Karlsruher Institut für Technologie

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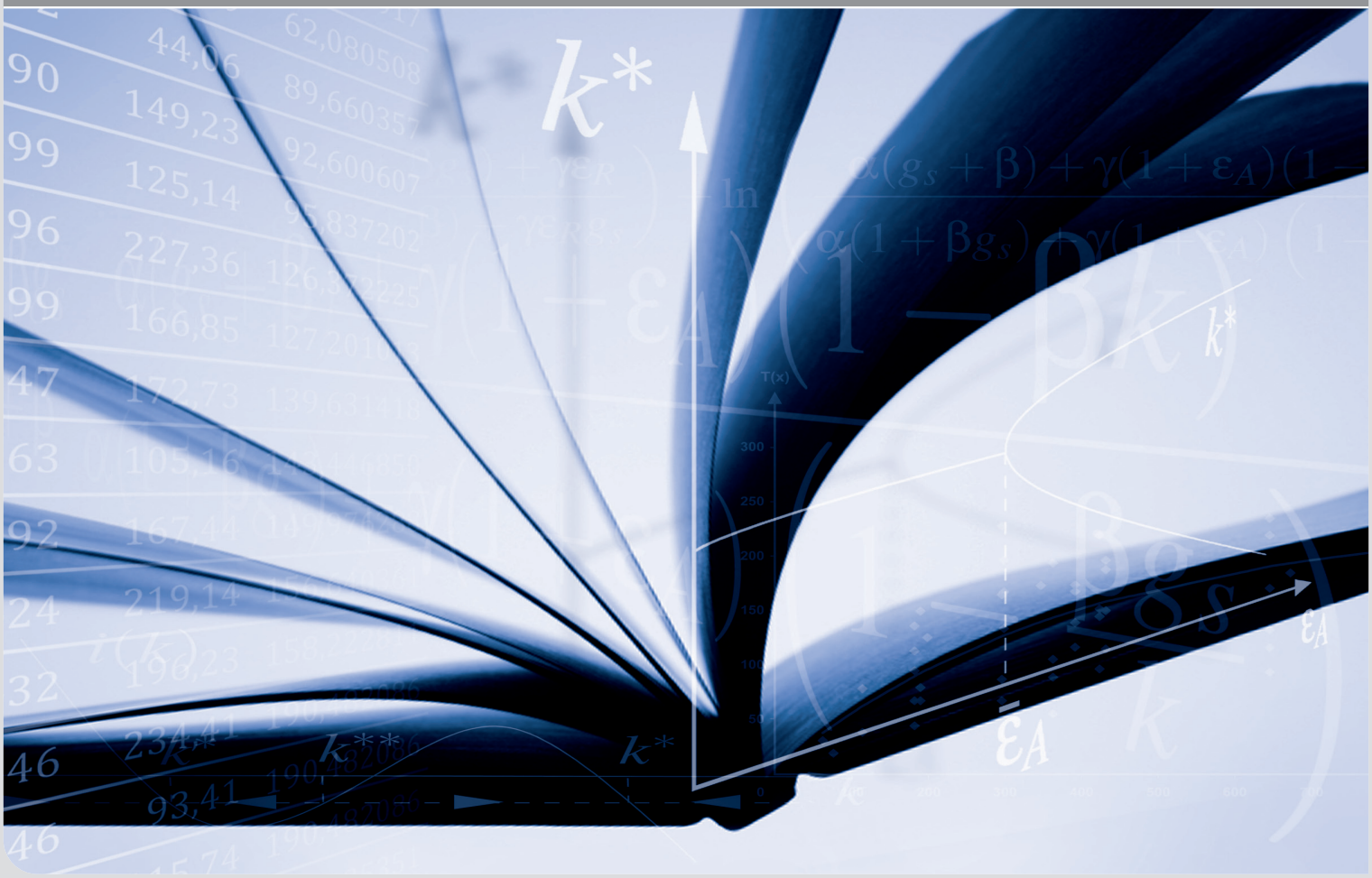
by Antje Schimke

No. 54 | JANUARY 2014

WORKING PAPER SERIES IN ECONOMICS



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Impressum

Karlsruher Institut für Technologie (KIT)
Fakultät für Wirtschaftswissenschaften
Institut für Volkswirtschaftslehre (ECON)

Schlossbezirk 12
76131 Karlsruhe

KIT – Universität des Landes Baden-Württemberg und
nationales Forschungszentrum in der Helmholtz-Gemeinschaft

Working Paper Series in Economics
No. 54, January 2014

ISSN 2190-9806

econpapers.wiwi.kit.edu

Aging workforce and firm growth in the context of "extreme" employment growth events

Dr. Antje Schimke[*$]

January, 2014

[$] *Research Planning, Fraunhofer-Gesellschaft (FhG), Munich, Germany*
** Institute of Economics (ECON), Karlsruhe Institute of Technology (KIT), Germany*

Abstract

In recent years demographic aging and its consequences have been recognized and discussed on macroeconomic levels, such as health care system, infrastructure, housing and labour market. However, the consequences are not only present on the macroeconomic level but also affect microeconomic issues such as a firm's growth and workforce. This exploratory study realises a microeconomic issue and investigates the linkage between aging workers and employment growth. More precisely, it aims to analyse the potential effect that age composition of a firm's workforce may have on a firm's employment growth. The study applies a linked employer-employee dataset of 2100 German firms, covering the time period from 2001 to 2006. We used quantile regression techniques to address the aging effect in the context of "extreme" employment growth events. The empirical investigation shows that, on average, employment growth slows down as the average age of the workforce increases.

Keywords Workers aging; workforce; "extreme" employment growth events; demographic trends; age management

JEL codes **J11, J21, L22, O40**

1 Introduction

The growth of firms has positive macro- and micro-economic effects. Therefore, firm growth (coupled with the related factors and its explanation) is a well-studied field of research in the economic literature (e.g. Metcalfe 1993, Hannan and Freeman 1977, Penrose 1959). A wide range of factors are found to affect firm growth, such as firm-internal and firm-external factors (e.g. Acar 1993). Usually, the impacts of firm characteristics on firm growth are studied without explicitly considering the socio-demographic characteristics of the workforce, entrepreneurs and employees. Put differently, our study focuses on the influence of workers aging on employment growth. In general, the implications of demographic aging on economic growth (Börsch-Supan et al. 2007) and regional disparities are repeatedly studied (e.g. Ludwig 2005). The age distribution of the workforce (i.e. aging of the employees and workers) can be expected to have an important influence on firms' activities (e.g. Lévesque and Minniti 2005). However, too much emphasis has been put on the macro-economic effects of demographic aging (e.g. Gonzalez-Eiras and Niepelt 2012) by neglecting the micro-economic effects, such as the effect on firm growth. Our study deals with an important and under-researched issue. In recent years, researchers and policy makers have paid increasing attention to aging because of its impact on several developed countries, where average age is increasing, and many developing countries, where the average age is declining. Both situations have huge effects on the economy and also on microeconomic effects (e.g. workers' issues) which so far, have been almost entirely ignored. In a nutshell, demographic aging and its consequences have for the most part been recognized and discussed on macroeconomic levels such as health care system, infrastructure, housing and labour market. However, the consequences are increasingly present on the microeconomic level such as a firm's growth and workforce rather workers' issues. Furthermore, workers' issues have other characteristics that make them a perfect factor for the study. Firstly, the activities, competencies and socio-demographic characteristics of workers can be assumed to influence firm growth in many different ways. It can be expected that younger and older workers and employees work differently and, as a consequence, engender different strategies and competencies in the way firms grow (e.g. Friedberg 2003). However, it is very difficult to disentangle the socio-demographic structure of the workforce and its impact on firm growth. Secondly, it can be expected that some firms do not show any impact of workers aging on firm growth, meaning that firms usually remain completely independent of the age structure of the workforce (e.g. small-sized firms). But studying these relationships within different firm size classes, we observe different relationships, implying that smaller and larger firms are affected by age (understood as a static measure) and aging (understood as a dynamic measure) in completely different ways. We therefore aim to obtain a clearer picture of the impact of workers aging on employment growth.

The purpose of this paper is to understand the potential effect that age composition of a firm's workforce might have on a firm's employment growth. In addition, we also examine the overall impact of the age structure, because it is impossible to explicitly study the workers' structure without knowing the latter. The overall impact of demographic aging on firm growth has been repeatedly studied in the literature (e.g. Ludwig 2005). However, the findings vary. We repeat this analysis in order to see which results from the literature are confirmed and in order to obtain a basis of comparison for the estimations. The analysis is divided into two major parts: firstly, we set up estimations, in which we analyse the impact of the average age structure (i.e. understood as a current firm characteristic) of the workforce on employment growth. Secondly, we study the impact of the average aging effect (understood as a direct temporal effect) on firm growth in terms of employment growth. The study explores the relationship between the age structure of the workforce and the growth in employment among

2100 German firms between 2001 and 2006. In other words, the study focuses on the cases of "extreme" employment growth events, that is, growth among the best performing (i.e. highly growing) firms and growth among the worst performing (i.e. highly shrinking) firms. The paper finds on average, that the relationship between age structure (average age of workforce) and the dynamics of firms is most appreciable when firms experience drastic changes in size. More specifically, a firm whose workforce is fairly young is more likely to grow more, the opposite holding for firms with an older workforce. The paper presents evidence by size (small, medium and large), sector (industry and services) and location (West and East) of the firms.

The structure of the paper is as follows. Section 2 derives the theoretical implications on the empirical evaluation of age and aging as well as their relevance for employment growth. The hypotheses are subsequently developed in the same section. Section 3 discusses the empirical variables, the regression approach as well as the data and data source we used. The findings are presented and discussed in Section 4. Section 5 presents the limitations of the study and section 6 concludes the paper.

2 Theoretical derivation and hypotheses

It can be suggested that firm growth and its explanations are an important and well-studied topic in existing economic and geographic literature. Yet firm growth is considered a heterogeneous process with high complexity, individual characteristics and various combinatorial and strategic issues (i.e. additive and multiplicative contributions). It can be regarded as idiosyncratic which also emphasises our motivation. Hence, there are a wide range of theories and empirical approaches that deal with firm growth and its growth-related factors (for an overview, see Coad 2009), and that address the topic from very different perspectives. Penrose's theory and the sociological concepts focus on the availability of resources and highlight them as a central source of firm growth (e.g. Penrose 1959, Metcalfe 1993, Hannan and Freeman 1977). Although the possibility of certain resources influencing growth has and is being discussed, the theory and empirical studies do not put much emphasis on the contribution from socio-demographic (i.e. age and aging) characteristics of the workforce which might affect firm growth. Thus, one important fact which the reader must certainly be aware of is the discussion around current social developments, such as demographic changes. For instance, the changing age distribution of the population and workforce may be an important influence on the rate of new firm formation, (e.g. Lévesque and Minniti 2005) or specifically firm growth which has not been studied so far. Because of the complexity in this domain, there is a need for additional research with regard to key dimensions, strategic issues and managerial practices. This paper tries to improve the understanding of current developments and generates an informational and explanatory value by updating existing knowledge in the areas of firm growth and an aging workforce. Previous empirical studies have often dealt with the impact of demographic change on a macro-level (e.g. Gonzalez-Eiras and Niepelt 2012, Weber 2010). There are several studies dealing with the overall importance of employment and the availability of qualified labour for innovation (e.g. Acs and Audretsch 1990, Pianta 2005, López-García and Puente 2009).

To the best of our knowledge, there is hardly any empirical literature analysing the impact of an aging workforce on employment growth. Therefore, our work specifically deals with the consequences of aging at a micro-level (i.e. firm level). A few studies have already dealt with the discussion on aging implications and firm performance (e.g. Ilmakunnas and Maliranta 2007). As such, Ashworth (2006) investigates workforces in the electric power industry (i.e. knowledge-intensive industry) and finds that aging of the workforce could cause short-term

and permanent loss of knowledge. Moreover, Meyer (2011) presents some empirical evidence on the relationship between the age structure of the workforce and the adoption of new improved technologies. She found that a homogeneous workforce in terms of age is positively related to the probability of technological adoption. There are several other studies dealing with individual characteristics (i.e. employment mobility) of older workers and their competencies and strategic skills (Malo and Munoz-Bullon 2003). The studies try to explain the productivity of firms using the characteristics (e.g. competencies and strategies) of the workforce (e.g. Ilmakunnas and Ilmakunnas 2001). Furthermore, some studies highlight the linkage between the age structure and technological innovativeness. Schneider (2008) discovers significant coefficients of the age structure of the workforce within technological innovativeness. In the same vein, Nishimura et al. (2004) pointed to the fact that a higher share of older workers decreases the rate of technological progress in firms. Rouvinen (2002) investigates the fact that an increasing average age of the workforce within a firm reduces the probability of process innovation. Therefore, the discussion already contains a strong focus on the relationship between workforce age and innovation activity (Frosch 2011). When dealing with the aging issue, our study also addresses the main works in management practices, to tackle the important issue of aging. Specifically, management literature suggests managerial practices that are effective for addressing the challenges identified. Those suggestions will be supported by evidence from the study described. Some very important studies discuss practical implications for the effective management of an increasingly age-diverse workforce. Thus, our study might provide practical value for managing the issue of workers' aging. As a consequence, it might deal with managerial practices that are effective for addressing the challenges identified. Some authors discuss management practices such as recruitment practices, training and flexible work options to tackle the consequences of an aging workforce (e.g. Žnidaršič and Dimovski 2009) or by developing an aging workforce management concept (Streb et al. 2009, Lazazzara and Bombelli 2011). Other studies address the human resources management challenges, by an aging public sector and discuss the need for strategic staff planning (e.g., McKinnon 2010, Größler and Zack 2010). With regard to the latter, some studies even discuss aging problems and their effect on public policy (e.g. Schmähl 2003). Additional studies focus on the question whether an aging workforce hampers the innovativeness of firms (e.g. Verworn and Hipp 2009). However, most of the empirical studies do not emphasise the linkage between aging and employment growth. This means that we are especially interested in the question whether a worker aging really does have an impact on firm growth in terms of employment growth. We therefore tackle the question, whether the age distribution of a firm's workforce matters for employment growth decisions. Therefore, it might be possible for firms to acquire new (younger) workers to compensate for the negative aging effects. Therefore, we hypothesise:

H1: The average age of the workforce affects employment growth. This is generally due to the fact that employment growth tends to increase more slowly as the workforce gets older. Firm-specific characteristics influence this process.

The empirical considerations with regard to the average age structure and employment growth lead to the discussion on the duration of employment. Generally speaking, Lazear (1998) already states that different properties and characteristics can be attributed to younger and older workers. For instance, younger workers are more comfortable with the use of technology (e.g. computer), while older employees have a better knowledge of the strategies and structures of a firm. One suggests that the average duration of employment also plays an important part. Therefore, workers are not reaching their peak efficiency before they have reached their threshold job tenure. Put differently, employees most presumably cannot reach their peak efficiency until they have worked in their positions for a minimum acclimatisation

period. With regard to the study by Malo and Munoz-Bullon (2003 p: 150), who suggested that "the mobility in employment status has increased along the twentieth century", one therefore formulates:

H2: Employment growth might be superior as the average duration of employment increases. Firm-specific characteristics influence this process.

Finally, we analyse the impact of aging on employment growth. Thus, we investigate whether the aging effect (i.e. age shift) might interfere with employment growth rates. It can therefore be suggested that an extremely rapid change of the age effect causes a corresponding shift in competencies (i.e. depending on whether the workers are younger or older), which might affect the firm's employment growth. A few studies analyse the linkages and interrelations between age heterogeneity and group performance (Pelled et al. 1999, Simons et al. 1999). We therefore more technically assume that:

H3: Employment growth tends to decline when the average aging effect of the workforce rapidly accelerates. Firm-specific characteristics influence this process.

Generally speaking, the previous literature points to the fact that extreme growth events are not just mere outliers, but a fundamental phenomenon of firm growth (e.g. Bottazzi et al. 2007). This holds especially true for employment growth - since employees are discrete in nature, they change in numbers rather abruptly and in a lumpy fashion (Bottazzi et al. 2007). With respect to this issue, the discussion on extreme growth events comes into focus - most firms do not grow (or only slightly), whilst a small, but non-negligible part of firms, experiences very rapid growth or decline. It might be that the firms with extreme growth rates (highly shrinking and highly growing) exhibit significantly different growth behaviour. This theoretical consideration on the emergence of extreme growth events motivates to estimate the contribution of socio-demographic characteristics on the growth of firms, identifying differences in their employment growth activities. As there are very few studies on the role of the age of a workforce on firms' growth, we position the study as an exploratory one, without claiming to identify the underlying mechanisms which drive the results.

3 Variables, regression approach and data source

3.1 Variables

With regard to the data availability from the Federal Statistical Office and the Statistical Offices of the Länder, the study uses employment number as the dependent growth measure. The growth rates (*EMP*) are calculated by taking the differences of the natural logarithms of the size of firm *i* between the first year size and the last-year size *t*:

$$EMP_{i,t} = \ln(size_{i,t+1}) - \ln(size_{i,t})$$

Regarding the hypotheses, we use several independent variables. These variables represent (1) socio-demographic characteristics of the employees and (2) firm-specific characteristics. The socio-demographic variables, for instance, will reflect the individual employee/worker characteristics that are specific to the overall workforce within the firm. The firm-specific variables indicate rather common factors found to influence employment growth, such as firm size, industry affiliation and location. An overview of the description of explanatory variables

is given in Table 2 and the descriptive statistics of all variables are shown in Table A1.1 (in the appendix).

(1) Socio-demographic characteristics

The socio-demographic variables refer to the individual role of the workforce, particularly to possible competencies and strategies of the employees and workers. With *AGE*, we introduce an *AGE* variable showing whether a firm has a certain share of older employees, measured by the average age structure of the employees. It is suggested that the average age structure is not independent of the different subgroups. Some results can be seen, for instance, as standard results (so-called 'stylized facts') and we therefore assume that the average age of the workforce decreases as the firms become smaller. Table 1 shows the average age structure of the workforce within the different subgroups. Contrary to expectations, the average age of the small-sized firms is slightly higher than the mean value for firms with more than 50 employees. This finding might have been influenced by the small number of observations for the subgroup, due to the selection bias of the sample.

Table 1: Average age structure of the workforce within subgroups (rounded off values)

Subgroups	Obs.	Mean	Std. Dev.	Min	Max
All firms	2098	40.52	4.798292	19	60
Small-sized firms	112	41.28	6.813379	27	60
Medium-sized firms	673	40.24	5.437826	19	59
Large-sized firms	1313	40.56	4.199341	25	56
Industry sector	1236	41.09	4.550781	23	60
Service sector	762	39.41	4.914714	19	56
East Germany	612	41.16	5.289078	23	60
West Germany	1486	40.22	4.554269	19	59

Furthermore, Table 1 clearly shows that the lowest average age belongs to the employees/workers in the service sector. The *AGING* variable, by contrast, displays the age shift (i.e. *AGING* dynamic effect) of employees in the firms. The variable is calculated by taking the difference between the average age of the employees in the first year of observation and the average age of the employees in the last year of observation. The dynamic *AGING* variable is calculated as:

$$AGING = \frac{1}{N_{2001}} \cdot \frac{N_{2001}}{Zi=1} \cdot AGE_{2001i} - \frac{1}{N_{2006}} \cdot \frac{N_{2006}}{Zi=1} \cdot AGE_{2006i}$$

(Denoting: N= Number of employees/workers; *AGE*= Average age structure of the employees)

In both the *AGE* and *AGING* variables we therefore implicitly assume that the socio-demographic characteristics of the workforce display firm-internal knowledge resources, which is commonly the case, as knowledge can be considered to be incorporated in individuals who are able to process it (e.g. Grund and Westergard 2008). The distinction between these two variables is very useful, as *AGE* is the average measurement of the age structure in the firm, whereas *AGING* is more dynamic, pointing to the actual strength of the firm's aging. We expect both to have a direct impact on firm growth in terms of employment growth. *TENURE* represents a strategic component of the firm and is understood as a dynamic measure. *TENURE* is measured by the average duration of employment (i.e. *TENURE* dynamic effect). It is constructed to highlight the discussion on the impact of the duration of employment on firm growth. One suggests that the average duration of employment (*TENURE*) also has an influence, indicating that employees and workers most presumably

cannot reach their peak efficiency until they have worked in their positions for a minimum acclimatisation period. The dynamic *TENURE* variable is calculated as:

$$TENURE = \frac{1}{N_{2001}} \cdot \frac{N_{2001}}{Zi=1} \cdot TENURE_{2001i} - \frac{1}{N_{2006}} \cdot \frac{N_{2006}}{Zi=1} \cdot TENURE_{2006i}$$

(Denoting: N= Number of employees/workers; *TENURE*= Average duration of employment)

(2) Firm-specific characteristics

The *SIZE* variable controls the size of the firm, as smaller firms (*SIZE=1*) rely more intensively and more frequently on creative knowledge spilling over in order to generate new knowledge and innovative activity (especially in the start-up phase) than larger firms (Audretsch 1998). Hence, it is assumed that small-sized firms benefit differently from socio-demographic characteristics than medium-sized and larger ones. The *SIZE* variable is defined by European Commission (2003) (see Table 2). The *INDUSTRY*-dummy is constructed by the simple NACE-2-digit classification. It indicates whether a firm belongs to a particular manufacturing sector (*INDUSTRY*=1) within the sample (NACE industry classification=15-36) or to the service sector (*INDUSTRY=0*) understood as NACE service classification=40-93. We use this dummy in order to distinguish between firms that are operating in the manufacturing sector and in the service sector. It is also investigated whether firm location (*EAST*) is an initial trigger for employment growth in firms. This variable might be able to reflect the structural differences between East (*EAST=1*) and West (*EAST=0*) Germany. It is hence assumed that firms located in East Germany are more likely to be affected by socio-demographic characteristics than firms located in West Germany. Then we also controlled the institutions. Hence, the aging phenomena might significantly depend on the institutional settings of the firms. The variable *CONTRACT* embraces the fact that firms promote more *(CONTRACT=1)* or less *(CONTRACT=0)* employment contracts of indefinite duration as a usual form of employment. It analyses whether the issue of aging might be explained by having an unstable job. It might be explained that a high number of contracts with indefinite duration may cause growth arrest. The *PART*-variable indicates whether a firm is influenced by the participation of public authorities in the capital of the firms *(PART=1)* or not *(PART=0)*. It discusses the cases where public officials directly or indirectly own majority of the capital stock in the firm, owns majority of shares with voting rights, or pay at least more than half the staff under government, management and supervisory body departments.

Table 2: Description of explanatory variables

Category	Variable	Description
Socio-demographic characteristics	AGE	measured by the average age of the employees
	AGING	calculated by taking the differences of the average age of employees in the first year and in the last year of observation
	TENURE	measured by the average duration of the employment
Firm-specific characteristics	SIZE	small enterprises, defined as those with less than 11 employees (SME=1); medium-sized: 50-250 employees and large-sized: >250 employees
	INDUSTRY	industry classification: 15-36; service classification: 40–93
	EAST	structural differences between East and West Germany
	CONTRACT	number of employment contracts of indefinite duration
	PART	influence of participation of public authorities

3.2 Regression approach

It is assumed that high-growth firms (and shrinking firms), a dominant feature of firm growth, rely differently on socio-demographic (*AGE* and *AGING*) properties than on other factors. Looking at the average employment growth, firms may obscure these relationships (Coad and Rao 2008). A special focus is dedicated to different growth levels. We therefore distinguish between different employment growth events, so-called "extreme" employment growth events, such as high-growth, (medium growth) and extreme shrinking growth. We set up quantile regressions to analyse workforce characteristics that also come together with a firms' employment growth in cases of "extreme" employment growth events. Using quantile regression techniques, the specific conditional quantiles θ of extremely growing or shrinking firms can be highlighted explicitly (Chernozhukov 2005). Hence, the study identifies socio-demographic variables (*AGE*, *AGING*) that stimulate highly expanding ($\theta_{0.90}$) and highly shrinking firms ($\theta_{0.10}$). Furthermore, the results are compared with the median firm ($\theta_{0.50}$) to gain an estimation basis. Two further features make quantile regression techniques suitable for studying the growth dynamics of firms (Buchinsky 1998). Firstly, it is not sensitive to outliers of the dependent variable. This is especially relevant here, because the previous analysis of the stochastic properties (i.e. growth rates distribution) highlights the high frequency of "extreme" employment growth events, which would strongly influence OLS estimates. Therefore, we analyse the stochastic properties of the firms' growth rates, because it yields substantial information about the growth process. To deal with that issue, the distributional model (introduced by Bottazzi et al. 2002) is used, which describes the observed stochastic properties of the employment growth rates (i.e. Subbotin family of distributions). By the way, values of *b* smaller than one indicate super-Laplace tails and values of *b* larger than 1 show a Gaussian distribution (for an overview, see Fagiolo et al. 2006). The shape parameter *b* is the crucial one for our analyses, because it gives information about the fatness of the tails. This means, once again, that the larger *b* is, the thinner the tails will be (i.e. if *b* decreases, the tails of the density become fatter). Small values of *b* indicate that "extreme" employment growth events are not just mere outliers. This holds especially for employment growth - the shape parameter *b= 0.5887 (Std.err= .0392)*. Secondly, no distributional assumption is made on the error term. Thus, quantile regression techniques are more appropriate to study heavy-tailed phenomena (extreme growth and extreme decline) than regression techniques, which assume normally distributed errors (Coad and Hölzl 2009). We already know from the literature that growth-related variables might impact the different firm samples differently. Therefore, we set up different estimations (see equation 1) for different firm size classes, different sectors (i.e. industry and service) as well as for the location dummy (i.e. east and west). The analysis only focuses on the coefficient estimates that can be interpreted in the same way as OLS regression coefficients, through a partial derivative of the conditional quantile of the dependent variable $EMP_{i,t}$:

$$(1)\quad (\log(EMP_{2006}) - \log(EMP_{2001}))_j = a_o + a_1 AGE_j / a_1 AGING_j + a_2 TENURE_j + \sum_{k=3}^{5} a_k SIZE_{kj} + \sum_{k=4}^{7} a_k INDUSTRY_{kj} + \sum_{k=5}^{9} a_k EAST_{kj} + \sum_{k=6}^{11} a_k CONTRACT_{kj} + \sum_{k=7}^{13} a_k PART_{kj} + \varepsilon$$

Finally, we test for multicollinearity (see appendix correlation matrix in Table A2) and endogeneity. Moreover, to avoid endogeneity problems, the value of the very first year (i.e. 2001) is used as an independent variable, for all variables. In this case, some of the explanatory variables are correlated, such as *TENURE* and *AGE* (r=0.5635***), but one therefore suspects multicollinearity is not a major problem here. Nevertheless, in the case of *AGE* and *AGING* we find that the variables are strongly correlated with r=-0.7095***. We

therefore set up different regression models for these explanatory variables (i.e. *AGE* and *AGING*).

3.3 Data and data source

The data used in our study originates from the Federal Statistical Office and the Statistical Offices of the Länder, the so-called "AFiD-Modul Gehalts- und Lohnstrukturerhebung im produzierenden Gewerbe und im Dienstleistungsbereich"[1]. The study is based on a sample of 2098 firms (manufacturing firms and service firms) operating in Germany in the period from 2001 to 2006. The collected micro-data, a linked employer-employee database, provides information on the individual employee (e.g. age, year of entry) as well as information on the individual firm (e.g. number of employees, industry affiliation, location). The earnings structure survey, is a linked employer-employee data set, this means data correlating to the workers are related to the attributes of the firms. The data set conveys valid information regarding gender related income inequality, and helps the investigation into the earning differences of firms that follow a pay scheme, and firms that allow payment negotiation. Since the data is taken from a random selection at a federal state level, no conclusive results for smaller, regional firms can be obtained. The salary and wages structure survey will be replaced by the earnings structure survey 2006, but even the earnings structure survey will be conducted every four years in firms residing in relevant industries and the service sector. The first surveys in 2006 were conducted in the economics sections M(Education and Learning), N(Health, Veterinary and Social welfare) and O(Other public and personal services). The data for section M was taken directly from employee statistics. During 2001 roughly 22.000 firms, containing 846.000 workers were surveyed, as a result the earnings structure survey 2006 encompasses information from 28.500 firms and about 3.2 Million workers. As opposed to the salary and wages structure survey, the earnings structure survey does not differentiate between workers and employees. Data from the survey contains information about the person (Gender, age, education), activity (Class of social security, job title, performance group, working hours, duration of contract) and their earnings (Gross, net, shift and night work bonuses, fringe benefits, wage tax, social costs and wage agreements). There is additional data at an operational level depending on whether public officials participate in the firm as well as on the number of employees broken down by gender.[2]

Several additional conditions are applied that should be taken into account. Firstly, we find that 61.9 percent of the firms are active in the manufacturing sector (NACE-2-digit classification: 15 - 36) and less than half of the sample (38.1 percent) are identified as service firms (NACE-2-digit classification: 40 – 93). Secondly, our sample covers different firm size classes ranging from small-sized to large-sized enterprises. Therefore, the sample is split in accordance with the European Commission (2003) into the three size bins small [10-50), medium [50-250) and large [250-1000), based on the average annual firm size. Thus, the distribution of firm size is presented as follows: (i) small-sized enterprises: 5.3 percent (ii) medium-sized enterprises: 32.1 percent and (iii) large-sized enterprises: 62.6 percent. Hence, most of the firms in our sample are considered as large-sized firms (more than 250 employees). Put differently, the small-sized firms (with less than 11 employees) are clearly underrepresented in our study. Thirdly, we have obtained information on where the firms are

[1] The research data centres are meant to enable the scientific community to use anonymised micro-data of official statistics. For that purpose, selected statistics are processed successively for use in the research data centres and documented by metadata. Thus, a data offer is prepared which is geared towards the requirements of the scientific community and can be used via different access channels.

[2] http://www.forschungsdatenzentrum.de/bestand/gls/index.asp (Stand: 31.07.2012)

located. This variable might be able to reflect the structural differences between East and West Germany. One therefore explores the fact that 70.7 percent of the sample firms are located in West Germany and 29.3 percent in East Germany.

4 Estimations, interpretation and discussion of possible mechanisms

In the following section, the main findings of the estimations and the interpretation will be discussed. The complete estimations are reported in Tables A3 – A20.

4.1 Average age structure (hypothesis 1)

Because we especially want to gain information on the socio-demographic characteristics of the workforce that might contribute to the employment growth of firms, we basically differentiates between the average age of the workforce and the aging (see hypothesis 3). Our hypothesis 1 states that '*The average age of the workforce affects employment growth. This is generally due to the fact that employment growth tends to increase more slowly as the workforce gets older.'* The results of the estimations are presented in Table A3. One finds significantly negative coefficients for the independent socio-demographic variable *AGE* for all firms in the different quantiles ($\theta_{0.10,}$ $\theta_{0.5}$ and $\theta_{0.90}$). The results indicate that employment growth tends to decline as the workforce gets older. This holds for the lower quantile of employment growth ($\theta_{0.10}$), for median growth ($\theta_{0.50}$) as well as for the higher quantile ($\theta_{0.90}$). This finding points to the fact that, irrespective of the growth event, a higher average age of the workforce is less likely to coincide with firm growth in terms of employment growth. Nevertheless, the reader can see in Table A3 that the coefficient for median growth ($\theta_{0.50}$) ceases to be economically relevant, reflecting the fact that the average age of the workforce is much more decisive for firms in the context of "extreme" employment growth events ($\theta_{0.10}$ and $\theta_{0.90}$). We can therefore partially confirm hypothesis 1. Indeed, it is found that the average age of the workforce has a strong impact on employment growth. However, the effect appears to be negatively correlated with growth. Hence, an alternative hypothesis can be formulated stating that '*employment growth seems to decline as the workforce gets older'*. Furthermore, Tables A4 – A11 clearly show that the findings differ across firm size classes (*SIZE*), industry affiliation (*INDUSTRY*) and location (*EAST*). Let us start with the results for different firm size classes (see Tables A5 - A7). For small-sized firms, we only find a slight negative effect for *AGE* in firms with medium growth ($\theta_{0.50}$). Interestingly, this also holds for medium-sized firms. Therefore, small firms as well as medium-sized firms seem less likely to experience strong (employment) growth as the workforce becomes older. This supports the above findings that especially small and medium-sized firms need a younger workforce to be able to strongly increase their employment growth (to be high-growing). In the case of large firms, we find strong statistically significant coefficients for high-growing ($\theta_{0.90}$) firms, implying that an older workforce (on average) makes firms more vulnerable towards experiencing "extreme" positive growth events. The dummy variable *CONTRACT* (see Tab A5) controls employment contracts of indefinite duration, and as a usual form of employment, shows a slight significant coefficient with a positive sign. It might indicate the fact that the issue of aging might be explained by having an unstable job especially in smaller firms. Furthermore, the results strongly vary between the two industry measures (*INDUSTRY*). In the context of firms in the industry sector (see Table A8), we do not find any significant relationship between average age and employment growth. We interpret this as statistical support for the assumption that the average age structure of a workforce in the industry sector plays a minor role in the context of employment growth. Nevertheless we find slight negative coefficients for the dummy variable *PART*, meaning that the participation of public authorities in the capital of the firms, makes firms less likely to experience high positive growth. Hence, growth

seems to decline as public authorities participate in the capital of the firms. We obtain completely different results for firms in the service sector (see Table A9). Here, statistically significant coefficients for medium-growing ($\theta_{0.50}$) and highly shrinking ($\theta_{0.10}$) firms are found. Although there is some indication that a higher average age makes firms in the service sector even more susceptible with respect to ("extreme") negative employment growth events. Finally, let us look at the results for the two different location variables (*EAST*). The analysis shows evidence that the average age structure negatively influences employment growth (i.e. medium-growing ($\theta_{0.50}$) when located in East Germany. We also find a slight positive coefficient for *CONTRACT* in medium-sized firms located in East Germany. An explanation for this issue might be that for employments in East Germany the contracts of indefinite duration play a major role. Furthermore, the negative *AGE* effect also holds for rapidly expanding firms ($\theta_{0.90}$) in West Germany.

With regard to the impact of the average age structure, the estimations present standard results. The statistically negative coefficient for *AGE* is consistent with the so-called 'stylized fact', indicating two general results: in the case of medium growth ($\theta_{0.50}$) and high growth ($\theta_{0.90}$), employment growth tends to decline as the workforce gets older. In the case of highly shrinking firms ($\theta_{0.10}$), the results point to the fact that an older workforce makes these firms more susceptible to "extreme" negative employment growth.

4.2 Duration of employment (hypothesis 2)

Remember that it is assumed that the average duration of employment (*TENURE*) represents a strategic component of the firm. It is therefore constructed to highlight the discussion on whether the duration of employment influences firm growth. It might be that the average duration of employment enables firms to perform better or not (in terms of employment growth). Hence, hypothesis 2 states that '*employment growth might be superior as the average duration of employment increases. Firm-specific characteristics influence this process'*. The results of the estimations are presented in Table A4 – A20. As we already know, the independent variables *AGE* and *AGING* are highly correlated with r=-0.7095***. Therefore, we set up different regression models. Let us start with the estimations for *AGE* and *TENURE* (see Tables A4 – A11). Most important in the context of multicollinearity is the correlation between *AGE* and *TENURE* (r=0.5636***). In this respect, the average age structure of the workforce does not *necessarily* result in an increase of the average duration of employment. Two further issues should be taken into account: firstly, this correlation is likely impacted by different firm-specific characteristics. Secondly, the effect of *TENURE* might be captured by the impact of *AGE* on employment growth. Actually, we find a statistically significant coefficient for *TENURE* across the different firm size classes. For small-sized firms, we do not find any significant relationship between growth and *TENURE*. If we focus our interest on medium-sized firms, we find slightly negative coefficients of *TENURE* for highly shrinking firms ($\theta_{0.10}$) highlighting a negative impact on growth as the duration of employment increases. This effect also holds for large firms with medium growth ($\theta_{0.50}$). It can therefore be concluded that there is evidence that shows that the average duration of employment influences employment growth rates within different firm size classes. While the negative and statistically significant coefficient of *TENURE* indicates that medium employment growth ($\theta_{0.50}$) and high growth ($\theta_{0.90}$) in the industry sector tends to decline with the duration of employment, the slightly positive coefficients of *TENURE* in the service sector suggest that firm growth in terms of high growth ($\theta_{0.90}$) seems to increase more slowly as the duration of employment increases. In the case of the differences in location (*EAST*), we do not find any statistically significant coefficient for different quantiles.

Furthermore, we set up regressions where *AGING* and *TENURE* are included in the model (see Table A12 – A20). The explanatory variables are weakly correlated with r=-0.3656***. Thus, a strong problem of multicollinearity does not appear; it is therefore not necessary to set up different regression models. For the different firm size samples one finds different results. In the case of larger firms in West Germany, the coefficients indicate that firm growth is negatively influenced as the average duration of employment increases, especially for medium growth ($\theta_{0.50}$) and high growth ($\theta_{0.90}$). For firms in the industry sector, we find statistically negative coefficients for all growth levels ($\theta_{0.10,}$ $\theta_{0.50,}$ $\theta_{0.90}$), indicating that firm growth seems to decrease as the duration of employment increases.

In summary, it can be stated that the average duration of employment does have a mostly negative impact on employment growth, even though not in the same way for all firms, but depending on their firm-specific characteristics. However, in case of highly growing firms at $\theta_{0.90}$ in the service sector, employment growth might be superior as the average duration of employment increases. Our hypothesis 2 can therefore be partially confirmed.

4.3 Average aging effect (hypothesis 3)

Furthermore, it is distinguished between two socio-demographic variables: *AGE* (as discussed above) and *AGING* as a more dynamic explanatory variable, indicating the actual strength of the firm's aging process. We expect *AGING* to have a direct impact on employment growth. It is therefore suggested in hypothesis 3 that '*employment growth tends to decline when the average aging (age shift) of the workforce quickly accelerates. Firm-specific characteristics influence this process.*' Let us first consider the results for all firms, irrespective of the firm-specific characteristics (see Tables A12 and A13). We again obtain statistically significant coefficients with a negative sign for *AGING*. As in the case of the *AGE* estimations, the findings reflect that the firm growth indeed declines when average aging of the workforce accelerates. This result especially holds for medium-sized firms and firms in the industry sector across the different growth levels (i.e. highly growing ($\theta_{0.90}$), medium-growing ($\theta_{0.50}$) and highly shrinking ($\theta_{0.10}$) firms). With regard to the small-sized firms, we find no evidence that the average aging of the workforce influences the employment growth rates. This result might be linked to a general characteristic of smaller firms to employ on average younger workers than their larger counterparts (Hölzl and Friesenbichler 2008). Furthermore, previous literature presents evidence that younger and smaller firms (such as start-ups) are more likely to hire younger employees. At the start-up stage, the firm faces such issues as the availability of seed capital and the process of incubation (e.g. Hölzl and Friesenbichler 2008). As a result, cost-reducing effects, even in the start-up stage, are of much higher importance than hiring cost-intensive and older workers rich in experience. Our results support the finding from the literature that especially medium-sized and larger firms are more affected by the shortage of skilled workers. Continuous growth requires adequate skills and explicit management (e.g. Hölzl and Friesenbichler 2008). The mixture between younger and older workers and talented entrepreneurs is highly important. For employees in smaller firms contracts of indefinite duration are much more important (*CONTRACT*) than having the status of being a high growing firm (see Tab A14). The regional variable (*EAST*), which represents structural differences between East and West Germany, is statistically significant. While we obtained negative statistical coefficients for medium growth ($\theta_{0.50}$) in East Germany, the negative coefficients for medium-growth ($\theta_{0.50}$) and "extreme" negative growth events ($\theta_{0.10}$) in West Germany strengthens our assumption. We can therefore confirm hypothesis 3 and conclude that growth events seem to be less likely when the average aging of the workforce rapidly accelerates. We again find support for the fact that contracts of indefinite duration (*CONTRACT*) are decisive for employees in East Germany (see Tab A19). Interestingly, for

high growing firms ($\theta_{0.90}$) in West Germany it is more or less the opposite of what we can observe in East Germany (see Tab A20). Here we find for *CONTRACT* a slight statistically negative coefficient indicating that a high number of contracts with indefinite duration may cause growth arrest.

Generally speaking, the analysis presents the impact of aging on employment growth in different subgroups. We find some important results that can be interpreted as stylized facts. For small-sized firms, there is no evidence that the *AGING* effect influences employment growth, while the *AGING* effect does appear as the firm evolves over its life cycle (e.g. Audretsch and Dohse 2007). More precisely, the negative effects of *AGING* are more pronounced for the median growing firms at $\theta_{0.50.}$ With regard to extremely high-growing firms at $\theta_{0.90}$, the strong negative linkage suggests that firm growth appears less likely when the average aging of the workforce rapidly accelerates.

5 Limitations

Firstly, the important issue of workers aging is significantly dependent on the institutional settings. We need to actually address this limitation because our study is limited to a German context. In the German labour market the institutional setting is of high importance. Therefore, it might significantly influence the individual performance of employees. More generally, institutional setting is highly important to consider when dealing within this context because it affects the structure of economic incentives in firms. To control this effect we propose to include some more proxies such as labour laws and costs or conditions for bonus or special payments (individual payments for significant improvements). Secondly, the analysis proposed in the paper has the limitation, one of reversed causality, in which economic performance leads to a change in the age structure of the workforce. And this problem is serious in the case of this article, because economic performance is measured as change in employment, whose age is supposed to be the driving force of change in the former. For this conjecture to be acceptable, age should be expected to be independent from change in employment: everybody, irrespective of their age, has the same likelihood of being hired or fired during economic cycles. We agree that this is not the case, as the cost of hiring and firing increases with the age of the employee: young workers are the first to be fired during downturns and the first to be hired during booms, whereas older employees have problems of employability once they lose their jobs. Hence, a younger workforce is likely to be the outcome of a positive change in employment, whereas the opposite holds for a negative change. The same rationale applies to the change in age structure (*AGING*), which is more likely to be the outcome of the changes in the composition of the workforce - change in the size of employment - rather than preceding it. When firms grow, new employees are brought in, which are likely to be younger and hence make the average age decrease. To solve this problem, we analyse the change in employment between 2001 and 2006 against the average age of the employment workforce in 2001. Thirdly, the study has a limitation in the operationalisation of growth. The way the measure is operationalised in the current version of the paper is very sensitive to the initial condition. Indeed, *EMP* can be rewritten as log(size(t+1)/size(t)). Now imagine two firms, A and B. Firm A moves from 1 employee to 5 employees. Firm B, instead, moves from 200 to 230 employees. Both firms grow, yet growth in firm A would be considered more extreme as the ratio of employment between the two years is 5 versus 1.15 for firm B (irrespective of the log transformation). Instead, one might agree that the growth in firm B is more relevant from an economic standpoint than the growth in A - 30 versus 5 employees. For the next analysis, we try to include different measures of employment growth to see whether the results still hold. Third, the problem of the study is

one of representativeness of the sample, where large firms are over-represented. This calls for slight caution in the interpretation of the results and their generalizability.

6 Conclusion and future work

The analysis complements existing literature on firm growth and the literature on the impact of workers aging. It therefore discusses the general implications of age and aging on firm growth. Most important in the context of our investigation is the impact of the variables representing socio-demographic characteristics. There are different prominent features to be highlighted. Firstly, the paper suggests that it is useful to bring socio-demographic characteristics and firm growth, in terms of "extreme" employment growth events, together. More specifically, employment growth does appear to be influenced by socio-demographic properties. In fact, the empirical investigation clearly shows that the average age structure does indeed have a strong effect on employment growth. In the case of medium growth ($\theta_{0.50}$) and high growth ($\theta_{0.90}$), employment growth tends to decline when the average age of the workforce increases. In the case of highly shrinking firms ($\theta_{0.90}$), the results point to the fact that an older workforce makes these firms more susceptible with respect to "extreme" negative employment growth. Secondly, one can state that the average duration of employment does have a mostly negative impact on employment growth, even though not in the same way for all firms, but depending on their firm-specific characteristics. Put differently, employees most presumably cannot reach their peak efficiency before they have worked in their positions for a minimum acclimatisation period. Thirdly, the aging effect of firms strongly depends on the firm-specific characteristics. For instance, while one finds strong negative linkages between employment growth and aging in firms with more than 50 employees, the aging effect entirely disappears in terms of smaller firms. For future work, the study can be easily transmitted and extended to firms that are not directly affected by aging, but by the aging of the region in which the firm is located.

We also want to mention that our study is limited to only some socio-demographic characteristics (i.e. *AGE*, *AGING* and *TENURE*) due to the availability of data. Therefore, some other features (embedded in datasets) of the socio-demographic consequences should be taken into account, such as information on labour turnover rate and contract periods. Basically, the study is limited to the overall impact of the average age structure on firm growth. Further studies should provide case analyses to capture the individual and idiosyncratic characteristics and activities of an aging workforce and firms. Considering the theoretical discussion on the knowledge complementarities between older and younger employees and workers, further studies should focus on the heterogeneity or even homogeneity of a workforce and their impact on firm growth. It can therefore be suggested that an extremely rapid change of the age effect might cause a corresponding shift in competencies (i.e. depending on whether the workers are younger or older), which may consequently affect the firms' employment growth. The current study is understood as an exploratory one, without claiming to identify the underlying mechanisms behind the issue of an aging workforce. In order to do that, more detailed information about the previous experience of the workforce is necessary. It is therefore valuable to investigate the possible mechanisms more deeply. As one of the next steps, we will link the employer-employee database to location-specific and region-specific characteristics, such as the share of employees in different age groups; share of first-year students and graduates; birth rates; and migration measures. To sum up, the study aims to gain a deeper insight into the consequences of demographic aging to identify predicted changes in firms' activities.

Acknowledgement

Special thanks go to the Institute of Economics (ECON) at the Karlsruhe Institute of Technology (KIT) for giving me the opportunity and financial support to conduct this research, the Federal Statistical Office and the Statistical Offices of the Länder for providing me with data, and the Fraunhofer-Gesellschaft (FhG) for its encouragement and its sustained interest in my work.

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Appendix

Table A1.1: Descriptive statistics (rounded values)

Variable	Obs.	Mean	Std. Dev.	Min	Max
EMP	2098	-0.0334432	0.7983919	-5	4
AGE	2098	40.50048	4.798292	19	60
AGING	2098	-2.824444	4.161982	24.30769	19.2939
TENURE	2098	10.89466	6.230577	0	36
SIZE	2098	909.3716	2397.819	3	51669
INDUSTRY	2098	39146.44	18472.66	10101	74848
EAST	2098	0.2882713	0.4530647	0	1
CONTRACT	2098	0.9980934	0.436331	0	1
PART	2098	0.0244936	0.1546123	0	1

Table A1.2: Linked-employer-employee database

Verdienststrukturerhebung (EVAS 62111)			
	Accessibility		
Year of survey	Public-Use-File	Scientific-Use-File	On-Site-Access
2010	-	Metadata available	Metadata available
2006	Campus-File available	Metadata available	Metadata available
Gehalts- und Lohnstrukturerhebung im Produzierenden Gewerbe und Dienstleistungsbereich (EVAS 62111)			
	Accessibility		
Year of survey	Public-Use-File	Scientific-Use-File	On-Site-Access
2001	Campus-File available	Metadata available	available
1995	-	-	available
1992	-	-	available*
1990	-	-	available*

* Data availability: not for all German federal states

Table A2: Correlation matrix

	EMP	AGE	AGING	TENURE	SIZE	INDUSTRY	EAST	CONTRACT	PART
EMP	1.0000								
AGE	-0.0678 (0.0019)	1.0000							
AGING	-0.0502 (0.0058)	-0.7095 (0.0000)	1.0000						
TENURE	-0.0644 (0.0032)	0.5635 (0.0000)	-0.3656(0.0000)	1.0000					
SIZE	-0.1045 (0.0000)	0.0229 (0.2942)	-0.0270 (0.2169)	-0.1062 (0.0000)	1.0000				
INDUSTRY	-0.0317 (0.1468)	-0.1837 (0.0000)	-0.1370(0.0000)	-0.1173 (0.0000)	-0.0096 (0.6609)	1.0000			
EAST	-0.0503 (0.0205)	0.0886 (0.0000)	-0.0627 (0.0041)	-0.0491 (0.0245)	-0.1307 (0.0000)	-0.0589 (0.0070)	1.0000		
CONTRACT	-0.0240 (0.2713)	0.1220 (0.0000)	-0.1000 (0.0000)	0.0693 (0.0015)	0.0141 (0.5175)	-0.0627 (0.0041)	0.0040 (0.8543)	1.0000	
PART	-0.0166 (0.4455)	0.0221 (0.3117)	0.0107 (0.6242)	0.0511 (0.0193)	0.0171 (0.4312)	0.1022 (0.0000)	0.0135 (0.5335)	0.0070 (0.7498)	1.0000

Table A3: Estimations for all firms (AGE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGE	-0.0164***	-0.00669***	-0.0143***
	(0.00626)	(0.00223)	(0.00459)
SIZE	-1.23e-05	-3.78e-06	-1.46e-05
	(3.38e-05)	(2.95e-06)	(9.24e-06)
INDUSTRY	-5.00e-06**	-4.66e-07	7.00e-06***
	(2.01e-06)	(4.25e-07)	(1.95e-06)
EAST	0.109	0.0705***	0.204***
	(0.0903)	(0.0183)	(0.0704)
CONTRACT	0.245	-0.0204	-1.378
	(0.406)	(1.178)	(0.997)
PART	-0.0595	-0.0539	-0.00241
	(0.347)	(0.0537)	(0.278)
Constant	-0.0923	0.251	2.129**
	(0.512)	(1.194)	(1.058)
R^2	0.01	0.01	0.03
Observation	2.098	2.098	2.098

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A4: Estimations for all firms (AGE/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGE	-0.0158	-0.00552***	-0.0167***
	(0.0123)	(0.00206)	(0.00521)
TENURE	-0.00503	-0.00149	0.00195
	(0.00791)	(0.00181)	(0.00599)
SIZE	-1.16e-05	-3.93e-06	-1.45e-05
	(6.33e-05)	(3.56e-06)	(1.01e-05)
INDUSTRY	-4.64e-06***	-5.94e-07	6.83e-06***
	(1.55e-06)	(5.53e-07)	(2.06e-06)
EAST	0.0937	0.0668***	0.209***
	(0.0832)	(0.0198)	(0.0446)
CONTRACT	0.293	-0.0287	-1.357
	(0.733)	(1.014)	(1.098)
PART	-0.106	-0.0743	-0.0214
	(0.355)	(0.0731)	(0.303)
Constant	-0.132	0.235	2.191**
	(0.878)	(1.022)	(1.072)
R^2	0.01	0.01	0.03
Observation	2.098	2.098	2.098

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A5: Estimations for small-sized firms (AGE/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGE	-0.00976	-0.0283*	-0.0418
	(0.0194)	(0.0157)	(0.0354)
TENURE	0.0145	0.0147	0.0176
	(0.0257)	(0.0276)	(0.0390)
INDUSTRY	2.88e-06	1.30e-05	2.32e-05*
	(7.12e-06)	(8.87e-06)	(1.33e-05)
EAST	-0.0530	0.0772	-0.914*
	(0.222)	(0.225)	(0.494)
CONTRACT	0.00638	0.987*	2.100
	(0.152)	(0.522)	(1.279)
PART	0.261	1.603	-0.334
	(1.297)	(1.210)	(1.153)
Constant	0.0381	0.162	1.155
	(0.713)	(0.907)	(2.731)
R^2	0.02	0.02	0.06
Observation	112	112	112

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A6: Estimations for medium-sized firms (AGE/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGE	-0.0395***	-0.0104***	0.00709
	(0.0110)	(0.00311)	(0.0129)
TENURE	0.0204*	0.00280	0.0144
	(0.0112)	(0.00334)	(0.00927)
INDUSTRY	-2.01e-06	1.12e-06**	1.35e-05***
	(3.04e-06)	(5.70e-07)	(5.07e-06)
EAST	-0.00230	0.107***	-0.0509
	(0.105)	(0.0259)	(0.149)
CONTRACT	0.747	0.0698	-1.258
	(1.160)	(1.414)	(1.056)
PART	-0.0890	0.0309	0.246
	(0.442)	(0.348)	(0.325)
Constant	0.120	0.240	1.156
	(1.152)	(1.399)	(1.174)
R^2	0.02	0.02	0.06
Observation	673	673	673

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A7: Estimations for large-sized firms (AGE/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGE	-0.00211	-0.000668	-0.0145***
	(0.0124)	(0.00249)	(0.00423)
TENURE	-0.0145	-0.00309*	-0.00257
	(0.0101)	(0.00187)	(0.00337)
INDUSTRY	-3.39e-06	-4.77e-07	4.17e-06***
	(2.08e-06)	(7.58e-07)	(1.54e-06)
EAST	0.197**	0.0166	0.138***
	(0.0943)	(0.0222)	(0.0404)
PART	-0.384	-0.124**	-0.157
	(0.371)	(0.0591)	(0.125)
Constant	-0.439	-0.00569	0.701***
	(0.475)	(0.131)	(0.186)
R^2	0.01	0.001	0.04
Observation	1.313	1.313	1.313

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A8: Estimations for firms in industry sector (AGE/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGE	-0.00811	-0.00314	-0.00856
	(0.0187)	(0.00246)	(0.00667)
TENURE	-0.00235	-0.00569***	-0.00994**
	(0.0121)	(0.00206)	(0.00500)
SIZE	-1.52e-05	-2.86e-06	-1.07e-05*
	(1.91e-05)	(1.75e-06)	(5.66e-06)
EAST	0.118	0.0590***	0.180*
	(0.0839)	(0.0216)	(0.0948)
PART	-0.930*	-0.331*	-0.375***
	(0.534)	(0.173)	(0.0621)
Constant	-0.286	0.152*	0.778***
	(0.726)	(0.0906)	(0.234)
R^2	0.004	0.02	0.04
Observation	1.236	1.236	1.236

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A9: Estimations for firms in service sector (AGE/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGE	-0.0315*	-0.0128**	-0.0149
	(0.0171)	(0.00563)	(0.0201)
TENURE	0.00116	0.00659	0.0375*
	(0.0154)	(0.00462)	(0.0196)
SIZE	-0.000263***	-8.73e-05*	-9.84e-05
	(9.81e-05)	(5.02e-05)	(7.97e-05)
EAST	0.135	0.0141	0.0410
	(0.161)	(0.0296)	(0.224)
CONTRACT	0.660	0.0638	-1.598
	(0.746)	(0.811)	(1.035)
PART	0.0559	0.0137	-0.245
	(0.452)	(0.0631)	(0.345)
Constant	-0.126	0.362	2.635*
	(0.877)	(0.773)	(1.473)
R^2	0.03	0.01	0.04
Observation	762	762	762

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A10: Estimations for firms in Eastern Germany (AGE/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGE	-0.0226	-0.00622***	-0.0107
	(0.0137)	(0.00217)	(0.0100)
TENURE	-0.00866	0.000885	0.0116
	(0.0150)	(0.00208)	(0.00773)
SIZE	-8.44e-05	-0.000123**	-0.000200**
	(0.000114)	(5.03e-05)	(9.83e-05)
INDUSTRY	-1.82e-06	-6.41e-07	5.24e-06
	(3.36e-06)	(6.17e-07)	(5.14e-06)
CONTRACT	-0.383	0.261*	0.952*
	(0.253)	(0.142)	(0.555)
PART	-1.061	-0.288*	0.0578
	(0.754)	(0.170)	(0.505)
Constant	0.923	0.0637	-0.107
	(0.568)	(0.183)	(0.823)
R^2	0.03	0.02	0.03
Observation	612	612	612

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A11: Estimations for firms in Western Germany (AGE/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGE	-0.0139	-0.00321	-0.0173**
	(0.0169)	(0.00386)	(0.00717)
TENURE	-0.00180	-0.00296	0.000927
	(0.0117)	(0.00246)	(0.00603)
SIZE	-1.27e-05	-3.03e-06***	-1.44e-05**
	(3.73e-05)	(1.17e-06)	(5.98e-06)
INDUSTRY	-5.55e-06*	-2.45e-07	6.76e-06***
	(2.99e-06)	(4.85e-07)	(1.62e-06)
CONTRACT	0.191	-0.0562	-1.343
	(0.386)	(0.947)	(1.180)
PART	0.0720	-0.0451	-0.0250
	(0.227)	(0.0623)	(0.806)
Constant	-0.0995	0.171	2.211*
	(0.561)	(0.997)	(1.180)
R^2	0.01	0.003	0.04
Observation	1.486	1.486	1.486

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A12: Estimations for all firms (AGING)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGING	-0.0222***	-0.00767***	-0.0111
	(0.00851)	(0.00202)	(0.00815)
SIZE	-2.01e-05	-4.00e-06	-1.63e-05
	(4.02e-05)	(3.90e-06)	(1.09e-05)
INDUSTRY	-3.11e-06	6.50e-07	8.58e-06***
	(2.34e-06)	(4.00e-07)	(2.04e-06)
EAST	0.0767	0.0641***	0.137***
	(0.0552)	(0.0170)	(0.0318)
CONTRACT	-0.399	-0.316	-1.494
	(0.630)	(0.668)	(1.225)
PART	-0.268	-0.0849	0.196
	(0.314)	(0.0652)	(0.291)
Constant	-0.228	0.204	1.629
	(0.645)	(0.664)	(1.227)
R^2	0.01	0.01	0.03
Observation	2,098	2,098	2,098

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A13: Estimations for all firms (AGING/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGING	-0.0280***	-0.0135***	-0.0118*
	(0.00922)	(0.00257)	(0.00703)
TENURE	-0.0126***	-0.00787***	-0.00619
	(0.00420)	(0.00156)	(0.00403)
SIZE	-2.07e-05	-4.40e-06	-1.60e-05
	(4.25e-05)	(3.88e-06)	(1.18e-05)
INDUSTRY	-3.90e-06*	-1.69e-09	8.16e-06***
	(2.22e-06)	(5.63e-07)	(2.23e-06)
EAST	0.0475	0.0497***	0.138*
	(0.1000)	(0.0167)	(0.0769)
CONTRACT	-0.329	-0.371	-1.469
	(0.729)	(0.822)	(1.022)
PART	-0.211	-0.0497	0.208
	(0.287)	(0.0660)	(0.313)
Constant	-0.144	0.358	1.662
	(0.754)	(0.823)	(1.048)
R^2	0.02	0.01	0.03
Observation	2,098	2,098	2,098

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A14: Estimations for small-sized firms (AGING/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGING	0.00121	0.00300	0.00545
	(0.0217)	(0.0168)	(0.0387)
TENURE	0.00877	0.00818	0.0108
	(0.0170)	(0.0227)	(0.0412)
INDUSTRY	2.91e-06	1.32e-05	2.76e-05***
	(6.98e-06)	(8.91e-06)	(9.92e-06)
EAST	-0.0344	-0.0146	-0.691
	(0.209)	(0.171)	(0.452)
CONTRACT	0.123	1.140*	2.671*
	(0.119)	(0.667)	(1.403)
PART	0.323	1.602	-0.406
	(1.332)	(1.239)	(0.899)
Constant	-0.426	-1.068	-1.268
	(0.599)	(0.802)	(1.527)
R^2	0.01	0.05	0.19
Observation	112	112	112

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A15: Estimations for medium-sized firms (AGING/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGING	-0.0288***	-0.0135***	-0.0430***
	(0.0107)	(0.00418)	(0.00989)
TENURE	-0.0137	-0.00621	0.0105
	(0.00862)	(0.00394)	(0.00772)
INDUSTRY	-1.25e-06	1.17e-06	1.57e-05***
	(2.16e-06)	(1.17e-06)	(4.91e-06)
EAST	-0.105	0.0995**	-0.0125
	(0.0667)	(0.0436)	(0.0752)
CONTRACT	-0.202	-0.359	-0.867
	(1.010)	(1.151)	(0.734)
PART	0.0109	0.130	0.186
	(0.180)	(0.234)	(0.449)
Constant	-0.201	0.294	0.889
	(1.043)	(1.150)	(0.756)
R^2	0.01	0.01	0.09
Observation	673	673	673

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A16: Estimations for large-sized firms (AGING/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGING	-0.0231	-0.0148***	-0.00472
	(0.0170)	(0.00226)	(0.00620)
TENURE	-0.0162*	-0.00710***	-0.00917**
	(0.00839)	(0.00176)	(0.00427)
INDUSTRY	-3.79e-06*	-3.87e-08	4.62e-06***
	(2.21e-06)	(6.30e-07)	(1.56e-06)
EAST	0.141*	0.00939	0.129***
	(0.0827)	(0.0211)	(0.0305)
PART	-0.445	-0.136**	-0.160
	(0.320)	(0.0581)	(0.164)
Constant	-0.540***	-0.0430	0.155**
	(0.141)	(0.0372)	(0.0788)
R^2	0.01	0.01	0.03
Observation	1.313	1.313	1.313

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A17: Estimations for firms in industry sector (AGING/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGING	-0.0422***	-0.0177***	-0.0262***
	(0.00909)	(0.00311)	(0.00823)
TENURE	-0.0161*	-0.0121***	-0.0234***
	(0.00959)	(0.00259)	(0.00551)
SIZE	-2.46e-05	-1.92e-06	-6.20e-06
	(1.91e-05)	(2.54e-06)	(5.24e-06)
EAST	0.0547	0.0505**	0.191***
	(0.0744)	(0.0210)	(0.0617)
PART	-0.861	-0.289	-0.379***
	(0.542)	(0.288)	(0.136)
Constant	-0.583***	0.0299	0.489***
	(0.122)	(0.0283)	(0.0505)
R^2	0.03	0.03	0.05
Observation	1.236	1.236	1.236

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A18: Estimations for firms in service sector (AGING/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGING	0.0164	-0.00437	-0.00388
	(0.0205)	(0.00536)	(0.0162)
TENURE	-0.00870	-0.000256	0.0264
	(0.0127)	(0.00376)	(0.0163)
SIZE	-0.000252**	-6.99e-05*	-9.18e-05
	(0.000105)	(3.78e-05)	(6.74e-05)
EAST	0.153	0.00326	-0.0328
	(0.120)	(0.0350)	(0.191)
CONTRACT	0.462	-0.218	-1.716*
	(0.484)	(0.908)	(0.974)
PART	-0.203	0.00969	-0.0954
	(0.529)	(0.0861)	(0.717)
Constant	-1.003*	0.188	2.294**
	(0.537)	(0.914)	(0.996)
R^2	0.02	0.01	0.03
Observation	762	762	762

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A19: Estimations for firms in Eastern Germany (AGING/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGING	-0.0169	-0.00844*	-0.0152
	(0.0143)	(0.00512)	(0.0114)
TENURE	-0.0243***	-0.00398	0.00524
	(0.00693)	(0.00333)	(0.00648)
SIZE	-7.34e-05	-0.000110*	-0.000175*
	(0.000127)	(5.81e-05)	(9.28e-05)
INDUSTRY	-1.66e-06	-4.60e-07	8.57e-06*
	(3.38e-06)	(9.68e-07)	(4.93e-06)
CONTRACT	-0.0806	0.337**	1.107*
	(0.127)	(0.168)	(0.595)
PART	-0.943	-0.282	0.141
	(0.830)	(0.222)	(0.466)
Constant	-0.173	-0.258	-0.851
	(0.229)	(0.188)	(0.633)
R^2	0.02	0.02	0.03
Observation	612	612	612

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A20: Estimations for firms in Western Germany (AGING/TENURE)

VARIABLES	(EMP) q10	(EMP) q50	(EMP) q90
AGING	-0.0296**	-0.0162***	-0.00961
	(0.0148)	(0.00254)	(0.0114)
TENURE	-0.0128	-0.00923***	-0.0124**
	(0.00828)	(0.00158)	(0.00579)
SIZE	-1.98e-05	-4.52e-06	-1.54e-05*
	(6.20e-05)	(3.79e-06)	(8.11e-06)
INDUSTRY	-3.94e-06	2.21e-07	8.42e-06***
	(2.98e-06)	(4.14e-07)	(2.33e-06)
CONTRACT	-0.518	-0.413	-1.438*
	(0.726)	(0.950)	(0.824)
PART	0.154	-0.0307	0.195
	(0.208)	(0.0512)	(0.549)
Constant	0.0163	0.400	1.662**
	(0.757)	(0.951)	(0.836)
R^2	0.02	0.02	0.03
Observation	1.486	1.486	1.486

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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