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Positive Effects of Ageing and Age-Diversity in Innovative Companies – Large Scale Evidence on Company Productivity

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Positive Effects of Ageing and Age-Diversity in Innovative Companies – Large-Scale Empirical Evidence on Company Productivity

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Abstract

This paper investigates how age diversity within a company's workforce affects company productivity. It introduces a theoretical framework that helps to integrate results from a broad disciplinary spectrum of ageing and diversity research to derive empirically testable hypotheses on the effects of age diversity on company productivity. It argues that first the balance between costs and benefits of diversity determines the effect of age diversity on company productivity and that second the type of task performed acts as a moderator. To test these hypotheses, it uses a large-scale employer-employee panel data set (the LIAB.) Results show that increasing age diversity has a positive effect on company productivity if and only if a company engages in creative rather than routine tasks.

Keywords
Age Diversity, Company Performance, Productivity in Innovative Industries, Aging Societies

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Introduction

Previous literature from various disciplines has produced extensive evidence in respect to the relationship between age and *individual* productivity, some studies finding negative effects, others positive, and yet others none at all (for a meta-analysis see Ng & Feldman, 2008.) However, it has not yet been studied how such *individual* aging effects transform into *company* productivity, which so far has, at most, been implicitly viewed as the simple sum of *individual* productivities. Age differences among coworkers have not played a role in such analyses. However, Riach (2009) already pointed out that it is important to focus on 'differences' in organizations and to become more aware of the effects that age diversity may have. Ennen and Richter (2010,) meanwhile, have shown through their extensive literature review that in a typical organization there are complementarities between workers, i.e. "the whole is more than the sum of its parts." They also argue that the more diverse the "elements" of an organization are, the stronger is this complementarity effect. However, the "elements" they study do not include workers' age diversity. They use a somewhat related "element", '*knowledge and capabilities,'* but found no consistent results for it. Our paper argues that age-diverse workers are one of these aforementioned "elements" because they increase the value of the "whole" by bringing in additional knowledge and capabilities, be they quantitatively or qualitatively different. Therefore, it is not only workers' *individual* aging but also—perhaps even more significantly—the *interplay* of different individual aging effects that is relevant for company productivity.

We provide an economic framework to conceptually model how age diversity may affect company productivity and under what circumstances this productivity effect will be posi-

tive or negative. Our theoretical framework consists of three components: diversity benefits, diversity costs, and the contextual factor of companies' task requirements. To determine how diversity *benefits* and diversity *costs* may look like, we survey literature on team, group and organizational diversity and its effect on performance, and find that results are rather inconclusive so far (Horwitz and Horwitz 2007; Bell, Villado, Lukasik, Belau and Briggs 2011) Recent research of Lauring and Selmer (2012) further points out that results for demographic diversity (including age) are different from results for cultural or linguistic diversity. Particularly, results are mixed for studies that have produced evidence on how the *interaction* of age-diverse workers within an organization may influence *organizational* performance: some studies indicate positive effects (Page, 2007, Backes-Gellner & Tuor 2010), others negative effects (Cleveland & Lim, 2007), and some find no consistent effects for age diversity (Leonard & Levine, 2006). We argue that these inconsistent results are partly due to moderators that may differ from study to study, one of the most important moderators being *task requirements.* We assume that task requirements determine how large the benefits or cost effects are – and consequently, how large the total effect will be. As task requirements may differ substantially between companies, we hypothesize that having more creative vs. more routine tasks determines whether in a company positive, negative or no productivity effects occur as a result of increased age diversity. If this hypothesis is correct, our results will help to explain the inconsistency of previous research on age diversity.

We test our hypotheses by using a matched employer-employee panel data set (the LIAB.) The employer side of this matched data set includes more than 18,000 German companies and is representative for firms in the private sector (Alda, Bender & Gartner 2005.) The employee side of the data set provides employment and socio-economic information on all workers in all of these companies (except for managers and small part-time workers without social security coverage;) it includes about 2 million employees and spans a time period of ten years. With this longitudinal data set we overcome one of the major problems of exist-

ing literature on the relation between HRM and performance that Guest (2011) points out after his review of 20 years of research. He claims that even after two decades of extensive research, "(…) we are still unable to answer core questions about the relationship between human resource management and performance. According to him, this is largely attributed to the limited amount of research that is longitudinal (…)" (Guest, 2011: 3.) The major question that he sees unanswered is that of causation. With our data set, we hope to be better able to solve this problem and contribute to the question on whether differences in HRM cause differences in productivity. The data set also provides important control variables such as tenure, education, age, or gender for all workers (more information is provided in the data section.) So we also try to address the second problem pointed out by Guest (2011: 7,) namely the lack of control variables.

From the employer side of the matched data set we are also able to construct a quantitative measure for company productivity (our dependent variable) and to introduce important company-related control variables such as size, capital stock, or industry. And from the matching of the employer and employee side of the data we are able to construct our quantitative measures for age diversity (our explanatory variable) because we know the ages of all workers for all companies. We exploit the panel structure of the data to apply fixed effects estimations, among others. We also provide a number of robustness checks including OLS and random effects estimations. All our estimations strongly support our hypotheses.

Our paper makes two main contributions. First, it makes a theoretical contribution by providing a framework that is novel to the study of productivity effects of age diversity and particularly helps to demonstrate the impact of contextual factors (such as different types of task requirements.) This framework is an analytical tool to aid in structuring the analysis of the relationship between diversity and firm productivity. It provides a graphical analysis to visualize and clarify the concrete interplay between benefits and costs, as well as the associ-

ated effects on productivity. Although in our case we concentrate on *age*-diverse workers, the framework also applies to other types of diversity.

Second, based on a novel and very large data set, our paper provides new empirical insights with respect to the effects of ageing and age diversity on company productivity, an issue with ever-increasing importance in many industrialized countries with aging societies. Our results show that in addition to age itself, age *diversity* also has a significant effect on company productivity and that the magnitude and direction of this effect depends on the types of tasks performed in a company. Our results run somewhat counter to general intuition, as we find that innovative companies with more creative tasks gain an increase in productivity with increasing age and age diversity, whereas companies with non-innovative tasks often suffer productivity losses. These results show that aging is not necessarily a threat to the competitiveness of companies or nations. On the contrary, it may even be a chance to enhance competitiveness if company strategies and types of tasks are adjusted to reflect a changing workforce.

Theoretical Background and Hypotheses

When individuals in organizations work alongside and together with other individuals, we expect *organizational* productivity to constitute more than merely the sum of individual productivities due to typical *complementarity effects*. Medical, psychological and economic research has shown that employees of different age groups differ in skills, attitudes, and abilities, and that these differing characteristics have different effects on productivity depending on the type of tasks that have to be performed (see Johnson, 2005, for an overview of previous research.) Therefore, it is not immediately obvious if and when a combination of old and young employees is favorable. In order to derive empirically testable hypotheses, we need a theoretical framework to model the interplay of all these effects. In the following chapters, we

first present a framework that helps to structure our arguments and derive empirically testable hypotheses. It is a stylized economic model of benefits and costs.

After introducing the framework, we review in a second step empirical results on age effects that are presented in social psychology, sociology or gerontology,[1] and use them to determine the direction and magnitude of the costs and benefits. Combining these results in our economic model helps to illustrate the overall effect of ageing.

Cost-Benefit Framework

In our stylized model we distinguish between costs of age diversity on the one hand and benefits of age diversity on the other. Figure 1 shows how these two factors work together by illustrating a simple cost-benefit framework based on Lazear's (1999) analysis of teamwork effects. We transfer his idea to the problem of age diversity to show how costs and benefits of age diversity interact and how the joint effect will look like. The model also helps to illustrate how different task requirements change this joint effect.

Insert Figure 1 about here

The horizontal axis in Figure 1 represents different degrees of age diversity, while the vertical axis represents diversity costs, diversity benefits and the resulting overall productivity; all costs and benefits as well as productivity are measured in monetary terms (so we do not measure at the level of pieces or products, but at the level of the value of all products and services sold by a company). Accordingly, our productivity analysis comprises all types of tasks and services involved in making an organization run smoothly and bringing its products to the market. Thus, the y-axis measures total value added stemming from a company's com-

[1] Due to limited space we do not systematically review results from economics but we do take care of the two economic factors most relevant to our research question – internal labor markets (ILMs) and wages – in the empirical section.

plete workforce, irrespective of the jobs or types of tasks individual workers fulfill. Although in our model we think of benefits and costs in monetary terms, the intention is not to actually measure the costs or benefits in Dollars or Euros. Rather, the model is an analytical tool to structure the results from previous research.

Benefits of Increasing (Age) Diversity

A large body of research highlights the *benefits* of increasing workforce diversity. The magnitude of the benefits depends on the type of tasks that have to be performed and on the type of diversity (demographic or cultural, as pointed out by Lauring and Selmer 2012.) The benefits are essentially due 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 norms (cultural values) from older to younger generations.

First, previous research shows that age-diverse workforces display a host of different knowledge, values, and preferences. They have different perspectives, interpretations, and heuristics and their mental models are different (Page 2007; Canella, Park, & Lin, 2008; Richard & Shelor, 2002.) Thus, as a team, they have a larger pool of knowledge and a larger problem solving toolbox. Knowledge may be of different types (for example technical, social or cultural) or similar types but different levels (e.g., beginners or advanced) and combined with other types on other levels. Younger cohorts may have high academic skills but may be socially inexperienced whereas older cohorts may have lower academic skills but more work experience or social skills. Combining workers with such different knowledge pools reduces the risk of being one-sided and innovation-averse, as compared to homogeneous workers with highly similar problem-solving approaches. We assume that combining more age diverse workers increases the knowledge pool of the workforce as a whole, which has positive effects on problem solving and productivity. For example, Backes-Gellner, Schneider, and Veen (2011) examine age-diverse workforces in German labor courts and show that a more diverse

workforce increases organizational performance because it is better able to serve multiple performance dimensions. However, as Lauring and Selmer (2012) recently pointed out, different types of diversity (e.g. demographic or cultural) may lead to different outcomes of knowledge sharing. So our empirical results will have to tell whether the benefits of age-diversity are ultimately high enough to cause increased company productivity.

Additionally, existing studies show that the type of task performed plays a critical role in determining the magnitude of the productivity effects (Page, 2007; Warr, 1994.) Diversity clearly enhances productivity when the work performed requires either a high degree of creativity or entails dealing with strategic and complex decision-making with vaguely defined problems in a dynamic setting (Jackson & Joshi, 2004; Page, 2007; Richard & Shelor, 2002.) In these situations, increased age diversity can lead to enhanced group discussion, better analysis, and superior problem solving (see, e.g., Richard & Shelor, 2002.)[2] Conversely, diversity does not provide a competitive advantage for *routine* problems in stable environments where problems and solutions are already well defined. Thus, we expect benefits to be much stronger in innovative environments where creative tasks predominate.

Second, research shows that greater age diversity can help counteract *incentive problems*. A more homogeneous age group reduces career options for the up-and-coming age group (because the older group clogs the corporate career ladder) and can demotivate the younger groups because it diminishes promotion-based incentives (Cremer, 1986; Gibbons & Waldman, 2006) Conversely, higher age diversity should increase productivity by providing such career incentives.

Third, age-homogeneous workforces make it difficult to transfer company-specific knowledge from one generation of workers to the next. Only if the workforce is sufficiently age-diverse will an internal labor market be able to optimally perform its assigned function (e.g., Gibbons & Waldman, 2006.) A lack of promotion options may prevent a company from

[2] For the sake of simplicity, we will jointly refer to these types of tasks as *„creative tasks“* in the remainder of the paper.

promoting workers with important knowledge. These workers, in turn, are more likely to leave the company and take their knowledge with them. This is particularly troublesome in settings where specific knowledge about production facilities and technologies or practical knowledge about firm specific work styles is important. A more diverse age spectrum makes transfer of tacit knowledge and organizational culture between generations easier (Cremer 1986.) Older employees serve as the "standard bearers," and socialize younger employees. A continuous succession of "new older employees" is necessary for retaining an efficient organizational code of conduct. These effects are most pronounced where output is difficult to measure (Lazega, 2000.) To summarize, we expect growing benefits with increasing age diversity, and we also expect these benefits to be more pronounced in companies that engage in innovative activities and creative tasks. This further emphasizes the importance of distinguishing between different types of tasks in our theoretical framework.

Costs of Increasing (Age) Diversity

However, a large number of studies also suggest increasing negative effects or coordination costs with increasing (age) diversity, resulting from three major issues: increasing communication difficulties, value conflicts resulting in a lower degree of social integration, and increasing turnover.

Existing social psychology research shows that the costs of communication between individuals generally increase as group heterogeneity increases. As people who have underwent different socialization processes generally develop a different system of knowledge and values, objectively identical events are perceived differently by different individuals. These differences in perception tend to impede cross-generational communication and may prevent a mutually acceptable problem-solving approach (cf. Gevers & Peeters, 2009; Horwitz & Horwitz, 2007; Lazear, 1999; Page, 2007; Richard & Shelor, 2002.)

Age diversity may also negatively affect team productivity due to differences in employees' values and preferences. Different age cohorts, each with their own socialization processes, often display very different cultural and normative attitudes, which heightens the likelihood of value conflicts. These, in turn, lower the degree of social integration between generations, increase the potential for conflict and ultimately diminish productivity (Chrobot-Mason, Ruderman, Weber, Ohlott, & Dalton, 2007; Jackson & Joshi, 2004; Leonard & Levine, 2006; Somech, Desivilya, & Lidogostor, 2009; Lau & Murnighan, 2005; Gevers & Peeters, 2009.)

Lastly, increased age diversity can have an indirect productivity-inhibiting effect by increasing the rate of turnover. Increased turnover is one way for workers to solve increased value conflicts due to low social integration or constant communication problems. Such increased turnover, in a typical business context, causes productivity losses through absenteeism and adjustment costs. These costs are particularly high when joint efforts and interactive tasks are required (Richard & Shelor 2002.)

The Joint Effect of Costs and Benefits of Increasing Age-Diversity

Summarizing the findings of existing research on diversity in teams, work groups or companies, we conclude that increasing age-diversity in companies leads to both increasing costs (due to increased communiation costs, social problems, etc.) and increasing benefits (due to a larger knowledge base, experience, etc.) for them. Based on standard economic theory, we also argue that costs can be expected to increase progressively with increasing diversity, i.e. we expect increasing marginal costs. Likewise, based on standard economic theory we expect decreasing marginal benefits, i.e. increased diversity causes additional benefits but these benefits decrease in size with ever increasing diversity.

As one simple example to illustrate the concrete meaning of increasing marginal costs and decreasing marginal returns in our context, one can examine the effect of increasing di-

versity in workers' languages on company performance. Increasing *marginal* costs of language diversity would suggest that while coping with one additional language in a given workforce may be fairly easy, *further* increases in language diversity will cause costs to increase exponentially due to a disproportionate increase in communication errors and translation fees. Decreasing *marginal* returns imply that although having one additional language in a workforce may entail a large benefit (e.g., enabling an organization to communicate directly with its most important groups of foreign customers,) such benefits will decline with each *additional* language added.

Our two assumptions translate to the cost and benefits curves in Figure 1 as follows: first, the costs and benefits curves, respectively, increase with increasing age diversity; second, the slope of the cost curve increases with increasing age diversity, while the slope of the benefits curve decreases. To find the joint effect of costs and benefits on total productivity we have to subtract the total costs from the total benefits, as represented by the dotted curve at the bottom of Figure 1. As Figure 1 shows, increasing age diversity initially has a positive effect on overall productivity because benefits grow faster than costs; but from a certain point on (H*) the increase in costs dominates the increase in benefits. The productivity function (P) thus follows an inverted U-shape.

By definition, total productivity of increasing age diversity is positive as long as the total benefits exceed the total costs of diversity (the area left of Z in Fig.1,) and becomes negative when the opposite is true, i.e. when the cost curve is above the benefits curve (right of Z.) For example, if our empirical results show negative total productivity effects at a given point, then this point represents a level of diversity higher than Z.

Our next question is what moderating effect different types of tasks have on the relation between age diversity and total productivity. We can again map the results from existing literature into our graphical model and show how changing tasks affect total productivity. Figure 2 visualizes this situation with three different types of tasks.

Insert Figure 2 about here

The benefits curve (cf. dashed line C in Fig.2) shifts upward with increasing innovativeness of tasks, because more creative tasks e.g. benefit more from a larger knowledge pool. By shifting the benefits curve upward total productivity rises (P_C), peaks at a higher diversity degree (H^*_C), and only becomes negative with a much higher diversity degree (Z'.) In our empirical regression analysis, this effect is caught by an interaction effect, which reflects the difference between the benefits curves for creative tasks (line P_C) vs. other tasks (P.)[3] The benefits of diversity for routine tasks, on the other hand, are comparatively lower (P_R.) The overall productivity effect thus shifts downwards and, ceteris paribus, therefore becomes negative more quickly and the optimal diversity level shifts to the left, in the extreme case even to point H^*_R. Based on the three effects shown in Figure 2, we expect the overall productivity effect of increased age diversity to crucially depend on the type of task a workforce performs. Based on this analysis we can derive two concrete, empirically testable hypotheses.

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

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

Research Setting

We use the linked employer-employee panel data set (LIAB) collected by the German Institute for Employment Research in Nuremberg. The LIAB matches a large company data set with an equally large data set consisting of the social security records of their respective employees. This matched employer-employee data set has several advantages, as well as some unavoidable disadvantages, for exploring the issue we are examining.

[3] For the sake of simplicity we do not show the case where costs differ for different types of tasks, as the analysis is just analogous to the analysis of differing benefits.

The four major benefits of the data set are as follows. First, the company data stems from an annual panel survey of about 18,000 companies representative for Germany and has very low panel attrition, a major advantage because it allows us to follow changes in age structure and productivity over an extended period. Second, it includes a broad set of company data such as size, sales, investments, industry, and business area, and it covers numerous organizational and operational details such as innovative activities and human resource issues (such as wages and training,) which allows us to control for various types of intervening variables that may affect company productivity. Third, the data on workers that is matched with the company data is drawn from social security records and is therefore very reliable. The social security data set is also very large, containing data from approximately 2 million workers for each year, and covers the most important variables and control variables needed for our analysis, e.g., age, tenure, level of education, gender, nationality, and occupational status (Alda, Bender, & Gartner, 2005.) Fourth, the data set spans a panel period of 10 years (1993 to 2003) with about 20 million individual observations, allowing us to study in detail the effect of changes in workforce age structure on company productivity.[4]

The key problem of the data set is the lack of depth in which processes can be studied. One significant disadvantage is that we have no influence on the kind of data collected and that the number of variables—although large for a panel data set—is small in comparison to typical socio-psychological studies on team diversity. Nevertheless, we were able to build proxies for the most important variables that we were interested in; thus, for our study the benefits of the data set clearly outweigh its disadvantages.

[4] For our productivity estimates, the data at employee level was selected as follows: since the number of working hours is not included in the data we included only full-time employees to avoid estimation errors. Also excluded are individuals who hold more than one job because it is not possible to establish their precise contribution to productivity. Additionally, we only included employees aged 16 to 80. Only employees in companies with more than 3 employees who are clearly identifiable within the company are included (reducing the number of company-years by about 3300,) as it is not possible to establish meaningful diversity measures for companies with fewer employees. 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. At company level, only profit-oriented companies reporting annual sales were included.

Overall, given the inevitable tradeoff between depth and breadth that any study faces, we chose a data set focused on breadth. Its strength, therefore, lies in providing simplified yet highly representative structural patterns between aging and company performance.

Measures

To test our hypotheses, we regress a proxy for company productivity on our main explanatory variables: age diversity and type of tasks.

Company productivity is measured as in previous studies with similar data (Grund &Westergard-Nielsen 2008; Haltiwanger, Lane &Spletzer 2007; Schneider 2007; and Skirbekk 2005.) We use the log of "(sales minus input costs) per employee" as a proxy for company productivity. Since in our control variables we include industry dummies, firm size, capital stock, investments, status of technology and other factors that typically determine the level of sales and costs, we catch the value-added of very similar firms with our productivity measure. The assumption is that any differences in value-added for such similar companies reflect the outcome that we are interested in – namely differences in labor productivity – because differences in technology, capital intensity, or market factors are kept constant. The advantage of this variable is that it is an *objective* measure for company productivity drawn from bookkeeping data. Its most important feature in our context is that it is not age-biased (because it is a general company survey without any relation to aging studies.) In contrast, the *subjective* performance ratings often used in special age-related studies may cover a broader range of detailed performance issues but may also be biased by positive or negative images of, as well as prejudices against, older workers (Cleveland & Lim, 2007). Therefore, we conclude that our variable C*ompany Productivity* is well suited for the question we are interested in.

Age diversity is operationalized via either the standard deviation of age or the variation coefficient of age, which is defined as the ratio of the standard deviation of age σ to the mean of age μ (as e.g. in Grund & Westergard-Nielsen 2008; Richard & Shelor 2002.) Since results

are essentially the same, we will only report results for the variation coefficient because it better addresses the problem that age-diversity may have different effects within different age groups. Here, the coefficient of variation has the advantage that it sets the standard deviation in relation to the average age, thereby catching potential systematic differences.

Type of tasks is difficult to measure in large quantitative data sets. To reduce the problem of an imperfect measure to differentiate between creative and routine tasks, we decided to use three different measures that have each been used in existing literature and proved to be good proxies in those cases. By using multiple, well-established measures for types of task we hope to overcome various shortcomings and determine their effects on our results and the stability of our coefficients. First, we used a product-related *company-level* proxy for type of tasks. It is a dummy variable denoting whether a particular company is innovative in the sense that it has developed or introduced a new product in a given year. Secondly, in our robustness checks, we used a proxy that is often used in innovation economics and defines innovative companies on a broad and aggregated *industry level*. Borrowing from Daveri and Maliranta (2007,) Ilmakunnas & Maliranta (2007,) and Richard & Shelor (2002,) we used the following industries as a proxy for more creative tasks: corporate services, trading/distribution, consumer goods manufacturing, and consumer services (as opposed to mining/energy, heavy industry, component/specialty products manufacturing, and public administration.) Thirdly, also in our robustness checks, we constructed another proxy that relates the first indicator (the innovativeness of an individual company over time) to the average innovativeness of all companies in its industry and is therefore called a "sector de-*meaned*" innovativeness indicator. Because results turn out to be very similar for the three measures, we will only report results for the company-level proxy because this is the one that best fits our level of analysis.

Method

We use the following regression model to estimate the impact of age diversity on company performance:

$$Productivity = \beta_1 Age\ diversity + \beta_2 Tasks + \beta_3 Diversity*Tasks + \beta_4 Age + \beta_5 X' + e$$

To account for the different productivity effects of age diversity depending on the type of task that the company performs (more routine or more creative,) we use an interaction term as suggested by Ennen and Richter (2010) to analyze complementarities. This interaction term *Diversity*Tasks* reflects the effect of increasing age diversity in an innovative work environment. It ensures that the coefficient of *Age Diversity* captures only the pure effect of age diversity on productivity, while the coefficient of the dummy variable *Tasks* captures only the pure effect of differences in the degree of innovativeness of the work environment on productivity. The interaction term *Age Diversity*Tasks* captures only the extent to which age diversity has an *additional* effect in creative task environments. If it is positive, it indicates that in addition to creative businesses being more productive as such, increased age diversity has an increased positive effect in a *creative* business (i.e., an effect not observable in *routine* businesses.) This is what we would expect according to hypotheses 1 and 2: a positive effect with creative tasks (H2,) but not routine tasks (H1.)

In addition to our explanatory variables, we use a standard set of control variables. First, we control for the average *age* of a company's workforce in order to separate mere aging effects from age *diversity* effects. Second, we include a broad set of control variables X' that are typically used in productivity studies. Specifically, X' includes a standard set of *individual* control variables such as tenure, experience, and education, and a set of *company*-related control variables such as company size, export sales, and investments or capital stock per employee.[5] One of our important *economic* control variables are the variables *"tenure"* and

[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 year being 2000. The capital stock was calculated using the "per-

"*fluctuation*" that help to capture internal labor market differences. We have to include controls for internal labor markets (ILMs) because one could expect companies with internal labor markets, where workers have been a long time with the company, to be more productive as such than companies with a hire and fire policy. Our controls ensure that age-related productivity differences we measure are not just due to differences in ILMs. To control for ILMs we use not only *tenure*, i.e. the length of time individual workers have been with a company, but also *standard deviation of tenure*, and *fluctuation* as control variables. [6] Thus, if internal labor markets made all the difference, we would have strong effects for these variables and find no significant results for the variable *age diversity*. Our results show that this is not the case.

Other important economic control variables are those related to capital or technology intensity because they are also likely to have positive productivity effects. By using several variables characterizing the technological status of the company as control variables, we can be quite confident that the coefficient for age diversity does indeed measure changes in labor productivity, as opposed to just differences in technology. In all estimations, we also include a complete set of year dummies to control for year-specific effects (for a similar procedure, see Daveri & Maliranta, 2007; Grund & Westergard-Nielsen, 2008; Haltiwanger, Lane & Spletzer, 2007; Ilmakunnas & Maliranta, 2007; Schneider, 2007.) A full set of the variables used in our estimations and their descriptive statistics is provided in Table 1.

Insert Table 1 about here

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petual inventory method" from figures for investments and assumptions regarding depreciation and growth rates (see Schneider 2007.)

[6] This serves to disentangle the effects of ILMs and age because even companies with the strongest ILMs (recruiting exclusively from ports of entry) can have a large variation in age diversity. If workers that have been with a firm longer have higher productivity, this productivity effect is caught by the variable *tenure*; if older workers or a more diverse workforce are more productive, this effect is then caught by the variable *age* and *age diversity*.

Different Estimation Methods

With our econometric analyses of our panel data we also try to eliminate biases due to company-specific unobservables—as identified by Daveri and Maliranta (2007) and Ilmakunnas and Maliranta (2007)—as well as reduce biases due to positive employee selection (as argued by Skirbekk, 2005.) The most important bias that we have to consider in our analysis is the problem that unobservable characteristics of companies may affect their productivity and their age diversity at the same time; this could make it seem as if higher productivity were due to age diversity, when in reality unobservable third factors could be the cause of both. For example, if one firm is just well managed while another firm is not, the first firm may have higher productivity than the second firm because of better management style; if better management style also correlates with higher age diversity, because a better-managed firm is better able to keep its best older workers and to attract the best younger workers, it would look as if age diversity causes higher productivity, when in reality both are driven by differences in management style. To avoid such problems of unobserved heterogeneity and omitted variables we use fixed effects estimations with our longitudinal data. Fixed effects estimations keep the company fixed and use the variation in the explanatory variable (in our case age diversity) within one company over time. As the company is kept constant, the effect of the unobservable characteristics of the company (such as management style) is constant as well, so these characteristics cannot cause the productivity differences that we observe. Thus, fixed effects estimations avoid or at least reduce the problems of unobserved and omitted variables and are therefore better suited for estimating the causal effects of age diversity than OLS regressions. They are therefore our preferred method in the interpretation sections.[7] In our robustness checks we nevertheless use two more estimation methods: OLS regressions with pooled data, and random effects estimators.

[7] A Hausmann test also shows that fixed effects estimations are preferable to random effects estimations for all estimations.

Results

Table 2 presents the regression results of our fixed effects estimations with *Company Productivity* as the dependent variable and the coefficient of variation as a proxy for the explanatory variable *Age Diversity*.[8] To test our hypotheses we look at coefficient $ß_3$ of the interaction term *Diversity *Type of Tasks,* which is significantly positive. This implies that the effect of an increase in age diversity in *creative companies* is strongly positive in comparison to *routine companies*, supporting Hypotheses 1 and 2. The coefficient $ß_3$ is 0.289, i.e. if age diversity in a company in a creative industry increases by 1% company productivity increases by 0.289%. Not only are these results statistically significant, they are also economically relevant. In a creative company, a 10% increase in age diversity (a percentage similar to the maximum change in diversity over the 10-year observation period in our sample) would increase productivity by approximately 3.5% per year. This productivity increase is especially relevant if one considers that in the same period, aggregate productivity growth in Germany was around 1% per year. This indicates that age diversity can be a considerable source of productivity growth for companies with creative types of tasks and, as such, positively impact overall GDP. Our theoretical framework shows that in creative companies or industries, the benefits of increasing age diversity clearly outweigh the increase in costs due to age diversity. The costs or negative effects from increasing age diversity per se are reflected in the coefficient $ß_1$, which measures the pure effect of *Age Diversity*. It is significantly negative (-0.457), meaning that while increasing age diversity tends to have a negative impact on *Company Productivity,* this effect is offset by a positive effect of increasing age diversity present only in

[8] Tables with results of alternative estimation methods (OLS and random effects) and of alternative diversity or task measures can be provided by the authors on request. All regressions were additionally estimated with a squared age diversity variable to find possible evidence for an inverted U-shape. Since we did not find any significant effects for the squared variables we drop them in the reported results because it simplifies the interpretation of the interaction terms.

companies with creative types of tasks (Hypothesis 2,) not in companies with routine types of tasks (Hypothesis 1.)[9]

Insert Table 2 about here

For our main control variable *Average Age,* we find a significantly positive coefficient in all estimations, which suggests that an increase in *Average Age* has a positive effect on *Company Productivity* when the effects of *Age Diversity* and *Type of Tasks* are controlled for. Although one might conclude from previous studies on *individual* age-productivity profiles that increasing average age may have a negative productivity effect, the opposite is true on *company* level: We do not find that increasing (average) age of a company's workforce has a negative effect on *company* productivity. On the contrary, increasing average age even has a positive productivity effect if the age-composition of the workforce is properly balanced.

Robustness Checks and Sensitivity Analyses

To see whether our results are stable we apply various robustness checks. First we use the two alternative proxies for *Type of Tasks.* We find that results are essentially the same and are quantitatively even stronger. With the indicator "innovative industry" we find that a 1% increase in age diversity increases overall productivity by 0.347%, and with the "sector de-meaned indicator" we find an increase of 0.343% (both coefficients are significant at the 1% level.) Second, we used our alternative proxy for *Age Diversity*, namely the *standard deviation of age* as opposed to the *variation coefficient*. Again we find basically the same results.

Third, we used alternative estimation methods for all *Type of Tasks* proxies and *Age Diversity* indicators. This helps to solve major empirical problems our results may suffer from.

[9] At the same time, the coefficient for the pure *Types of Tasks* variable, $ß_2$, is always small and rarely significant, meaning that productivity differences between routine companies and creative companies per se are generally rather small.

First, problems may result from unobserved heterogeneity or typical endogeneity issues. Although these problems are already reduced by our fixed effects estimations, they may not have been fully eliminated. To better take endogeneity problems into account, we therefore also use *time-lagged* variables for *Age Diversity* as instruments (a similar method is used by Skirbekk, 2005.) We find that the results for companies with *Creative Tasks* essentially remain the same (for all three indicators)—although not all coefficients remain significant due to the substantial reduction in the number of cases resulting from the use of time-lagged variables in addition to fixed effects estimations. Second, problems may result from a biased subsample that we get due to a heavy reduction in cases because with the above estimations we can only use industry changers for our industry proxy. We therefore also use an alternative estimation strategy and estimate our equation separately for companies in creative and for companies in routine industries. As expected, we again find that *Age Diversity* has a positive effect on productivity only in the estimation for industries with creative tasks but not in the estimations for industries with routine tasks.

To summarize, the results of the robustness checks match confirm our earlier estimation results. Thus, we find no evidence for rejecting hypotheses 1 or 2.

Discussion and Conclusions

This paper investigates how age diversity within a company's workforce affects company productivity and focuses on task structure as a moderating effect. Based on a large-scale employer-employee data set it shows that increasing age diversity has a positive effect on company productivity if and only if a company engages in creative rather than routine tasks. The effects are also economically important, e.g. a 10% increase in age diversity (the approximate variation during the survey period) leads to an increase in company productivity by approximately 3.5% per year in a company with creative tasks. In comparison to average GDP growth rates of about 1% in the respective period, this is a considerable effect. Our re-

sults are very stable given alternative measures for *age diversity* or *types of tasks*. To reduce problems of reverse causality and omitted variables we use fixed effects estimations and run several robustness checks (OLS, random effects estimations and time-lags.) We also control for alternative economic explanations such as internal labor markets or fluctuation. We find that results always remain stable. Thus, our results strongly indicate that age diversity has positive productivity effects for companies in more innovative industries. In innovative industries the ideal age mix involves a broad mixture of old and young employees, as opposed to only young employees as one might initially suspect. Whether these effects can be even further improved by using high performance work systems – particularly HR practices to keep and attract older employees as shown by Armstrong-Stassen (2008) – cannot be investigated with the data at hand but should be investigated in future research.

We explain the observed productivity growth as a joint effect of benefits and costs of age diversity. A more age diverse workforce provides a larger knowledge pool and can therefore find more creative solutions. At the same time a more age diverse workgroup may also be faced with increasing communication or social integration problems (the costs of diversity.) Therefore, the overall effect of age diversity on company productivity depends on the type of tasks and challenges the workforce has to master. In work environments with very standardized requirements there is not much to be gained by a broader knowledge pool because tasks are well defined and provide limited leeway for applying new knowledge; the costs of more diversity, however, (e.g. due to increased communication problems) remain equally high. Therefore, in a company with only standardized tasks the balance of benefits and costs most likely will not be positive. In a company with innovative tasks, on the contrary, problems are new and different every day; there is much to be gained from a more diverse workforce with a broader knowledge pool. The varied nature of everyday tasks and problems in such companies rewards a deeper knowledge base and the acquisition of new knowledge. Thus, in a company with innovative tasks, the benefits of age diversity outweigh

the costs. Naturally, this may not be the case in every single company, but in general our data clearly supports this conclusion and our hypotheses.

As a very important by-product of our analysis, we find that *organizational* productivity—unlike *individual* productivity—does not necessarily decline with the *average age* of a workforce. When *age diversity* and *types of tasks* are controlled for, an increase in average age has a positive effect on company productivity. As demographic changes are rapidly approaching, these results are of the utmost importance for organizational performance because they show that aging workforces do not necessarily signify decreasing productivity, as one may have expected based on research examining *individual* age productivity profiles.

Future research should try to develop better task measurements that can be used even in large data sets. In addition, future research should also use qualitative approaches with small data sets to construct more precise measures for different types of task structures and should try to replicate the effects that we find in our large data set, investigating where further refinement in the conclusion or policy implications is needed. Furthermore, future research should use more large-scale studies to analyze the relationship between different types of diversity (age, gender, culture, nationality etc) and their consequences on productivity, particularly on knowledge-sharing—as already argued by Lauring & Selmer 2012)— because in a more and more knowledge-intensive environment this will become one of the key competitiveness factors.

Our results carry important new practical and policy implications. They suggest that anticipated demographic changes (specifically aging in advanced industrial countries) should be seen not only as a threat to companies but also as a valuable resource. Changes in age structure could particularly support productivity growth in innovative companies if they approach these changes correctly. Since it may become more and more difficult to substitute the knowledge of retiring workers by the knowledge of newly hired workers in light of anticipated

demographic changes, it may also be important for a company to work with an even larger age span by combining their active workforce with their post-retirement workforce (for example through post-retirement volunteering as argued by Schlosser & Zinni, 2011, or through part-time work as argued by Backes-Gellner et al., 2010.) In this context, the types of tasks performed within a company particularly moderate the effects of age diversity on productivity. Thus, if companies move in a direction where they have to cope with more age diverse workforces, managers should try to steer towards products or processes where age diversity has its highest advantages when taking strategic decisions – i.e., move towards more creative rather than routine and standardized tasks.

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TABLE 1 Descriptive Overview of Variables Used in Estimations (Year 2003)

Variables		Variables	
Age of Workforce		**Educational Shares in %**	
Mean	39.3	Without Vocational Educ.	17.1
Median	40.0	With Vocational Educ.	71.2
Age Diversity		With Tertiary Educ.	8.7
Standard Deviation	10.27	**Socio-Economic**	
Variation Coefficient	0.27	**Characteristics in %**	
Share of Age Groups in %		Share of German Employees	95.3
16-24	13.5	Share of Male Employees	66.4
25-34	20.8	**Company Size in %**	
35-44	31.2	Share of companies with	
45-54	24.2	< 20 employees	47.2
55-64	10.0	< 100 employees	30.5
65-80	0.3	< 500 employees	17.5
Tenure		500+ employees	4.8
Mean	7.1	**Company Characteristics in %**	
Median	6.6	Share of Innovative Comp.*	*31.3
Share of Tenure in %		*latest data are for year 2001	
0-3 years of tenure	43.6	Share of Comp. with Creative Tasks	58.6
4-7 years of tenure	21.8	Share of Comp. with Newest Production Technology	19.0
8-11 years of tenure	16.6	**Share of Companies in %**	
12-15 years of tenure	7.4	In West Germany	64.7
16-20 years of tenure	4.1	Established Before 1990	60.3
20+ years of tenure	6.5	With Works Councils	38.9
Type of Job Shares in %			
Apprentices	7.9		
Blue Collar Workers	50.7		
White Collar Workers	41.4		

TABLE 2 *Results of Fixed Effects Regressions for Age Diversity on Productivity*

Variables	**Coefficient**
Mean Age	0.008***
Variation Coefficient of Age	-0.457***
Creative Task	-0.168*
Variation Coefficient of Age * Creative Task	0.289*
Number of Observations	41815
Number of Groups	12448
f-value	66.18
Prob>f	0.000
R^2 within	0.105

* p < 0.1, ** p < 0.05. *** p < 0.01.

FIGURE 1 *Cost and Benefits of Age Diversity, and Overall Productivity*

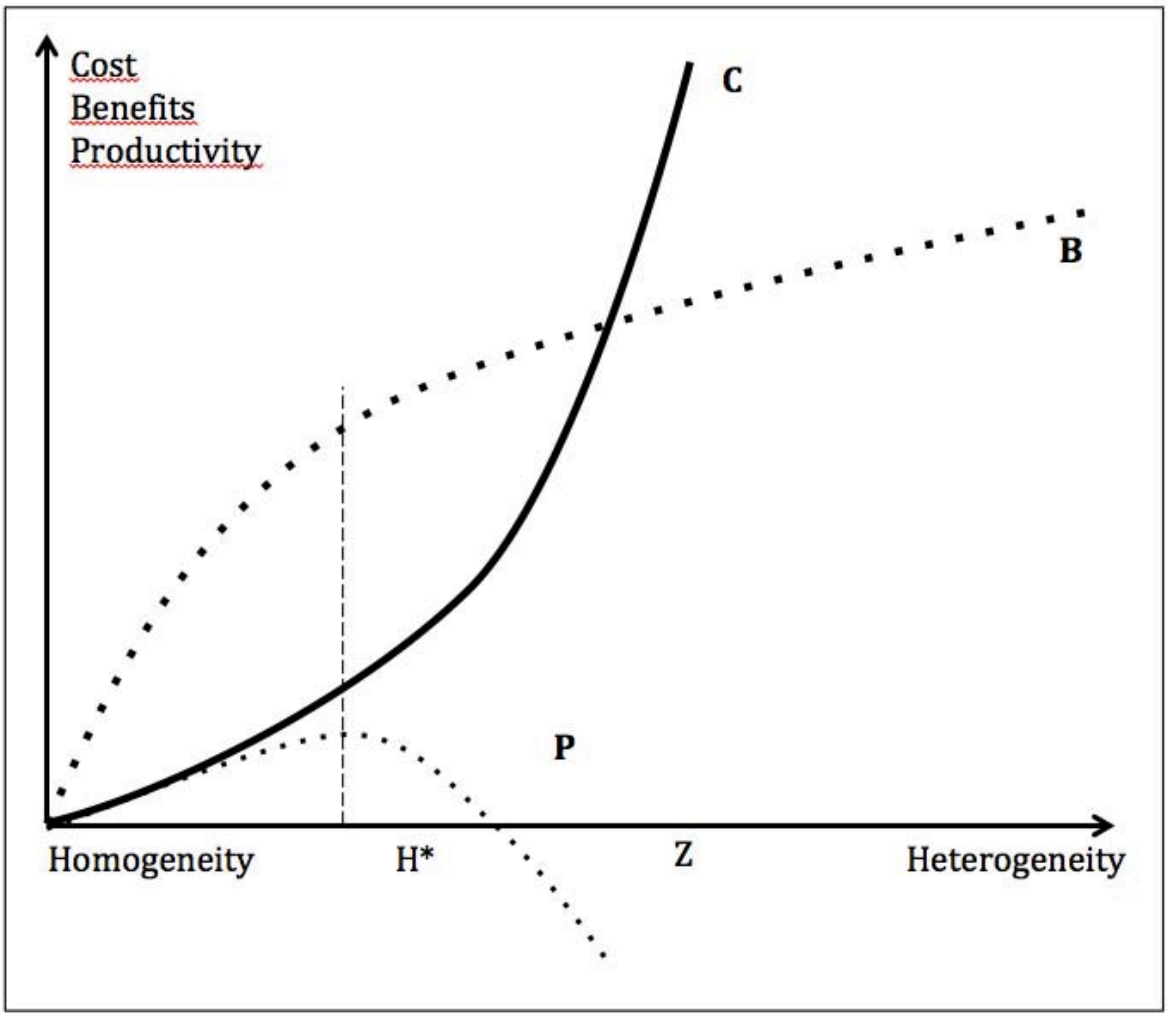

FIGURE 2 *Productivity Effects of Age Diversity for Routine vs. Creative Tasks*