 1, age heterogeneity of a company's workforce is plotted on the horizontal axis, with highly homogeneous age structures on the left and highly heterogeneous age structures on the right. The costs and benefits associated with increasing heterogeneity and the resultant overall productivity effects are plotted on the vertical axis. The increasing costs curve reflects the standard economic assumption of increasing marginal costs, meaning that heterogeneity problems increase faster with increasing heterogeneity; in other words, the more heterogeneous the workforce, the steeper the associated cost curve. The shape of the benefit curve likewise reflects the standard economic assumption of decreasing marginal returns, i.e., that although increasing heterogeneity may be associated with additional benefits, the additional returns decrease in size and the benefit curve levels off as heterogeneity increases. To give an example to illustrate what increasing marginal costs or decreasing marginal returns with increasing heterogeneity mean, one could think of increasing diversity in a workforce's languages and its effect on performance. Increasing marginal *costs* of language heterogeneity implies that while it may be fairly easy to cope with one or two additional languages in a given workforce, any further increases in language heterogeneity however will make it increasingly difficult to communicate, and the costs of translating into all languages and/or the costs of communication errors will rise disproportionately. Decreasing marginal *returns*

means that, although it may be a large benefit to have one or two additional languages represented in a workforce (for example, because it enables a team to communicate directly with its most important groups of foreign customers or vendors in an international business environment), such benefits will decline with increasing language heterogeneity until a point is reached at which any benefit is minimal or absent.

To find the diversity degree where the *overall* effect of age heterogeneity on productivity is largest one has to look at the distance between the benefits and costs curves in Figure 1. The distance between the two curves represents the overall productivity curve and is inversely u-shaped with increasing heterogeneity. Thus, overall productivity is very low if an organization has no diversity at all, but it is also very low if an organization is overwhelmingly diverse, and it peaks at a middle level of heterogeneity of H^* (a similar argument is made by Page 2007 and Richard and Shelor 2002 for diversity in teams).

We furthermore argue, that the exact shape of the costs and benefits curves depends on what type of skills and qualities the production process or business task of an organization requires. Hence, the cost and benefit curves and naturally also the overall productivity effect as well as the optimal heterogeneity level H* can be expected to vary depending on these requirements. For example, in a context such as a standard assembly line, where increasing heterogeneity has few benefits, the benefit curve may be very flat, meaning that the overall productivity effect may even diminish and become negative with increasing heterogeneity (see Figure 2, Case R). On the other hand, in an area where creative problem-solving is important and increasing heterogeneity brings major benefits because it, for example, significantly enhances the spectrum of proposed solutions, the benefit curve may be very steep. In this case, the overall productivity effect may also be quite large and peak at a higher level of heterogeneity H^*_K (see Figure 2, Case K). Accordingly, we hypothesize that the net productivity effect of

increased age heterogeneity crucially depends on whether in a particular work setting the expected benefits of heterogeneity can be assumed to be large or small.[2]

Figure 2 about here: Optimum level of heterogeneity for routine and creative tasks

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To more precisely identify the amount of costs and benefits of heterogeneity, we use the multi-disciplinary management and diversity research to gain insight on the effects in different environments and different tasks. In the following section, we therefore systematically assemble the findings from a large variety of disciplines on the effects of age heterogeneity in various business contexts and use these results to more clearly identify the shape of the costs and benefits curves given different types of production processes. Thus, our simple economic model provides the basic framework for our analysis, while the wide array of results from other disciplines helps to provide valuable content to fill this framework, derive concrete and empirically-testable hypotheses and lay the ground for a genuine integration of multiple theories and data.

Costs of increasing (age) heterogeneity

There are several reasons for a general increase in burdens and costs within an organization with increasing (age) heterogeneity of the workforce.

Communication costs and interaction problems

Social psychological research shows that communication and the formation of social relationships between highly dissimilar individuals generally entail higher costs than that within homogenous groups of individuals (Gevers, Peeters 2009; Harrison, Price, Gavin, Florey 2002; Horwitz, Horwitz 2007; Lazear 1999; Page 2007; Prat 2002; Richard, Shelor

[2] Since most benefits of age-heterogeneity can be expressed as (opportunity) costs of age-homogeneity or vice versa, we have to concentrate on one side of the coin. To simplify the argument and the illustration we keep the cost curve constant for the tasks and concentrate on the different benefits of heterogeneity for different tasks. Arguing from the cost side yields the same results. What we do need to show is that the cost curve is generally increasing with heterogeneity. Therefore, to show that our cost-benefit structure is applicable, we present findings on that as a first step.

2002). Employees communicate better with people who are similar to themselves, because they share similar lifetime experiences, a common language and a common set of symbols. Objectively identical events are processed in a subjectively different manner from one generation to the next, since people who have experienced different socialization processes generally develop different knowledge and value systems. This tends to prevent a consensual view of problems and impede cross-generational communication. For an age-diverse group, a common approach and concerted action becomes more difficult. For these reasons, communication costs tend to be higher with a more age-heterogeneous workforce than with an age-homogenous workforce. In accordance therewith, organizational studies have produced empirical evidence that greater age diversity in work groups indeed makes communication more difficult and hence less frequent (Milliken, Martins 1996: 408), which means that the cost curve is increasing with age-heterogeneity.

Identification, integration, dissatisfaction and turnover

Besides the immediate costs caused by communication difficulties, heterogeneity can also have an indirect productivity-inhibiting effect by increasing the rate of turnover (Williams, O'Reilly III 1998). There is strong empirical evidence that age heterogeneity increases the turnover rate, as shown by Richard and Shelor (2002), Milliken and Martins (1996: 408) and O'Reilly, Caldwell and Barnett (1989). In a business context, absenteeism and turnover exert costs by causing productivity losses, particularly when team efforts are required and interactive tasks must be performed (Nicholson et al. 2004). Furthermore, empirical research on age diversity at top management level suggests that demographic heterogeneity exerts a negative effect on collaboration and turnover, thereby lowering productivity (Gevers, Peeters 2009; Pitcher, Smith 2001). Therefore, it can generally be assumed that the above-mentioned negative productivity effects of age heterogeneity are magnified through an increase in absenteeism and turnover rates, causing an increasing cost curve with heterogeneity.

Conflicts and turnover

An additional indirect mechanism by which age heterogeneity can negatively affect productivity concerns differences in the values and preferences of distinct age groups. Different age cohorts, each with varying socialization processes behind them, regard their environment against the backdrop of very different cultural and normative attitudes, which heightens the likelihood of value conflicts. This, in turn, lessens the degree of social integration and ultimately diminishes productivity (Somech, Desilvilya, Lidogoster 2009; Jackson, Joshi 2004: 681). It has been shown that productivity-diminishing conflicts are particularly frequent in the presence of "generation gaps" and demographic faultlines (Lau, Murnighan 2005: 645; Pitcher, Smith 2001), causing an increase in costs with increasing age-heterogeneity.

In summary, based on previous empirical findings the costs and the productivity-diminishing effects of increasing age diversity are generally rising. Some of the costs of heterogeneity are opportunity costs, i.e. benefits that may be realized, when working with a more heterogeneous workforce. If these benefits may be realized and if the costs are outweighed by accordingly increasing benefits highly depends on the task a company's workforce is involved in, especially on how routine the task is, that has to be performed.

Benefits of increasing (age) heterogeneity

The costs of age heterogeneity may be juxtaposed with its potential benefits. The general drivers of these benefits are positive complementarities and composition effects. Complementarity effects emerge when collaboration in a group enables individuals to be more productive than when working on their own. As a result, the overall output of the group surpasses the sum of the individual outputs. Composition benefits emerge when different organizational activities can be better performed by staff with differing skills. Having

employees of different ages, for example, can help a firm maintain better relationships with customers from different age groups. A group of employees consisting of different age groups would therefore be more productive than a group with employees belonging all to the same age group (Williams, O'Reilly III 1998; Zenger, Lawrence 1989). Hence, the benefits of age heterogeneity are based on additional productivity effects that arise due to the interaction among individuals of different ages with differing skill profiles, differing perspectives and perhaps also different personality traits. In the following section, we summarize empirical results that discuss the possible origins of the added value of age-specific differences that can make collaboration among age-heterogeneous staff productivity enhancing.

Diversity, problem-solving approaches and creativity

An age-diverse workforce will display a host of different values, preferences and experiences, which makes it very likely that employees will also express differing opinions and approach problems in different ways. In comparison, within a homogeneous workforce, there is the risk that only highly similar ways of looking at and approaching problems will emerge, which tends to engender more of an innovation-inhibiting culture. For example, it has been shown that relatively age-homogenous management teams modified their business strategy infrequently and were likely to adhere to previously adopted strategic plans (Mas, Moretti 2006; Wiersema, Bird 1993: 1015-1019). Age homogeneity tends to lead to "groupthink", which refers to a rigid, static style of decision-making that is conducive to within-group cliquish views and circles (Janis 1982). Page (2007) argues that the different perspectives, interpretations, heuristics and mental models within a relatively heterogeneous group represent a collection of cognitive tools that is enhanced by group diversity. This enlarged "tool box", in turn, enhances the group's flexibility and creativity, which ultimately leads to more creative, faster and flexible problem-solving processes with better outcomes (Page 2007: 293-294). This argument has been demonstrated quite convincingly, for example, in

studies of top management teams (Canella, Park, Lin 2008; Hamilton et al. 2004; Kilduff, Angelmar, Mehra 2000: 32; Richard, Shelor 2002: 961). However, it also has been shown that the company-specific context played a critical role with respect to productivity effects, because the relevance of the enhanced problem-solving competencies was basically dependent on the type of task at hand.

For example, it has been shown that social heterogeneity has clearly positive effects, particularly when the work to be done required a high degree of creativity and decision-making skills or when dealing with strategic and complex decision-making and vaguely-defined problems in a dynamic setting (Jackson 1992; Jackson, Joshi 2004; Page 2007: 314-328; Richard Shelor 2002). Here, conversely to routine problems in stable environments, conflicts can lead to enhanced group discussion, a better analysis and better solutions in settings where challenges and problems are in a constant state of flux. Hence, the strife arising from increasing age heterogeneity generally poses a potential benefit in such settings and may increase performance (Richard, Shelor 2002: 962; Williams, O'Reilly III 1998).

We therefore postulate that in dynamic work environments, increased age diversity exerts a more positive effect on firm productivity than in relatively routine work settings.

Dominance of an age group, organizational problems and the transfer of experience and knowledge

Another benefit of greater age diversity is that it tends to counteract the dominance of one particular age group and the ensuing organizational problems. A homogeneous and dominant age group might reduce career options for the up-and-coming age group, because they clog the corporate career ladder. Within a homogeneous age group, increased conflicts over scarce job vacancies can be expected, which diminishes the effectiveness of promotion-based incentives as a result. Such reduced performance incentives, in turn, negatively affect the productivity of firms with age-homogeneous workforces. Conversely, the productivity of

more age-heterogeneous workforces should be higher due to more effective promotion incentives (Pelled, Eisenhardt, Xin 1999).

In addition to such incentive problems, promotion backlogs in age-homogeneous workforces may also cause coordination problems, because they impede the transfer of knowledge from one working generation to the next. If, for example, due to a lack of promotion options, a firm is unable to promote workers with important knowledge into higher ranking positions, workers may leave and take their knowledge with them. In this respect, heterogeneity is also necessary for an efficient in-house distribution of knowledge, which is especially important in settings with a preponderance of implicit knowledge. This implicit knowledge can include specific knowledge about production facilities and technologies as well as practical knowledge about effective work styles. The only way companies can ensure that this implicit productivity-enhancing knowledge and awareness of working methods are retained and shared is by maintaining an appropriate degree of age heterogeneity. Only if the workforce is sufficiently age-heterogeneous will an internal labor market be able to optimally perform its assigned function (for a theoretical model, cf. Gibbons, Waldman 2006).

Additionally, Cremer (1986) presents evidence that a broader age spectrum and overlapping generations within a workforce encourage adherence to implicit contracts. Older employees serve as the “standard bearers”, i.e., the cornerstones and mentors of an efficient code of conduct. Older employees socialize younger employees, and a continuous succession of “new older employees” is necessary to retain an efficient organizational code of conduct that integrates all the unwritten rules and competencies over the long term. Hence, generational overlap also helps to resolve the typical incentive and end-game problems associated with incomplete employment contracts. Since incentive problems of this nature are particularly common in occupational fields where outputs are difficult to measure, one can expect that the positive effects of an age-heterogeneous workforce would be particularly strong in such

fields. Difficult-to-measure outputs are associated primarily with fields of work that are knowledge-intensive, highly innovative with little standardization, and in which information and knowledge transfer play a critical role. Hence, we hypothesize that age diversity will exercise a particularly strong influence on the resolution of incentive problems in such environments.

In other words, we expect the positive productivity effects of age diversity to be greater in knowledge-intensive and highly innovative work settings.

Summary of hypotheses

The findings presented thus far consistently suggest that the type of task performed and the production process itself greatly mediate the relationship between age heterogeneity and firm productivity. According to the literature, we suggest a distinction between two fundamentally different types of work settings: work settings with mostly routine tasks, on the one hand, and with creative problem-solving tasks, on the other.

Routine tasks in a stable environment with standard processes are generally characterized by modest problem-solving demands and coordination needs as well as by a low degree of innovation. Rationalized work processes necessitate rapid, efficient and standardized communication processes, where little is gained from diversity-related competencies. Therefore, under these circumstances, the possible benefits of age heterogeneity might not be sufficient to offset the increasing costs of age heterogeneity. In Figure 2, this setting is characterized by function R, where the productivity-maximizing degree of age heterogeneity (H^*_R) is displaced so far to the left that any increase in age heterogeneity can only lead to a reduction in productivity. So for routine work tasks, we expect that any reduction in age heterogeneity will have a favorable effect on productivity, while every increase in age heterogeneity will reduce productivity. Empirically, this should produce a significantly negative statistical coefficient between age heterogeneity and firm productivity.

In contrast, *innovative and creative tasks* are associated with more complex problem-solving requirements and low levels of standardization. The dynamic work environment associated with these problem-solving tasks engenders ill-defined and novel problems and necessitates flexible responses as well as a constant ability to adjust. Though communication may also be important in these areas, it is important not so much for coordination purposes but for group discussion and solution-finding efforts. This is where the benefits of heterogeneous competencies come into play, and thus these benefits may outweigh the losses due to standard communication problems. Hence, with creative tasks, the benefit curve tends to be steeper, causing the inverse u-shaped overall productivity curve to shift to the right, which in turn increases the productivity-maximizing degree of heterogeneity H^*_K. In Figure 2, the case for creative tasks is represented by function K.

In summary, we are able to derive two empirically-testable hypotheses from the preceding analyses.

Hypothesis 1: In companies with mainly routine tasks, increasing age heterogeneity has a negative effect on firm productivity.

Hypothesis 2: In companies with mainly creative problem-solving tasks, increasing age heterogeneity has a positive effect on firm productivity.

In the following section, these two hypotheses will be empirically tested based on a representative linked employer-employee dataset.

3. Age heterogeneity, type of tasks and firm productivity: Empirical analysis

Data, operationalization and descriptive findings

Since we need a comprehensive set of information about the types of tasks performed at a company as well as about individual employees in order to evaluate our hypotheses, this empirical analysis ideally requires the use of a linked employer-employee data set. To do so, we use LIAB, a linked employer-employee panel data set collected in Germany, collected by the Institute for Employment Research (IAB) at Nuremberg. LIAB matches a large company data set with employee data from public employment statistics of the German Federal Employment Agency (Alda, Bender, Gartner 2005; Bellmann, Bender, Kölling 2002). The company data stem from a representative annual panel survey with about 18,000 companies.[3] It includes an extensive set of company-related information, including size, sales, capital expenditure, industry, innovative activities, and numerous organizational and operational details. Added to this company data is information about all workers employed in these firms. These employee data are from social security records and are thus extremely reliable.[4] The employee data encompass detailed information regarding level of education, occupational status, tenure, age and income (Alda et al. 2005: 8-10; Bellmann et al. 2002: 23-24). We use the years 1993 to 2003, which means that with a total of 10 panel years, we have a very long time series for our estimations.[5] The company data for sales and investments were adjusted for inflation using the consumer price index and translated uniformly into euros with the base

[3] For this, a stratified random sample is taken based on company size class and economic sector, which in 2003 included about 18,000 companies; data were gathered via personal interviews (Alda et al. 2005: 8-10; Bellmann et al. 2002: 22-23).

[4] However, they do not include a small fraction of workers without a social security number (for example, workers with a very limited number of weekly working hours and therefore very small income or small internships; for more details, cf. Bellmann et al. 2002: 22).

[5] For the productivity estimates, the data at employee level were excluded as follows. Since the number of working hours is not included in the data, we included only full-time employees, borrowing from Zwick's methodology (2008: 13), in order to avoid estimation errors. People who hold more than one job are also excluded, because in their case, it is not possible to establish a precise contribution to productivity. Additionally, the observed age range from 16 to 80 was also narrowed. Also, only employees in companies with more than 3 employees were included, since for companies with fewer employees, it is not possible to establish meaningful heterogeneity measures. In addition to the content-based reduction of cases, additional adjustments to the employee data due to missing values or lack of a match with companies led to a maximum loss of 0.36% of the cases. In addition, at the company level, only profit-oriented companies that generated sales were included. This means that in some cases, publicly-administered companies as well as banks and insurance companies, which have a different measurement of output, are not included. As usual, agricultural companies are also excluded, since their production process differs significantly from those of other sectors (Aubert, Crepon 2006: 12; Schneider 2007: 86).

year being 2000. The capital stock was calculated using the "perpetual inventory method" from figures for investments and assumptions regarding depreciation and growth rates (see Hempell 2005: 434-437; Schneider 2007: 86). Table 1 provides the descriptive statistics for the important variables of the data set used in our paper.[6]

Table 1 about here: Descriptive Overview of Variables

Estimation method

In order to test the two hypotheses, we regress productivity on our three main explanatory variables: age heterogeneity, the type of tasks and an interaction variable of both. *AGE-HETEROGENEITY* is operationalized with two alternative variables: a) the coefficient of variation and b) the standard deviation.[7] The type of tasks is measured by a dummy variable, which is set to 1 if a company is mainly characterized by creative-innovative tasks and to 0 for mainly routine tasks. We interact this dummy with *AGE-HETEROGENEITY*. This interaction term then reflects the effect of increasing age heterogeneity in an innovative work environment. Thus, the coefficient of *AGE-HETEROGENEITY* captures the pure effect of heterogeneity on productivity, and the dummy variable *CREATIVE/INNOVATIVE* captures the pure effect of differences in a work-environment on productivity (for example, creative-innovative tasks generally go together with a higher productivity than routine tasks). The aforementioned interaction term *AGE-HETEROGENEITY* x *CREATIVE/INNOVATIVE* is of main interest here and captures to what extent age heterogeneity has a different effect in the case of creative tasks as opposed to in the case of routine tasks. A positive interaction term means that in the case of

[6] A complete overview of all variables is available from the authors upon request.

[7] In the literature we find varying preferences for both statistics (Grund, Westergard-Nielsen 2005: 8; Harrison, Klein 2007: 1210-1214; Richard, Shelor 2002: 965).

creative-innovative activities, increasing age diversity leads to an increase in productivity, whereas in the case of routine activities, it does not (cf. Hypothesis 2).[8] To operationalize *TYPE OF TASKS*, we use three alternative methods. First, we use a dummy variable that denotes whether a firm is operating in a creative industry. Here, borrowing from Daveri and Maliranta (2007), Ilmakunnas and Maliranta (2007), Prat (2002) and Richard and Shelor (2002), industries with creative tasks are primarily service industries.[9] Second, we use a dummy variable that denotes whether a particular firm is innovative in the sense that it has developed or introduced a new product in a given year. This company information has been collected and given in the data. Third, we use the innovativeness of a particular company in comparison to the average innovativeness in its industry sector. This so-called "sectoral demeaning" has the advantage that it represents a more appropriate basis for company comparisons, since companies are viewed in relation to the average level of innovation activity within their respective industries.

In addition, in our estimations we control for the average age of the employees in the company, since, as we formulated in our introduction, a mere aging effect should be separated from age-heterogeneity effects. Also we control for tenure to capture the pure age effect.

At the same time, we must keep constant other company characteristics that may also influence productivity. To solve this problem, we add a large number of common control variables and use different estimation techniques. The control variable set includes: a breakdown of the companies' tenure structure (divided into 6 groups), the share of male employees, the share of employees with German nationality, the shares of four different

[8] A negative interaction term would mean that increasing age heterogeneity has a negative effect on productivity in the case of creative-innovative activities but not in the case of routine tasks. This would falsify hypothesis 2.
[9] Routine industries include mining/energy, heavy industry, component/specialty products manufacturing, and public administration. Creative industries are defined as corporate services, trading/distribution, consumer goods manufacturing and consumer services.

occupational groups, the shares of three different qualification levels, the share of trainees, blue- and white-collar workers, and a turnover coefficient, which is calculated as new hires divided by departures per a year. Additionally, firm size, legal form, export sales, and the logarithm of investments and of capital stock per employee are incorporated. Additional control variables include whether the firm is foreign-owned, was founded before 1990, promotes continuing education, receives government subsidies, is concerned about a lack of qualified employees, has a works council, has a trainee program, is equipped with the latest technology, and whether it is located in West Germany. Additionally, a complete set of year dummies is included to control for year-specific effects (for a similar procedure, see Daveri, Maliranta 2007: 136; Grund, Westergard-Nielsen 2005: 8; Haltiwanger, Lane, Spletzer 2007; Ilmakunnas, Maliranta 2007: 14; Jackson, Joshi, Erhardt 2003: 804; Schneider 2007: 85-87).

Thus, the estimating equation appears as follows:

$$\textit{Company productivity} = \\ ß_1 \textit{Age heterogeneity} + ß_2 \textit{Work task area} + ß_3 \textit{Hetero.*Work} + ß_4 \textit{Age} + ß_5 X' + e \qquad (1)$$

As a dependent variable, we use “company productivity” measured in analogy to what is typically used in similar studies, i.e., we take the log of ‘(sales – input costs) per employee’ (cf. Grund, Westergard-Nielsen 2005: 7; Haltiwanger et al. 2007; Schneider 2007: 85; Skirbekk 2005: 92-93). Thus, our paper has the advantage of being based on an *objective* productivity measurement rather than on subjective ratings, which are frequently used in age-related productivity studies, yet may be biased by images and prejudices towards older workers (Cleveland, Lim 2007: 40-42).

Estimation results

First, we estimate equation (1) by simply using a pooled data set. These results serve only as a benchmark, since we expect that both age structure and company productivity are not independent over time, which means that the pooled results may be biased. Second, we use the panel structure of the data and apply fixed effects and random effects estimators, which eliminate biases due to company-specific unobservables (Daveri, Maliranta 2007: 137-138; Ilmakunnas, Maliranta 2007: 11-12). They also partly resolve biases due to positive employee selection (Skirbekk 2005: 99). The Hausmann test shows that for all estimations carried out, the fixed effects specification is preferable to the random effects estimation. Therefore, in the following section, we only interpret the fixed effects results. However, for purposes of documentation, the results of pooled and random effects are shown in the tables. Table 2 lists the results if the coefficient of variation is used as a proxy for *AGE-HETEROGENEITY*; Table 3 lists the results if the standard deviation is used as an alternative proxy for *AGE-HETEROGENEITY*.[10] However, as can been seen from the tables, results are very similar.

In both tables, we separately list the results that were found using each of our three alternative innovation variables: a) company being in a creative industry, b) company being innovative, c) company being innovative relative to the industry average.

Looking at the results in table 2, we see that the coefficient $ß_1$, which measures the pure heterogeneity effect, is significantly negative, i.e., an increase in age heterogeneity has in all cases a significant (at the 1% level) negative effect on company productivity. An increase in age heterogeneity of 1% leads, depending on the heterogeneity measure, to a decrease in productivity of 0.3% to 0.46%. Not only are these results statistically significant, but also they are economically relevant. For example, a 10% increase in age heterogeneity (which roughly equates to the maximum range of fluctuation for the 10-year period of observation in our

[10] All regressions were additionally estimated with a squared heterogeneity variable to see whether we find evidence for an inverted U-shape. Since we did not find any evidence for an inverted U-shape in the relevant area we only use a linear term in the estimates in this paper because it allows interpreting the interaction terms more clearly.

sample) leads to a reduction in productivity of 3% to 4.6%, which is a considerable order of magnitude considering that in recent years aggregate productivity growth in Germany was in the magnitude of around 1%.

If we look at the results for the coefficient $ß_2$, i.e., the pure effect of differences in the type of tasks on company productivity, we find that – with all else equal – there are very small or no significant productivity differences between companies with mainly routine as opposed to innovative/creative tasks.

However, if we look at the coefficient of the interaction term $ß_3$, i.e., the *additional* effect of an increase in age heterogeneity for innovative/creative companies (as opposed to companies with routine tasks), we find a significantly positive effect. In innovative/creative companies, an increase in age heterogeneity leads to an increase in productivity as compared to companies with routine tasks. If age heterogeneity of a company in an innovative/creative industry increases by 1%, productivity increases by 0.29%. The results of the alternative innovation indicator are even clearer. In innovative companies, a 1% increase in age heterogeneity increases overall productivity by 0.35% or 0.34% (both coefficients are significant at the 1% level). This means that for a 10% increase in age heterogeneity (which equals the maximum range within the observation period), productivity would increase by approximately 3.5% per year, which indicates a considerable source of productivity growth for these types of companies.

Thus we can conclude that although increasing age heterogeneity per se tends to have a negative impact on company productivity, this negative effect is offset in more innovative companies by a positive effect of increasing age heterogeneity on innovative/creative tasks. The additional benefits generated in innovative task areas are larger than the additional costs that generally result from increasing age heterogeneity.

Table 2 about here: Regressions with Coefficient of Variation of Age

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Next, we look at our alternative measurement of age heterogeneity, namely the standard deviation of age as opposed to the coefficient of variation (cf. Table 3). For the same reasons as above, we again only interpret the fixed effects estimations.[11] What we see is that the direction of the effects is unchanged. Age diversity, as measured by the standard deviation of age ($ß_1$), again has a significantly negative effect on company productivity. An increase in the standard deviation of age of 5 years (which equals the average range of fluctuation in the observation period) results in a drop in productivity of approximately 5%. Innovative firms ($ß_2$) compared with non-innovative firms are overall a little less productive than non-innovative firms, although the economic impact is negligible.[12] Furthermore, the interaction effect ($ß_3$) is again highly significant, and at the one percent level, it again more than offsets the general negative age-heterogeneity effect. For example, an increase in the standard deviation of age of 5 years (which is roughly the average fluctuation in the observation period) leads to an increase in productivity of approximately 6.5% and results, after including the pure age heterogeneity impact, in a net positive productivity effect of 1.5% per year at innovative companies. Thus, here too, there is an economically relevant productivity-enhancement effect from increased age heterogeneity.

Table 3 about here: Regressions with Standard Deviation of Age

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[11] The coefficients are generally smaller in all cases than when coefficients of variation are used, which is attributable to differences in the scaling of the two variables.

[12] The coefficient for company activity in a creative industry cannot be estimated here in the fixed effects specification. This is due to an identification problem, which we address in greater detail below.

At the same time, we find that an increase in average age has a significantly positive effect on company productivity when we control for the effects of age diversity and type of tasks. So, it seems that the age composition of a workforce is more important than merely the average age of a workforce. Thus, depending on the type of tasks a company performs, it is important for HR to ensure a well-balanced age mix in the workforce and focus on age-heterogeneity as much as on average age.

Sensitivity analysis

Despite our control variables, the above estimations may still suffer from the problem of endogeneity. Although the basic endogeneity problem is certainly mitigated by the use of fixed effects, it is possible that not all endogeneity problems are eliminated. Company workforce structures, and thus age structures, are not random, but rather they are to a certain degree consciously chosen by the companies (Prat 2002: 1187). To take into account such endogeneity problems, we used time-lagged variables for age heterogeneity as instruments in the above-mentioned estimation equations (for a similar procedure see also Skirbekk 2005: 95). We again find that the results for innovative companies are very stable, both using the coefficient of variation as well as the standard deviation of age as a heterogeneity proxy. The results are also stable when using the creative-sector indicator. Although not all values are significant, this was attributable in particular to the significant reduction of the number of cases as a result of using time-lagged variables in addition to the fixed effects estimations. As a result, we conclude that the above-mentioned endogeneity problems do not seem to undermine the results of our analyses.

A second potential problem involves the operationalization of the type of tasks by means of an industry indicator. The use of fixed effects estimations may cause an identification problem. Since fixed effects estimations use the changes between years, only variables that

change over the years may be kept in the estimation. Companies in a creative industry can thus only be identified if a company switches its industry. Since this is a very rare event, and leads to a very peculiar selection of companies, this could cause severe biases. To eliminate the fact that the sub-sample of identifiable companies might indeed be very peculiar, we also estimate separate fixed effects regressions for all companies in creative and routine industries as a final step. We find that age heterogeneity, as measured by the coefficient of variation and standard deviation, again has as expected a highly significant negative effect on productivity in industries with routine tasks. In industries with routine tasks, increasing age heterogeneity leads to an additional negative productivity effect, while as expected, both age heterogeneity measures have no significant negative influence for companies in creative industries. All in all, these patterns match well with the estimation results found above.

Table 4 about here: Separate Regressions for Routine and Creative Tasks

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Summary of empirical findings

To conclude, we find that age heterogeneity in general has a negative effect on firm productivity, but this negative effect is offset in companies that are engaged in innovative/creative tasks. According to our theoretical explanation, this is due to higher benefits of increasing age heterogeneity that emerge in creative activities; these benefits clearly offset the general costs of additional age diversity. In the case of routine tasks, however, there are no substantial gains from age heterogeneity that could offset the increasing costs resulting from greater age heterogeneity. Thus, in companies with routine types of work, increasing age heterogeneity overall leads to a decline in productivity.

Accordingly, Hypothesis 1 was confirmed: in companies operating in routine areas of work, increasing age heterogeneity has a negative effect on firm productivity.

Hypothesis 2 was also confirmed: in companies engaged in more innovative/creative tasks, increasing age heterogeneity has a positive effect on firm productivity.

4. Conclusions

The aim of this paper was to examine how the age structure of a company's workforce affects a company's productivity. In doing so, we do not focus on *individual* productivity effects but on *organizational* productivity effects, which we assume are more than the some of individual effects. Furthermore, we do not only address the effect of changes in *average* age but also of changes in *age diversity* on organizational performance. To investigate these problems we make a theoretical contribution by introducing a simple economic model to study the effects of age heterogeneity of a workforce on company performance. The model basically compares costs and benefits of increasing heterogeneity and demonstrates how changes in age diversity may affect organizational performance. We fill this framework by combining it with theoretical insights and empirical results from very diverse disciplines such as psychology, management, medicine and gerontology. This allows us to derive empirically testable hypotheses which we then test based on a linked employer employee dataset with more than 18.000 German firms and 2 million employees. In doing so we break new ground in several ways: we introduce a simple economic model to structure productivity effects due to changes in age diversity. That allows us to easily draw upon multiple disciplines but also to achieve a genuine integration of theory and data.

Our results show that *organizational* productivity does not necessarily decline with average workforce age, particularly if changes in age heterogeneity and type of tasks are controlled for. Instead, we find that increasing average age consistently shows a positive effect, which is a strong indication of a positive selection of those who stay in the workforce.

More importantly however, we show that *company* productivity is more than the sum of *individual* productivities. We argue that increasing age heterogeneity in general can cause both an increase and a decrease in company productivity. The effect depends on the kind of tasks a company's workforce is confronted with because the tasks determine whether costs or benefits of increased heterogeneity are larger. Benefits of a more heterogeneous workforce are greater diversity, a greater range of problem-solving techniques, more creativity, less dominance by any one age group and an enlarged pool of experience and knowledge. Costs of increased heterogeneity are increased interaction problems and communications costs, less identification and integration, greater dissatisfaction, conflicts and a higher turnover rate. We argue that the benefits of increased heterogeneity are more pronounced in companies with innovative/creative tasks and less pronounced in companies with routine tasks, because the latter require only a low degree of diversity or creativity. Thus, in firms with *routine tasks*, the benefits of heterogeneity are not expected to be sufficiently high to outweigh additional cost. In firms with *creative problem-solving tasks*, however, the benefits of heterogeneity are much larger and may outweigh additional costs, because ill-defined problems and varying circumstances create a need for greater problem-solving skills. Accordingly, our two empirically testable hypotheses are: 1) in companies with mainly routine tasks, increasing age-heterogeneity has a negative effect on firm productivity; 2), in companies with mainly creative problem-solving tasks, increasing age-heterogeneity has a positive effect on firm productivity. We test the hypotheses using a German linked employer-employee panel dataset spanning a ten-year period. We use different panel estimation methods and various specifications checking the robustness of our results. We consistently find that increasing age-heterogeneity does have a positive influence on firm productivity – but only in creative and innovative fields. The effect we find is not only statistically significant but also economically important. For example, in innovative companies a 10% increase in age heterogeneity (which equals the maximum range of age heterogeneity within the observation period) increases

annual productivity by approximately 3.5%. In comparison to average productivity growth rates in the respective time period, which were around 1%, this is a very large effect, meaning that the age composition of a workforce and organizational demography in general are a very important source of productivity growth particularly for innovative and creative companies. Furthermore, foreseeable demographic changes should not only be seen as a threat to companies but should be considered as a valuable resource that may particularly support productivity growth in innovative firms if utilized in an effective manner. Thus, firms are well advised to adapt their personnel policy and their production and outsourcing strategies to match these future challenges.

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Figure 1: Costs and benefits of age diversity and overall productivity

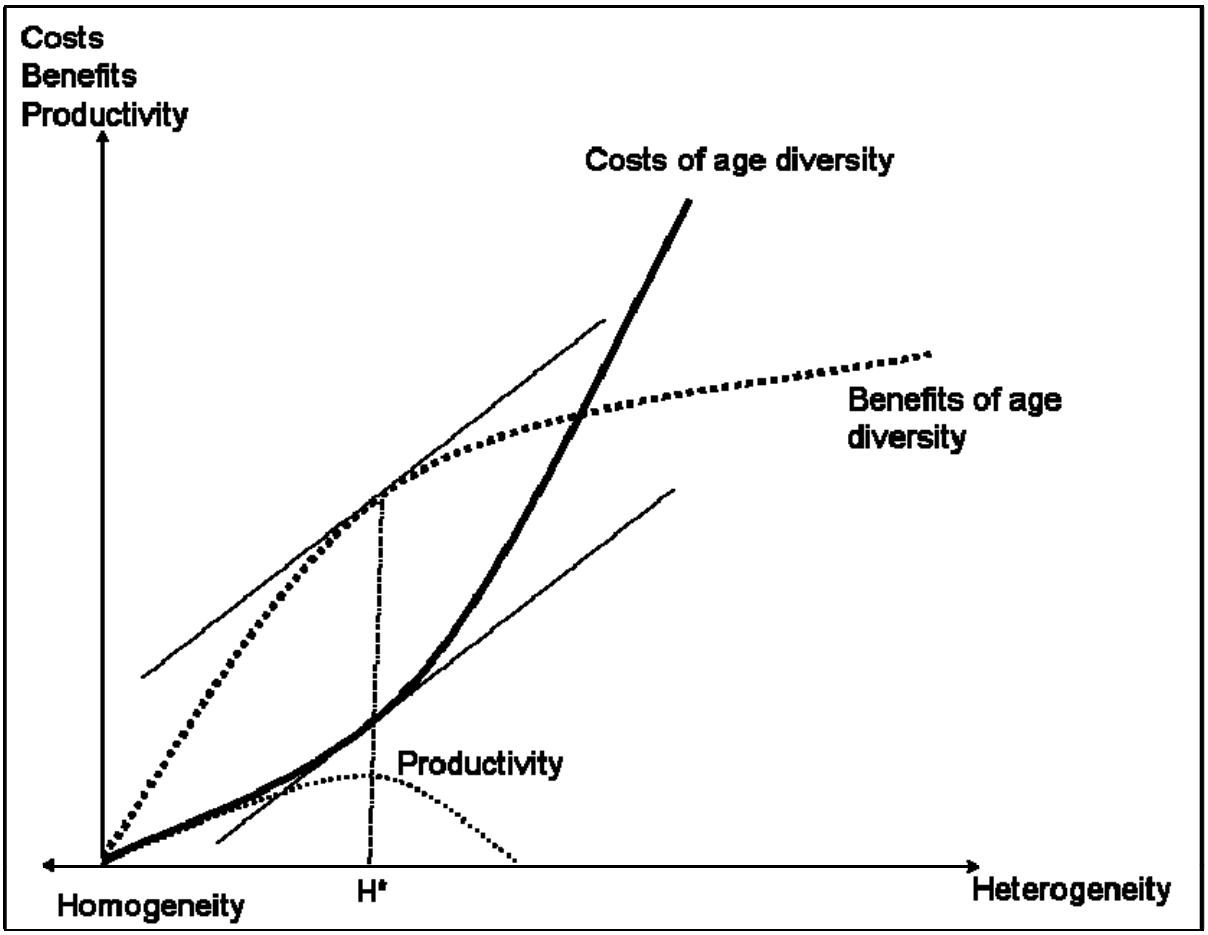

Figure 2: Optimum level of age heterogeneity for routine and creative tasks

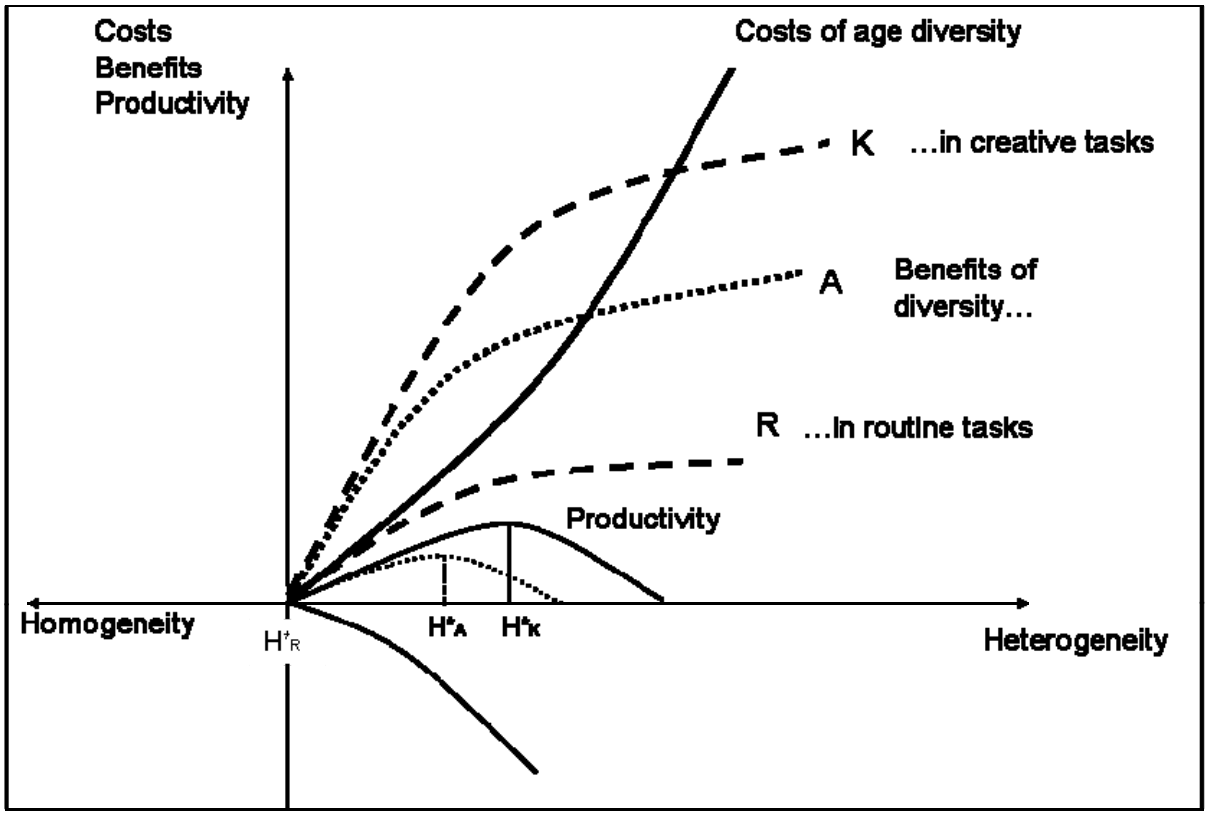

Table 1: Descriptive Overview of Variables

the mean values of the analysed companies are displayed

		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
number of observations		1,845	2,534	2,524	4,950	4,761	5,309	5,623	8,326	9,235	8,925	9,091
age of the work force	Mean	37.4	37.5	37.7	37.9	38.0	38.2	38.3	38.6	38.8	39.0	39.3
	Median	37	37	37	38	38	38	38.5	39	39	39.5	40
heterogeneity of age	standard deviation age	10.893	10.716	10.495	10.305	10.198	10.293	10.344	10.336	10.297	10.311	10.266
	variation coefficient age	0.293	0.287	0.280	0.275	0.272	0.274	0.274	0.272	0.269	0.269	0.266
share with job tenure	0-3 years	45.58%	43.34%	46.87%	57.17%	54.06%	49.70%	46.30%	46.77%	47.52%	46.08%	43.61%
	4-7 years	18.61%	20.65%	20.28%	19.30%	22.52%	26.06%	28.70%	24.18%	21.77%	21.06%	21.80%
	8-11years	10.35%	10.74%	10.21%	9.46%	9.23%	9.61%	10.21%	12.99%	14.30%	15.31%	16.57%
	12-15 years	9.07%	8.44%	7.15%	5.46%	5.35%	5.73%	5.82%	5.99%	6.21%	6.86%	7.40%
	16-20 years	11.13%	10.65%	7.78%	3.84%	3.78%	3.71%	3.69%	3.77%	3.65%	3.88%	4.07%
	more than 20 years	5.25%	6.18%	7.71%	4.76%	5.07%	5.20%	5.28%	6.30%	6.55%	6.81%	6.54%
company size	<20 employees	24.55%	25.61%	27.97%	32.32%	37.49%	36.92%	39.09%	41.36%	40.75%	43.97%	47.20%
	20-100 employees	23.25%	23.80%	24.68%	31.72%	29.28%	30.97%	31.53%	33.27%	33.35%	31.39%	30.50%
	100-500 employees	25.42%	25.06%	24.52%	22.95%	21.45%	21.74%	20.77%	19.18%	19.74%	19.01%	17.54%
	>500 employees	26.78%	25.53%	22.82%	13.01%	11.78%	10.38%	8.61%	6.19%	6.16%	5.62%	4.75%
share of	apprentices	5.98%	6.00%	5.80%	6.89%	7.76%	8.18%	8.23%	7.77%	7.64%	7.74%	7.91%
	blue collar workers	54.11%	53.68%	53.02%	54.86%	53.93%	54.83%	55.02%	53.74%	52.71%	51.54%	50.66%
	white collar workers	39.92%	40.32%	41.17%	38.24%	38.31%	36.98%	36.75%	38.49%	39.66%	40.73%	41.43%
qualification: share	without vocat. traning	25.22%	24.70%	22.94%	17.79%	17.98%	17.99%	17.87%	18.20%	17.96%	17.87%	17.09%
	with vocational training	68.20%	68.90%	69.85%	72.77%	72.13%	72.25%	72.12%	72.02%	71.71%	71.54%	71.20%
	with higher education	5.94%	5.80%	6.02%	7.46%	7.41%	7.70%	7.68%	7.42%	7.85%	7.96%	8.70%
share of German employees		89.02%	89.56%	89.52%	94.63%	94.80%	95.54%	95.89%	95.08%	94.81%	94.85%	95.28%
share of male employees		69.81%	69.47%	69.30%	67.99%	67.33%	68.40%	68.36%	68.52%	67.88%	67.12%	66.43%
share of innovative companies		50.73%	6.08%	23.02%	24.83%	27.91%	35.39%	20.38%	22.68%	31.27%	---	---
share of companies in creative tasks		52.48%	54.14%	55.11%	57.48%	58.17%	57.69%	55.08%	58.23%	58.35%	57.91%	58.62%
share of companies	in West Germany	100.00%	100.00%	100.00%	50.10%	49.34%	48.05%	46.63%	62.49%	65.05%	67.33%	64.69%
	established before 1990	96.77%	90.67%	82.58%	44.64%	40.96%	41.68%	41.63%	54.56%	54.19%	64.36%	60.30%
	with work council	61.37%	60.58%	58.68%	47.63%	45.00%	43.07%	41.43%	39.07%	39.22%	37.52%	38.88%
	with the newest prod. techn	29.78%	24.04%	23.38%	25.11%	23.07%	23.02%	22.56%	23.10%	19.67%	19.27%	19.04%
log capital stock/employee		8.76	8.87	9.12	8.73	8.92	8.88	8.92	8.61	8.68	8.69	8.29
log productivity/employee		11.01	11.03	11.06	10.92	10.83	10.83	10.84	10.89	10.90	11.01	11.01

Table 2: Regressions with Coefficient of Variation of Age

dependent variable: logarithmized company productivity per employee

creative dummy

	pooled OLS		FE		RE	
variables	coeff	p-value	coeff	p-value	coeff	p-value
mean age	0.002**	0.036	0.008***	0.000	0.008***	0.000
variation coefficient age	-0.930***	0.000	-0.457***	0.002	-0.709***	0.000
creative task	-0.339***	0.000	-0.168*	0.099	-0.411***	0.000
VC age*creative task	0.349***	0.005	0.289*	0.088	0.420**	0.002
	N	41815	N Obs	41815	N Obs	41815
			N Groups	12448	N Groups	12448
	f-value	252.16	f-value	66.18	Wald chi2	6320.70
	Prob>f	0.000	Prob>f	0.000	Prob>chi2	0.000
	R^2	0.239	R^2 within	0.105	R^2 overall	0.228

innovative dummy

	pooled OLS		FE		RE	
variables	coeff	p-value	coeff	p-value	coeff	p-value
mean age	0.003***	0.001	0.007***	0.000	0.008***	0.000
variation coefficient age	-0.689***	0.000	-0.365***	0.000	-0.490***	0.000
innovative company	0.007	0.853	-0.093***	0.006	-0.074**	0.020
VC age*innovative company	-0.127	0.354	0.347***	0.003	0.228**	0.041
	N	49935	N Obs	49935	N Obs	49935
			N Groups	14525	N Groups	14525
	f-value	297.84	f-value	76.78	Wald chi2	7713.95
	Prob>f	0.000	Prob>f	0.000	Prob>chi2	0.000
	R^2	0.246	R^2 within	0.107	R^2 overall	0.237

innovation activity as deviation from the sectorial mean

	pooled OLS		FE		RE	
variables	coeff	p-value	coeff	p-value	coeff	p-value
mean age	0.003***	0.001	0.007***	0.000	0.008***	0.000
variation coefficient age	-0.710***	0.000	-0.303***	0.000	-0.450***	0.000
innovative company	-0.010	0.792	-0.092***	0.006	-0.079	0.130
VC age*innovative company	-0.063	0.646	0.343***	0.004	0.247	0.270
	N	49935	N Obs	49935	N Obs	49935
			N Groups	14525	N Groups	14525
	f-value	297.84	f-value	76.78	Wald chi2	7714.51
	Prob>f	0.000	Prob>f	0.000	Prob>chi2	0.000
	R^2	0.246	R^2 within	0.107	R^2 overall	0.237

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

control variables: average tenure, tenure diversity, share of German employees, share of male employees, share of four occupational groups, share of three different skill levels, share of apprentices, blue-& white-collar workers, fluctuation coefficient, firm size, firm legal form, investments, export sales, capital stock, technical condition of assets, dummies for foreign property, foundation before 1990, training activity, use of public subsidies, fear of lack of qualified employees, work council, apprenticeship training, West Germany, ten industry dummies, year dummies.

Table 3: Regressions with Standard Deviation of Age

dependent variable: logarithmized company productivity per employee

creative dummy

	pooled OLS		FE		RE	
variables	coeff	p-value	coeff	p-value	coeff	p-value
mean age	0.007***	0.000	0.009***	0.000	0.011***	0.000
standard deviation age	-0.026***	0.000	-0.012***	0.002	-0.020***	0.000
creative task	-0.370***	0.000	dropped		-0.423***	0.000
SD age*creative task	0.011***	0.003	0.007	0.140	0.012***	0.003
	N	41815	N Obs	41815	N Obs	41815
			N Groups	12448	N Groups	12448
	f-value	252.13	f-value	66.19	Wald chi2	6320.87
	Prob>f	0.000	Prob>f	0.000	Prob>chi2	0.000
	R^2	0.239	R^2 within	0.105	R^2 overall	0.228

innovative dummy

	pooled OLS		FE		RE	
variables	coeff	p-value	coeff	p-value	coeff	p-value
mean age	0.008***	0.000	0.009	0.000	0.011***	0.000
standard deviation age	-0.019***	0.000	-0.011***	0.000	-0.014***	0.000
innovative company	-0.016	0.706	-0.134***	0.000	-0.099***	0.005
SD age*innovative company	-0.001	0.792	0.013***	0.000	0.008**	0.010
	N	49935	N Obs	49935	N Obs	49935
			N Groups	14525	N Groups	14525
	f-value	297.79	f-value	76.93	Wald chi2	7717.47
	Prob>f	0.000	Prob>f	0.000	Prob>chi2	0.000
	R^2	0.247	R^2 within	0.107	R^2 overall	0.237

innovation activity as deviation from the sectorial mean

	pooled OLS		FE		RE	
variables	coeff	p-value	coeff	p-value	coeff	p-value
mean age	0.008***	0.000	0.009***	0.000	0.011***	0.000
standard deviation age	-0.019***	0.000	-0.009***	0.000	-0.012***	0.000
innovative company	-0.044	0.306	-0.134***	0.000	-0.109***	0.002
SD age*innovative company	0.002	0.686	0.013***	0.000	0.009***	0.004
	N	49935	N Obs	49935	N Obs	49935
			N Groups	14525	N Groups	14525
	f-value	297.79	f-value	76.93	Wald chi2	7718.93
	Prob>f	0.000	Prob>f	0.000	Prob>chi2	0.000
	R^2	0.247	R^2 within	0.107	R^2 overall	0.237

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

control variables: average tenure, tenure diversity, share of German employees, share of male employees, share of four occupational groups, share of three different skill levels, share of apprentices, blue-& white-collar workers, fluctuation coefficient, firm size, firm legal form, investments, export sales, capital stock, technical condition of assets, dummies for foreign property, foundation before 1990, training activity, use of public subsidies, fear of lack of qualified employees, work council, apprenticeship training, West Germany, ten industry dummies, year dummies.

Table 4: Separate Regressions for Routine and Creative Tasks

dependent variable: logarithmized company productivity per employee

estimation separated for	**creative tasks**		**routine tasks**	
		FE		**FE**
variables	coeff	p-value	coeff	p-value
estimation with:				
variation coefficient age	-0.190	0.114	-0.412***	0.004
mean age	0.009***	0.001	0.006**	0.048
estimation with:				
standard deviation age	-0.005	0.093	-0.012***	0.002
mean age	0.010***	0.000	0.009***	0.005
	N Obs	23587	N Obs	18228
	N Groups	7438	N Groups	5259
	f-value	26.14	f-value	57.20
	Prob>f	0.000	Prob>f	0.000
	R^2 within	0.071	R^2 within	0.172

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

control variables: average tenure, tenure diversity, share of German employees, share of male employees, share of four occupational groups, share of three different skill levels, share of apprentices, blue-& white-collar workers, fluctuation coefficient, firm size, firm legal form, investments, export sales, capital stock, technical condition of assets, dummies for foreign property, foundation before 1990, training activity, use of public subsidies, fear of lack of qualified employees, work council, apprenticeship training, West Germany, ten industry dummies, year dummies.