

# Age-Differentiated Work Systems

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# Age-Differentiated Work Systems Enhance Productivity and Retention of Old Employees

Thomas Zwick, Christian Göbel and Jan Fries

## Lessons Learned

The rapid aging of the workforce in Germany threatens to undermine the competitiveness of enterprises mainly in two respects. The productivity of enterprises might decrease when relative productivity of old employees is lower than productivity of younger employees, and when employers cannot avoid an increase in the share of old employees. In addition, enterprises might lose valuable knowledge and skills when large cohorts of well-educated employees of the baby boom generation retire and have to be replaced by employees from smaller cohorts of labor market entrants.

This chapter reviews recent findings on the relationship between Specific Human Resource Measures that are targeted on Old Employees (SMOE) and establishment outcomes. More specifically, we study the relationship between SMOE and the relative productivity of older employees in comparison to younger employees and job stability of old employees. The studies summarized below put into question some traditional, widely accepted and frequently used paradigms. In the existing literature, old employees are often described less motivated, less productive or reluctant to learn. In addition, most previous studies concentrate on

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early retirement instead of ways to retain old employees. On the basis of extensive and detailed German linked employer-employee panel data, our project results show that there is no negative relationship between workforce age and establishment outcomes. We also find that SMOE increase the relative productivity of old employees and that some of them may be helpful for retaining productive old employees longer.

These are the most important lessons learned:

- Old employees are on average not less productive than younger employees; there are large variances between enterprises, however.
- The application of age-specific workplaces, specific jobs for old employees, and mixed-age working teams in establishments is associated with a significantly higher relative productivity of old employees.
- The relative productivity of old employees in establishments that apply reduced working time and training for old employees is not significantly different from establishments without these measures in our data set. Reduced working time has been mainly used to implement early retirement, and training of old workers frequently does not take into account age-specific learning motivation.
- The use of mixed-age working teams is associated with significantly longer employment durations of employees aged 50 and above. By contrast, an age-specific part-time program (*Altersteilzeit*) significantly reduces employment durations of older workers. We do not find a relationship between employment duration and training measures and other policies, such as reduced work requirements or specific equipment of workplaces for older employees.

## Introduction

Germany experienced a strong increase in workforce age and this trend is likely to continue in the future (Göbel and Zwick 2009). If older employees are structurally less productive than younger employees, then higher shares of older employees in the workforce might reduce productivity of concerned establishments and lower their competitiveness. On the other hand, retirement of the relatively large cohorts of highly educated baby-boomers and the labor market entry of relatively small cohorts of young people might lead to an undersupply of skilled employees and the loss of specific knowledge (Frosch et al. 2011). In order to assess the importance of the threats that are caused by an aging workforce, in a first step we compute the relative productivity of old employees. In other words, we investigate how productivity of establishments changes when the share of old employees increases.

The age composition of employees in the establishments changes significantly from year to year. It should also be noted, that the age structure cannot entirely be determined by the management because Germany has strict labor protection laws especially for old employees. We find that establishments apply different employment strategies in order to avoid strong aging. One group of establishments is mainly hiring younger employees while others mainly dismiss their old

employees. Strong variation in the age structure allows us to identify the impact of a change in the age structure of the employees on establishment productivity. We also consider that the effect of age on productivity might be different between economic sectors.

Enterprises have the possibility to respond to an expected reduction in establishment productivity when their workforce ages. They can, for example, use human resource management measures especially targeted on old employees. These measures can be important components of age-differentiated work systems. In order to study which human resource management measures are effective, we analyze the correlation between these measures and the relative productivity of old employees. SMOE might also be used for an increase in the tenure of old employees and a postponement of the retirement decision. We identify effective personnel measures that can keep valuable knowledge in the establishment and help to avoid skills shortages by prolonging the tenure of old employees.

## Background

The impact of the age structure on establishment productivity is at the center of a lively scientific debate. At the core of this debate is the question whether the decline in for example cognitive functioning, executive or memory capability measured, muscle strength and sight documented in many medical and psychological studies (Skirbekk 2008; Ng and Feldman 2008) leads to a measurable decline of average productivity of old employees. There are at least two arguments against this hypothesis. First, establishments might lay off old employees if they observe a decline in productivity. Second, productivity is not so much driven by peak or short period performance frequently measured in medical studies, but by long period performance. In addition, declining performance dimensions may be substituted by experiential knowledge (so-called crystallized intelligence, Kanfer and Ackerman 2004) and specific human capital or be compensated by mixed-age working teams, where members are selected according to their specific and complementary knowledge and skills.

Skirbekk (2008) reviews 14 chapters on the relationship between the age of employees and firm productivity, starting from the chapter by Hellerstein and Neumark (1995). Between 2008 and 2011, about the same number of studies appeared, covering different countries. One reason for the renewed interest in this subject is the availability of suitable representative panel data and a paradigm shift. Early chapters almost unanimously (in Skirbekk's literature review 13 out of 14 chapters) found that the relation between workforce age and productivity is hump-shaped (or describes an inverse “U”). In other words, young and old employees have a lower productivity than mid-aged employees. Consequently, the early literature had a focus on the question, at which age the decline in productivity starts.

The widely held belief that old employees lead to a reduction in productivity at the firm level first was put into question by the seminal work by Patrick Aubert and Bruno Crépon. In a series of chapters, they argue theoretically and show empirically that previous results have been driven by the endogeneity of the age structure in establishment productivity estimation (see for example Aubert and Crépon 2006). In other words, productivity and age structure are frequently jointly driven by third, mostly unobserved factors. One example is that establishments in declining industries see their productivity erode while they cannot afford to hire new employees and the existing workforce slowly ages. Another example is that establishments that are about to introduce an innovation can increase their productivity and at the same time hire young employees. In both cases, a cross-sectional analysis or a simple panel analysis that does not take endogeneity of the age structure into account leads to biased results for the effect of the age structure on productivity. Aubert and Crépon (2006) show how to mitigate this estimation problem and demonstrate that its correction mainly leads to an increase of the measured impact of the share of older employees on establishment productivity. In other words, in their estimation approach, the age productivity profile is like an inverse “*L*”—young employees contribute less than the average employee to establishment productivity but from a certain age onwards, the productivity contribution of employees in different age groups is stable.

The finding that the correction of endogeneity in age-productivity estimations leads to an increase in the relative productivity impact of old employees has been replicated several times since 2006. In 2011, two major international conferences in Louvain-La-Neuve and St. Gallen have been explicitly devoted to the relationship between aging workforces and productivity. Contributions to these conferences discuss estimation issues and differences between regions, economic sectors and age-productivity as well as age-earnings profiles. Many of the contributions to these conferences appeared or will appear in special issues of well-known international journals—*De Economist*, volume 159 (2) in 2011 and *Labour Economics*, forthcoming in 2012. Both special issues will certainly have influence on the discussion of age-productivity profiles and their estimation.

Besides the question whether old employees are as productive as younger employees, many chapters discuss the question whether specific personnel measures for old employees increase their productivity. The first insight from this literature is that old employees are on average not less motivated than younger employees, however, different measures are effective in motivating old employees (Stamov-Roßnagel and Hertel 2010). They stress that old employees mainly want to adopt their working environment to fit their (partly reduced) resources as well as possible. Younger people primarily strive for gains in, for example, earnings, status or employment security; older people, however, often focus on maintenance, returns from prior investment, and the prevention of losses. Stamov-Roßnagel and Hertel (2010) argue that interest in tasks that involve acquiring new skills, knowledge or career opportunities decrease with age. On average, motives like autonomy, positive relationships with colleagues and supervisors, and self-realization increase in importance during the life cycle. There are at least two

reasons for that. First, many old employees have already achieved goals that motivate younger employees, like employment security, promotion or a high income level. Another variant of this argument is that old employees enjoy better institutional rules like higher employment security, hiring subsidies or longer unemployment payments that also change their motivation (Boockmann et al. 2012b). Second, old employees do not want to compete for example in a promotion tournament in ability areas they have clear disadvantages in (Kanfer and Ackerman 2004). These authors stress that motivation for activities that mainly demand fluid cognitive abilities becomes less interesting because the ability to learn radically new things declines with age. Activities that are mainly based on the development of crystallized cognitive abilities remain attractive, however, because the experience of old employees is an advantage for such activities.

The most pervasive personnel measure specifically aimed at old employees is to select the most able and best fitting employees and dismiss less productive employees (Howard 1988; Frosch et al. 2011). Strict labor market protection for old employees in Germany does not allow selective dismissal of old employees or makes this strategy expensive. Strategic human resource management measures that directly tackle disadvantages of old employees therefore provide alternatives for early retirement, old age working time reductions or dismissals. These measures are based on the insight that old and younger employees have complementary competencies and capabilities (Boockmann and Zwick 2004; Skirbekk 2008). Specific measures might also increase the chances to retain old employees. Establishments that face a shortage of young skilled workers, or establishments where a large cohort of employees approaches retirement age, might have an interest in applying specific measures for old employees in order to lower quits. Moreover, employment duration of old employees is likely to depend on relative productivity of old employees. Therefore, specific measures that target an enhancement of older workers' productivity are likely to prolong employment, too. Therefore it may make sense to offer SMOE, even if this may be perceived as discrimination.

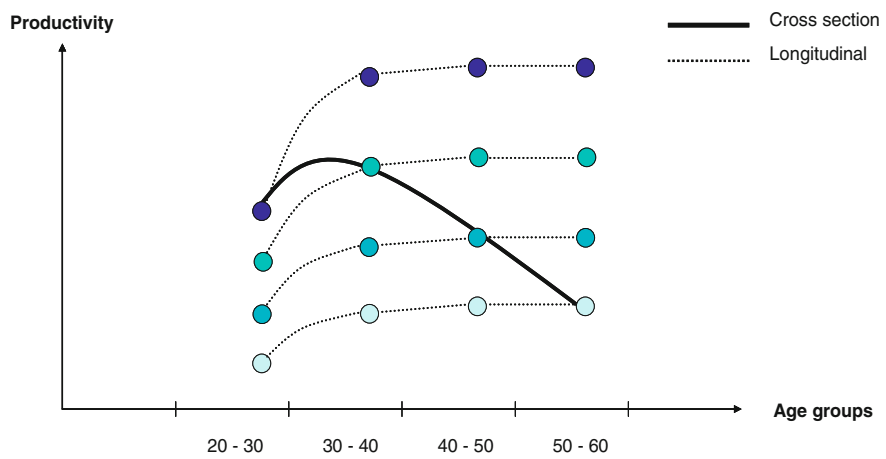
## Data and Empirical Strategy

All analyses presented in this chapter use linked employer-employee panel data sets (LIAB) of the Institute for Employment Research, Nuremberg (IAB). On the establishment level, the LIAB uses the survey data of the IAB establishment panel. This panel entails questions on value added, investment, industrial relations, sector, average employee characteristics and expectations of managers. The establishment data are linked to administrative records on employees, by the means of a common identifier. The employee data set is based on official data of the IAB employment register. Yearly information on wages, qualification, gender, tenure, and age can therefore be linked to the employer data. Altogether, our version of the LIAB covers almost 7 million employees and more than 8,500 establishments.

The data set therefore has the advantage that information on establishments from all economic sectors and the structure of their employees can be captured over time. We restrict our analysis to profit oriented enterprises with easily measureable output (and therefore exclude public administration enterprises, agriculture, banks and insurances). In addition, the individual information such as wage and age is drawn from administrative sources and is therefore practically free of measurement errors. One disadvantage is that there are problems with item non-response for several variables on the establishment level such as sales or innovations. In some chapters, we imputed missing observations of important variables, when values were reported before and after the missing observation. Dates for tenure and experience were reported only after January 1st 1975 in West Germany and after January 1st 1990 in East Germany. This means that more than 10 % of the West German and more than 25 % of the East German employees have censored values for tenure and experience. We account for censoring by multiply imputing their values. Yearly imputation of the values for tenure could lead to excess variance in these variables and therefore, for each employee, only the first value for tenure is imputed and following observations are derived from the initial value, accordingly; for each additional year the employee stays in the same establishment we update the value for tenure by adding one year to the value of the last year.

The panel data are provided in several versions, see Jacobebbinghaus (2008) for details. The so-called cross-sectional version used by Göbel and Zwick (2009, 2012a, 2012b) and Frosch et al. (2011), provides one observation per year for establishment characteristics and virtually all employees of the observed establishments on June 30th of the respective year. The so-called longitudinal version uses individual spell data. This means that employment spells and their characteristics such as wage and duration are completely known for all employees who worked in one of the included establishments. This version of the LIAB is used by Boockmann et al. (2012a). The spell data in the LIAB allow us to reconstruct employment spells that last for more than 25 years. The exact duration of an employment relationship can be observed with daily accuracy. One of the disadvantages of the longitudinal version of the LIAB is that there is no information on retirement. However, establishments that apply specific measures for old employees are mainly interested in employment duration, for which analysis the longitudinal version of the LIAB is well suited. We draw a sample of workers who are employed on January 1st 2002 and who are more than 40 years old, correcting for potential stock-sample bias. These individuals are followed in the data until they leave the establishment permanently or reach official retirement age at 65.

In Göbel and Zwick (2009, 2012a), we estimate the impact of the workforce age structure and its changes on establishment productivity. We argue that cross-section estimations of the relationship between the establishment age-structure and productivity are likely to give biased results. Assume that the productivity-contribution of employees aged 20–30 years is lower than that of the prime age workers (those aged 30–40 years). Moreover, the relative productivity of the 40–50 years old employees and the 50–60 years old employees is on the same



**Fig. 1** Longitudinal vs. cross-sectional observations of age and productivity

level as relative productivity of the 30–40 years old employees. This means that the relation between age share and productivity can be represented as shown in the lowest line in Fig. 1. Furthermore, let us assume that there is an exogenous technical improvement induced by learning and innovations that increases total establishment productivity uniformly over time for all age groups. The described upwards shift would for example occur when later birth cohorts are better educated or when they work with newer, more productive technologies or machines. The shift could apply for birth cohorts at the level of employees and for cohorts of establishments that are founded at the same moment in time. In other words, the technical improvement does not particularly favor a certain age group, but shifts the productivity of all age groups upwards, as shown in the second lowest line in comparison to the lowest line in Fig. 1. We finally assume that there are no age composition effects on productivity, i.e. the productivity of employees of a certain age group does not depend on the share distributions of the other age groups. In this case, the lowest line of Fig. 1 represents the true age productivity profile of the employees of one cohort. This profile represents what researchers would obtain if they could directly observe the development of the individual productivity contributions in this cohort for 40 years. Note that this is the approach for example proposed by Schaie and Willis in the Seattle Longitudinal Study (Schaie and Willis 2002) to study individual aging processes. The second lowest line is the analogous age-productivity profile for another cohort that enters the labor market 10 years later. From the longitudinal perspective, observing age and productivity over time, we obtain several trajectories of age-productivity curves in an inverted *L*-shape.

Now suppose that we compute age-productivity profiles derived from cross-sectional data, observing differences in age and productivity between our four cohorts at one point in time. This approach cannot take into account the



productivity trend over time because technological shocks or productivity changes based on innovations usually cannot be observed in cross sectional data sets. The cross-section approach results in an inverted U-shaped age-productivity profile as indicated by the bold line in Fig. 1.

In our empirical approach, we imitate the longitudinal and cross-sectional estimation approaches depicted in Fig. 1. First, we calculate an age-productivity pattern in a pooled ordinary least squares (OLS) approach that is driven by cross-sectional variation in the data. Then we take into account unobservable time-invariant heterogeneity between establishments (probably induced by unobservable technological shocks over time) in a longitudinal approach. Our preferred specification exploits changes in productivity and the age structure over time within the same firms and takes into account that third factors such as the business cycle might have an impact on both productivity and the age structure (which would lead to endogeneity). In addition, our data allow us to separate cohort effects from age effects. The simultaneous identification of age-, cohort- and calendar-effects is often awkward in empirical models. The fundamental issue is that at the individual level, year of birth plus age is equal to calendar time. This renders it impossible to separate the effects of birth-year, age, and calendar time at the individual level. This equality also can lead to estimation problems (collinearity) when analyzing establishment data. Here, the share of employees with a specific year of birth is equal to the corresponding share of employees with the corresponding age in years. Therefore, additional requirements have to be met for the simultaneous identification of cohort-, age- and calendar-effects with establishment data. First, the chosen time windows for age groups and cohort groups are not allowed to completely overlap. Complete overlap would lead to perfect collinearity and would render any estimation impossible. This implies that one has to decide on the width of the time windows, which can put constraints on the empirical specification. In empirical applications, time windows typically comprise several years. This requirement often does not put serious constraints on the specification. In order to analyze the sensitivity of the results, however, it is advisable to test different specifications of the window widths. Second, sufficient variation over the possible age and cohort shares is required. The use of panel data at the establishment level is certainly helpful to provide this variation, since there is typically ample variation over age and cohort composition within the enterprises over time (compare Göbel and Zwick 2009). This variation is the outcome of an aging workforce combined with employees that quit and enter the establishments in the course of the observation period.

We estimate a structural so-called Cobb-Douglas production function. Productivity of the establishments is measured by value added (sales minus input) per head. We explain productivity by capital per head, the share of employees in certain age groups, and other establishment characteristics. We include a broad range of relevant establishment-specific information besides capital and age shares. It is especially important to control for age related variables such as tenure (Haegeland et al. 1999; Daveri and Maliranta 2007), qualification (van Ours and Stoeldraijer 2011), the age of the firm (Cardoso et al. 2011), and the birth cohorts of the employees. Otherwise, the age of the employees might capture part of the

influence of these factors on productivity, which could lead to biased results. We use age classes in five-year brackets and only report the coefficients of employees between 20 and 60 years of age. The estimates for the other age classes are summarized in a separate variable, but are not reported because they are likely to be dominated by unobserved characteristics of employees at the fringes of the age distribution—very young employees and very old employees are usually specific individuals. In addition, they represent only a small fraction of the population of all employees (in the year 2005, only 3.5 % of the employees are younger than 20 years and only 3.8 % are older than 60 years old, OECD 2005). In order to allow for persistence in the level of productivity, we specify a dynamic model where the production level  $p$  of an establishment  $j$  of one year  $t$  is allowed to be a function of its past values  $p_{j,t-k}$ .

We consider various ways of estimating the production function. In a first step, we estimate pooled OLS of the Cobb-Douglas production function without the lagged dependent variables. However, the OLS estimates are likely to be biased because of endogeneity since the value added and the age structure are determined simultaneously. Successful establishments, for example, recruit more workers, and job entrants tend to be younger than those who leave the enterprise (Frosch et al. 2011). In addition, the variation between the establishments is likely to drive the results, and we can only observe part of the heterogeneity between establishments. For example, establishments with good industrial relations might be able to bind their employees longer, while they enjoy a higher productivity. Since we cannot control for all establishment characteristics, estimates from OLS estimation of the age-productivity profile are likely to be biased.

Therefore, we switch from a cross-sectional (between) estimation to a longitudinal (within) estimation in a next step and hereby control unobservable differences between enterprises (so-called unobservable time-invariant heterogeneity). In order to control for endogeneity, we apply so-called dynamic General Method of Moments (GMM) methods and use lagged values of the explanatory variable to instrument contemporary values (Arellano and Bover 1995; Blundell and Bond 1998). In order to find the correctly specified model, we start with moment conditions that require relatively mild assumptions and augment the set of instruments systematically. The validity of the additional instruments is tested by means of the standard Sargan/Hansen test for over-identifying restrictions. We also apply a test for serial correlation in the disturbance term in order to check whether the dynamic specification of the model is correct (for details see Göbel and Zwick 2009). Finally, we use the model with the smallest number of instruments and lags that satisfies all necessary test statistics.

In Göbel and Zwick (2012b), we use the age and establishment productivity profiles described above and split the establishments into groups with and without age-specific personnel measures. This allows us to test the hypothesis that the correlations between specific personnel measures and the relative productivity of different age groups are confined to the group of old employees. One exception is age-mixed teams because also younger employees might profit from the presence of older employees with complementary skills (Wegge et al. 2008, see chapter Age

**Diversity and Team Effectiveness**, Ries et al.). One disadvantage of our data set is that we only know whether an establishment uses SMOE or not, we do not know the effort or pervasiveness of the measure and which employee groups are affected.

In order to estimate the effect of human resource management measures on job durations of older employees, in Boockmann et al. (2012a) we implement a hazard rate model. In the existing empirical literature on employment duration there are two distinct types of models. One strand of the literature focuses on the duration of employment or tenure (van den Berg and van der Klaauw 2001). This literature emphasizes the correct empirical implementation of duration dependence and discusses how transitions out of employment depend on tenure. It is common in this literature not to pay particular attention to age effects; most studies focus on younger workers and exclude workers aged above 50 or 55. Another strand of the literature focuses on the analysis of employment duration of older workers or retirement decisions. It emphasizes age effects, but does not take duration dependence into account (for a recent application we refer to Hanel and Riphahn 2012). Blau (1994) and Blau and Riphahn (1999) derive their empirical duration model from a theoretical model of labor force transitions, without considering the interaction of age and duration dependence. However, the sampling probabilities, transition rates and survival probabilities during the observation period typically depend on both duration dependence as well as age dependence. Therefore, an appropriate empirical model should take both effects into account.

We specify a duration model where duration dependence, age dependence and the explanatory part enter multiplicatively. This specification is an extension of the proportional hazard model. In our specification, the transition rates are allowed to shift proportionally with the explanatory variables and age. Note that in this empirical model, survival in employment does not only depend on elapsed duration but also very flexibly on years of age. Our specification includes years of age as the baseline hazard; age effects are estimated in annual intervals for each year of age beyond 40. We can, thus, account for spikes in the probability of leaving the job, such as early retirement age. Identification of this model has been proven by Imbens (1994). This study extends existing results for identification of a parametric duration model by the simultaneous consideration of tenure and age effects.

We use the longitudinal version of the LIAB data to construct employment spells. Since we cannot observe the start of employment for spells before 1975 in Western Germany and 1991 in Eastern Germany, we have to take left-censoring into account. In order to limit the impact of left censoring, we only analyze the employment duration for Western Germany. Since we have a large sample, we use only transitions out of employment that occurred in 2002, the year in which we observe the application of specific measures for older employees. More precisely, we use a stock sample of all workers who are employed at January 1st, 2002 and who are older than 40 years, correcting for stock-sampling bias appropriately. We analyze transitions out of employment during the year 2002. Employment spells that continue beyond the year 2002 are right-censored at the end of the year and we adjust the likelihood accordingly. Since we have a large number of employment spells (59,099 spells from

300 establishments), the sample provides many transitions out of employment for all considered years of age and employment durations.

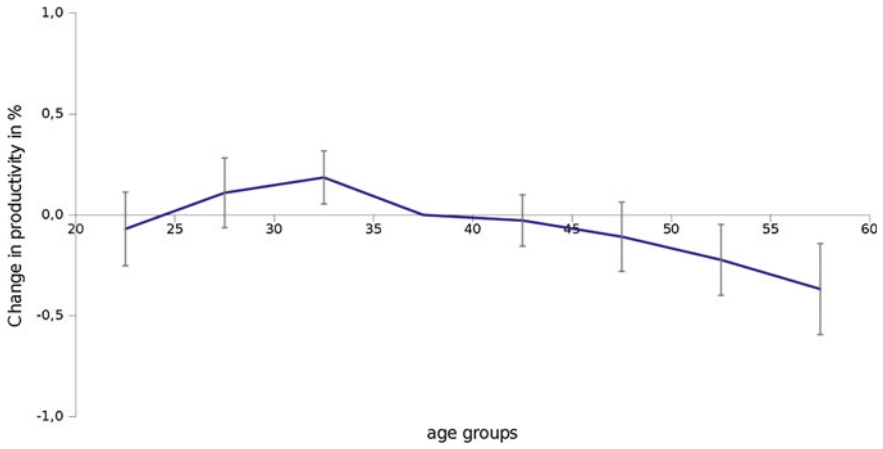
We exploit the rich information of the LIAB data and alternatively include employer characteristics or establishment fixed effects, as well as a set of employee characteristics. We then split our sample between establishments that use or use not particular measures and compare the age profile of the job exit probability (implied by our estimated baseline hazards) between these groups.

In Zwick (2011), the “Berufliche Weiterbildung als Bestandteil Lebenslangen Lernens—Continuing Training as Part of Lifelong Learning” (WeLL) data set is used. This data set is also based on establishments observed in the IAB establishment panel (like the LIAB data set). About 150 establishments that indicated that they invested in training have been chosen from this data set. In addition, more than 6,000 individual answers on training behavior and socio-demographic information from employees in these establishments have been added to the establishment characteristics from the years 2007 and 2008.

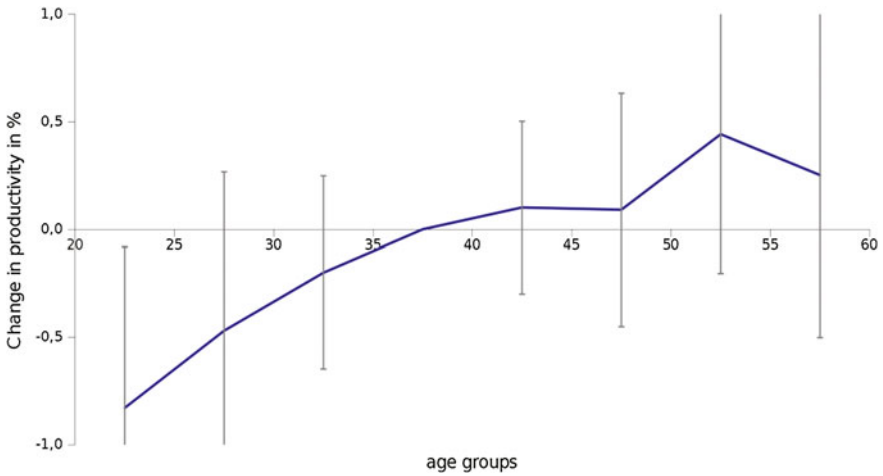
## Results

The aim of our Cobb-Douglas production function estimates is to show the relationship between the age shares and establishment productivity. We therefore mainly present these results here and refer the reader interested in the other coefficients, tests and sample details to the original chapters. In Göbel and Zwick (2009), the impact of different age groups on establishment productivity is first calculated for a pooled cross-section of establishments. The typical inverse U-shape of the age-productivity profile found in numerous studies can be replicated (see Fig. 2)—only the age groups older than 50 years are significantly less productive than the reference group 35–40 years (their confidence intervals do not overlap the zero line). Please note that the age group 35–40 years has no confidence intervals because it is the reference group. In addition, the value of the coefficient has to be normalized to zero. The influence of the different age groups depends on additional explanatory variables included. When we do not include decisive variables such as tenure, experience and cohorts, especially the impact of young age groups is much more negative than in the estimation presented here with the full range of explanatory variables (not shown here).

In a next step, endogeneity and unobserved time-invariable heterogeneity are taken into account by estimating the impact of changes in age groups on changes in productivity using GMM methods. All validity tests for the difference-GMM specification are fine. The age-productivity profile is an inverse L-shape and again, the included explanatory variables have a sizable impact on the results (see Fig. 3). Göbel and Zwick (2012a) show that there are no significant differences in age-productivity profiles between the manufacturing and services sectors. Even the metal manufacturing sector has a similar age-productivity profile, even though one



**Fig. 2** Pooled OLS estimates of the age-productivity profile (*Note* 95 % confidence intervals are indicated by bars)



**Fig. 3** Dynamic difference-GMM estimates of age-productivity profiles (*Note* 95 % confidence intervals are indicated by bars)

might assume that old employees have larger difficulties to keep up their productivity contribution in this sector.

The confidence intervals in our age-productivity profiles are relatively large, however. There are several possible explanations for the relatively imprecise estimation of age-productivity profiles. First, due to unobserved differences between enterprises or measurement errors, it could be that the specification does not capture the true correlations between age and productivity well. However, given the quality of the data, our rigorous specification and over-identification tests

**Table 1.1** Percentage of enterprises that offer specific measures for old employees (SMOE)

	Share (%)
At least one SMOE	27.8
Specific equipment of workplaces	1.8
Reduced working time	14.5
Age specific jobs	3.9
Mixed-age working teams	11.1
Training for old employees	10.4

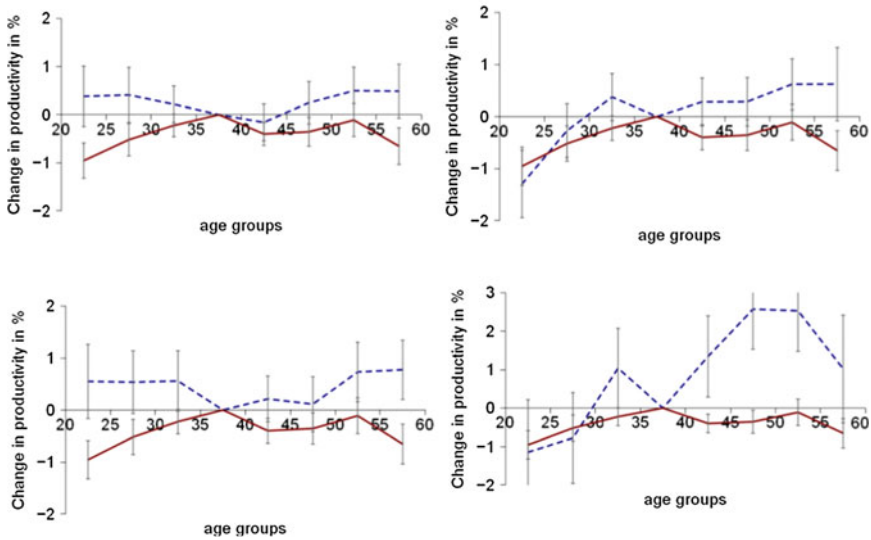
*Note* Source IAB establishment panel, wave 2002

and the flexible specification, we believe that this explanation seems not very likely. Second, there is indeed a large variance between enterprises—some enterprises actually can increase their productivity when the share of older employees increases and others see their productivity decline. The second interpretation can be tested by finding significant differences between these groups of enterprises and at the same time smaller variances for both groups.

Therefore, we re-estimate the age-productivity profiles separately for establishments with and without specific personnel measures for old employees in Göbel and Zwick (2012b). We find important differences between the age-productivity profiles depending on the application of different measures. This finding suggests that real variation in age-productivity profiles between establishments is one of the causes for the large standard errors of our estimates. The shares of establishments that use these specific measures are displayed in Table 1.

We find for three out of five measures that they have a positive impact on the relative productivity of old employees—the bands indicating the standard errors do not overlap here. In all cases, the variance bands for the separate enterprise samples are narrower than in the full sample. Establishments with a high relative productivity of old employees apply the following measures: specific workplaces for old employees, age-specific jobs for old employees, and mixed-age work teams (also see chapter [Age Diversity and Team Effectiveness](#), Ries et al.), see Fig. 4. Enterprises with mixed-age work teams also have a relatively high productivity of their younger employees.

Göbel and Zwick (2012b) also find that there are two measures that are not related to relative productivity of old employees: reduced working time for old employees and training of old employees. An important reason for the finding of reduced working time for old employees is that this measure has been used by about 90 % as the so-called block model. This means that instead of flexibly reducing their working time in old age, employees work full time with reduced income for a certain time span (usually two years) and fully retire earlier. This form of hidden early retirement proved to be attractive for establishments until recently because it was subsidized publicly. Zwick (2011) shows that training of old employees is frequently not effective because enterprises do not take age-specific differences in training motivation into account. The consequence is that although old training participants get the same resources and comparable contents



**Fig. 4** Dynamic difference-GMM estimates of age-productivity profiles for different samples of enterprise. (Note From left above to right below: Blue dashed lines: enterprises with any personnel measure, enterprises with age specific jobs for old employees, enterprises with age mixed work teams, and enterprises with specific workplaces for old employees. Red solid lines: always enterprises without any measures. Standard errors are indicated by bars.)

and training forms, the self-assessed training efficiency with respect to relevant variables such improvement of career chances, higher income, higher flexibility, workplace security or higher productivity is significantly lower than for younger employees.

According to the hypotheses by Roßnagel-Stamov and Hertel (2010) and Kanfer and Ackerman (2004) on shifts in motivation by old employees described above, some training contents and methods are more effective than other training measures. In a direct comparison of the effectiveness of training methods, Zwick (2011) shows that, for old employees, formal seminars are less effective than training on the job and self-managed learning. The interpretation of this finding is that seminars frequently do not deliver knowledge that can easily and immediately be used at the workplace and training periods in seminars are not flexible enough. In addition, training in information and communication technology and in technical contents is less effective than training in management and communication skills. These results demonstrate that old employees are not keen on acquiring knowledge that is demanding with respect to fluid skills. They instead prefer training contents that can be easier absorbed by crystallized abilities. Management and communication skills in addition deliver immediate value-added for the quality of the workplace and communication with colleagues or team members.

Frosch et al. (2011) investigate how establishments achieve workforce rejuvenation—from the inflow of employees who are younger than their workforce

or from outflows of relatively older employees. In addition, it is explored whether certain staffing patterns are more likely to appear under different economic regimes. The analysis of linked employer-employee data shows that most of the establishments covered rejuvenate by inflows of younger workers. Half of the establishments also use the outflow of older workers, however. Furthermore, in growing establishments, the workforce is more likely to become more age-heterogeneous. Moreover, in times of workforce decline, rejuvenation is primarily caused by outflows of older workers, and this is occurring regardless of the dominance regime (dominant firms have well-functioning internal labor markets and are able to attract and retain workers with high levels of human capital, dominated firms have less attractive career opportunities and lose valuable and self-trained workers to dominant firms). Further subdividing establishments into growth regimes according to whether they are dominant or dominated employers finally reveals that this phenomenon only proves true for dominated establishments. In contrast, more dominant establishments rejuvenate through the inflow of younger workers even in times of high external labor demand. Finally, the chapter does not find evidence for the hypothesis that a youth-centered human resource strategy (always) fosters innovation.

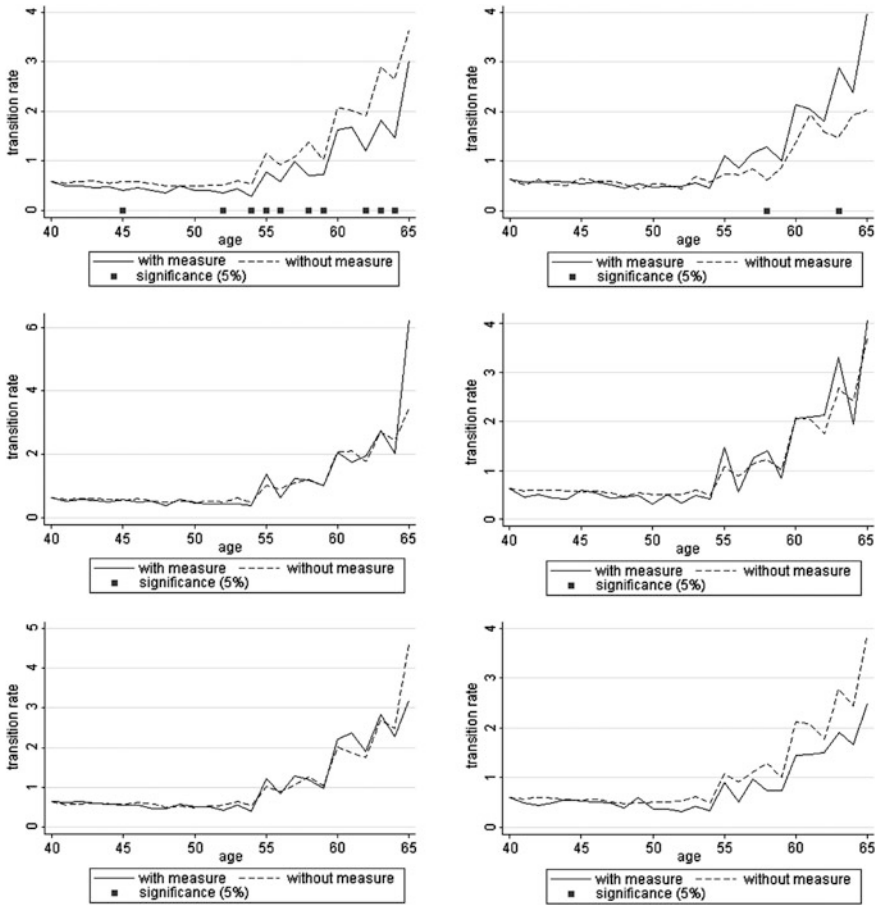
Now we present the results of Boockmann et al. (2012a). We focus on the effect of specific measures for older employees on the job exit probability at each year of age beyond 40, comparing between establishments that use or do not use particular measures for older workers: mixed-age working teams, age-specific part-time, reduced work requirements, a special subsidized part-time scheme, specific training for older employees, participation of older workers in general training, and age-specific equipment of workplaces. The main question behind our analysis is whether older workers stay longer with their employers if employers use one or several of these policies.

As we can see in Fig. 5, based on our preferred specification with establishment-level fixed effects, age does not play a dominant role for transitions out of employment until the age of 55 for most of the measures. Only after the age of 58 is there a sharp increase in the effect of age on the transition rate out of current employment. Because job mobility is low at more advanced ages, this sharp increase is likely to be caused by labour force exits of the older workers concerned rather than by job-to-job transitions. Emphasis is on the shape of the duration profile rather than on its level. Indeed, the level information is absorbed by the establishment fixed effects.

The use of mixed-age work teams seems to reduce transition rates of older workers substantially in most of the age groups (upper left graph). Even at ages 45 and 52, transition rates are significantly lower in establishments using mixed-age work teams. Starting at age 55, the differences in transition rates are quite large in magnitude and are further increasing with age.

In the upper right part of the graph, we show the transition profiles of establishments that do and those that do not offer age-specific part-time. As mentioned above, there is evidence that a large part of establishments that use this measure apply the so called “block-model” for reduced working time. This is basically a





**Fig. 5** Baseline hazards depending on age for the job exit probability. (*Note* Solid lines display estimates for establishments that apply a specific measure for old employees, dashed lines display estimates for establishment without this measure. From left above to right below mixed-age working teams, age-specific part-time, reduced work requirements, specific training for older employees, participation of older workers in general training, age-specific equipment of workplaces)

subsidized early-retirement scheme, and we would expect workers to quit earlier in establishments that apply this measure. Although the worker is effectively retired during half of the time within this scheme, he or she counts as being employed in our data. This underestimates the effective exit rates during the scheme. In spite of this underestimation, the results show that the application of age-specific part-time tends to reduce employment duration. However, the difference is only significant at particular ages. Results from other specifications show that job duration for younger age groups may be more stable in establishments using the part-time scheme.

Reduced work requirements for older workers do not influence employment duration of older workers; for none of the ages between 41 and 65 are there any significant differences between establishments applying or not applying this measure. The same applies to age-specific training and participation in standard training. In both cases, we would expect the measures to decrease transition rates. However, the figures show that exit rates have the same magnitudes irrespective of whether training is provided. Finally, the transition profile of establishments that have age-specific equipment of workplaces also does not indicate that this measure delays job exits.

Overall, we find that, among the measures considered, only aged-mixed teams are associated with lower job exit rates of older employees. This effect complements existing findings on the productivity effects of this particular measure. Age-specific part-time is related to shorter employment durations of older workers. This result is in line with descriptive information from the literature on the use of age-specific part-time as a means of early retirement. For other measures, such as training, reduced work requirements and specific equipment, we do not find a relation to employment duration. These results do not necessarily have a causal interpretation. Yet they show that one needs to evaluate each of the measures separately if one wishes to address the highly important question of how to achieve longer employment durations of older workers.

## Discussion

A core result of all studies described in this chapter is that many negative associations with old employees are a result of correlations between old employees and other (frequently unobserved) characteristics that reduce performance. When these other characteristics are taken into account in addition to age, the relationship between age and performance is much more positive and the impression that age has a negative effect on establishment performance vanishes. These are some examples of mechanisms that negatively bias our perception of the performance of old employees:

- they are on average less educated,
- they belong to a cohort that was less productive already when their members were younger because they had to work with older vintages of technology,
- they are more likely to work in declining industries and establishments.

Moreover, one should keep in mind that age is also associated with characteristics that are positively correlated with performance. Prime examples are tenure and experience.

Besides taking into account individual and enterprise characteristics that are correlated both with the share of old employees and productivity or innovativeness, we have learnt another important lesson from this research. Establishments can influence their age structure, and the way they rejuvenate their workforce is

correlated with their productivity. Highly productive and innovative enterprises with a high wage level for example have access to the best job candidates even in periods when less dominant firms do not find enough suited young applicants to fill their vacancies. Therefore we have also to be aware of the so-called reversed causality when looking at the relationship between age structure and employer performance—many firms might change their age structure after they have been successful or made an important invention and not the other way around.

Another important choice variable for enterprises is the selective use of early retirement or dismissals of old employees whose labor productivity is too low for their wage. The share of employees who have been dismissed against their will instead of voluntarily resigning from the job increases with age, and therefore the relatively high productivity of old employees may be a consequence of selectivity.

Also personnel measures aimed specifically at old employees are profit maximizing choices of managers and not random events. This means that we should not generalize positive effects of certain personnel measures on employee tenure and performance of establishments that have not used them so far. Probably their effects are smaller or their costs are higher for this group of establishments. In addition, personnel measures aimed at old employees might be part of a bundle of measures or be applied more frequently in enterprises with a specific work climate. An example is an establishment with strong internal labor markets that reserve many vacancies for promotion tournaments of insiders. This enterprise needs long-term incentives in order to motivate and retain its best employees and especially those who could not be promoted in a tournament. A widely used and efficient personnel measure to reach both goals is seniority wages where young employees get earnings below and long tenured old employees get earnings above their productivity (Zwick 2012). Seniority wages are associated with a longer tenure for old employees but also with a higher qualification level of the workforce and they are found more frequently in certain sectors than in others. A separate look at specific measures for old employees without taking into account the age earnings profile and internal labor markets would lead to biased results.

## Outlook

So far, the potential selectivity of old employees especially beyond the age of 60 has not been taken into account in the literature. We know, however, that selectivity currently strongly increases after the age of 60 and we also find that only the more productive old employees stay. After the abolition of public subsidies for early retirement and since recently many establishments are keen on retaining their old employees in order to avoid skill gaps, we expect that the share of employees older than 60 years to increase dramatically during the next years. The change of selectivity might strongly affect the impact of old employees on productivity and innovation performance (and of course retention of old employees). When establishments are forced to keep low performing old employees, specific

personnel measures for old employees might gain importance for the competitiveness of enterprises. So far, mainly establishment characteristics and their personnel measures have been analyzed in order to explain which enterprise can retain old employees. In order to obtain a complete picture, also individual characteristics should be included and compared with the weight of enterprise characteristics. Finally, the research so far is concentrated on employees until the age of 65 or before retirement. Almost ten percent of those who have been officially retired still work, however. Also the share of the so-called ‘silver workers’ is likely to increase in the future because people over 65 get healthier and the level of old age pensions guaranteed by enterprises and the state is bound to decrease further. Therefore, also this group of employees should be included in future research.

Göbel and Zwick (2012a) and Frosch et al. (2011) show that practitioners and policy makers should be aware that, despite all the efforts made in recent research, our knowledge about the interplay between workforce age, personnel measures and innovative performance remains very limited, especially due to the methodological caveats most studies so far experience. In this context, research on workforce age and innovation is still severely hampered by the lack of comprehensive innovation and human resource management data. This calls for the creation of a longitudinal dataset that includes reliable innovation indicators, such as patenting activity, detailed R&D expenditure or other innovation and personnel management activities as well as information on workers, their qualifications and previous careers. Combining existing linked employer-employee datasets with official and reliable patenting statistics or more detailed questionnaires on personnel measures and their intensity would provide the opportunity to study the career courses of workers and innovation processes and the impact of age-differentiated personnel measures on productivity on a methodologically and conceptually sound basis. Also multi-level approaches where case study evidence is combined with representative survey data seems promising for this research field.

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