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Ageing, productivity and wages in Austria ☆

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HIGHLIGHTS

► We study the relation between the age of employees and productivity as well as wages.
► Firm productivity is not negatively related to the share of older employees.
► We find a negative relationship between the young employees and labour productivity.
► We cannot find any hints for an overpayment of older employees.

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ABSTRACT

Current demographic developments in industrialized countries and their consequences for workforce ageing challenge the sustainability of intergenerational transfers and economic growth. A shrinking share of the young workforce will have to support a growing share of elderly, non-working people. Therefore, the productivity of the workforce is central to a sustainable economic future. Using a new matched employer–employee panel dataset for Austrian firms for the period 2002–2005, we study the relationship between the age structure of employees, labour productivity and wages. These data allow us to account, simultaneously, for both socio-demographic characteristics of employees and firm heterogeneity, in order to explain labour productivity and earnings. Our results indicate that firm productivity is not negatively related to the share of older employees it employs. We also find no evidence for overpayment of older employees. Our results do not show any association between wages and the share of older employees. Furthermore, we find a negative relationship between the share of young employees and labour productivity as well as wages, which is more prevalent in the industry and construction sector.

1. Introduction

Demographic change in industrialised countries will have profound consequences for economic sustainability in the years to come. Low levels of fertility, increasing survival at old age, accompanied by moderate levels of migration imply a pronounced ageing of the population. While individual ageing is argued to be a success story due to a rising number of years experienced in good health, population ageing is commonly associated with negative consequences for the financial sustainability of social security systems. This process of ageing becomes more apparent from a look at the population statistics for Austria in the year 2011, and their projection up to 2050 (VID, 2012). The median age of the population is expected to increase from 42.0 to 48.3 years, with the proportion of the population aged 65 and over rising from 17.6 to 30.2%. Thus, in less than 40 years from now, half of the Austrian population is projected to be older than 48.3 years and about one third will be

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at least 65 years old. Moreover, the old-age dependency ratio (defined as the population aged 65+ years divided by population aged 20–64 years) will rise from 28.5 to 58.1%. What are the consequences of ageing within the labour force itself, i.e. the economically supporting entity? Will an ageing workforce – in the light of shrinking size – be able to sustain economic well-being by increasing productivity?

Skirbekk (2008) finds that the development of cognitive abilities leads to a hump-shaped age–productivity profile at the individual level, whereby accumulated experience mitigates the decrease in the productivity potential at higher ages. Making use of cross-section data on Austrian firms in 2001, the findings in Prskawetz et al. (2007) and Mahlberg et al. (2009) confirm such a hump-shaped productivity profile over age. In contrast, however, recent panel data studies using firm-level data provide evidence against this age–productivity pattern. Aubert and Crépon (2006) and Göbel and Zwick (2009) show that the age–productivity relation is quite sensitive to the estimation method and indicate that controlling for unobserved time-invariant firm heterogeneity and endogeneity leads to a flattening of the age–productivity profile at higher ages.

Based on a yearly balanced panel dataset for Austrian firms ranging from 2002 to 2005, we analyse whether the age distribution of employees is systematically related to labour productivity. Our dataset is obtained by matching firm-level data from the structural business survey of Statistics Austria with data from the *Main Association of Austrian Social Security Institutions* (Hauptverband der Sozialversicherungsträger) of Austria. Our dataset allows us to account simultaneously for employee and firm characteristics. In addition, we analyse the relationship between the age structure of employees and average wages paid in the firm. Since seniority wage schemes are prevalent in certain sectors of the Austrian economy, one may expect that wages might not be an appropriate measure of labour productivity, since some (age) groups of employees may be under- or overpaid. However, the existing evidence in the literature concerning such a relationship is somewhat ambiguous (see e.g. Hellerstein et al., 1999; Crépon et al., 2002; Dostie, 2011).

Our results give some evidence concerning the fact that labour productivity is negatively related to the share of young workers (≤29 years) for firms in the industry and construction sector. Independently of the specific sector affiliation, we cannot find any association between the share of older workers (50+ years) and productivity. After controlling for a large set of potential determinants of productivity and wages, we find robust evidence that firms with employees whose age distribution is concentrated on relatively young age groups tend to pay lower wages.

The paper is structured as follows. In Section 2 we review the recent literature on ageing, productivity and wages. The theoretical framework is introduced in Section 3. The dataset is presented in Section 4 and the empirical analysis is discussed in Section 5. Section 6 concludes.

2. Previous studies on age, wages and productivity

During recent years several studies have been conducted at various levels of aggregation (e.g. firm, plant) to estimate both age–productivity and age–wage profiles. This section provides a brief overview of selected studies and their results (see also Börsch-Supan et al., 2005; Gelderblom, 2006; Skirbekk, 2008).

A study of the relationship between age, productivity and wages requires data at the level of the firm rather than at the individual level, since labour productivity is shaped by the interaction of individual productivity, team work and firm environment. It has became common in the literature to make use of so-called matched employer–employee datasets for such a type of analysis. These datasets contain firm characteristics as well as attributes of employees working for the respective enterprises.

Several empirical studies based on cross-sectional data indicate that a larger share of old workers has a detrimental effect on firm productivity (e.g. Haltiwanger et al., 1999; Lallemand and Rycx, 2009; Mahlberg et al., 2009; Prskawetz et al., 2007). Recent studies (e.g. Malmberg et al., 2008; Göbel and Zwick, 2009) are often based on longitudinal matched employer–employee datasets and tend to find that a larger share of older workers does not necessarily affect firm productivity.

The studies referred to so far concentrated exclusively on the link between age structure and firm-level productivity, without assessing its relation to the wage profile. An early study on this issue is the work of Medoff and Abraham (1980), who document a positive association between pay and experience which is independent of the individual performance on the job (as rated by the supervisors). These results are consistent with Lazear (1979)'s theory of deferred compensation, which assumes that workers and firms want to be engaged in long-term relationships and concludes that rising earnings do not necessarily fully reflect increased productivity.

The first study focusing on comparing age–productivity and age–wage profiles is Hellerstein and Neumark (1995). Relying on matched employer–employee data from Israel, they build up two structural equations to estimate the relationship between age and productivity, as well as the link between age and wages. Their findings indicate that the upward sloping age–wage profile mirrors the upward sloping age–productivity profile. Similar results were obtained by Hellerstein et al. (1999), while Hægeland and Klette (1999) find that the wage premium for workers with higher experience (more than 15 years) exceeds their relative productivity, whereas the opposite is true for workers with 8–15 years of experience.

The need to base the empirical work on longitudinal data, so as to control more effectively for relevant firm characteristics (including unobserved time-invariant characteristics), is now widely agreed upon (Hellerstein et al., 1999). Productivity shocks at the firm level (which are by definition time-varying and therefore not captured by firm fixed-effects) might influence the results if inference is based on cross-sectional datasets. Some firms may have more difficulties in adjusting some types of labour than others due, for example, to employer/works council agreements. In such cases, the bias in the estimation of the productivity older workers would be caused by the fact that changes in input shares are endogenously determined by firm performance. Attempts to overcome of this problem include the use of dynamic panel data methods such as those proposed by Arellano and Bond (1991) (see also Aubert and Crépon, 2006; Cardoso et al., 2011; van Ours and Stoeldraijer, 2011) and two-stage regression methods (Dostie, 2011).

Recent studies report different outcomes with respect to the age–productivity and age–wage relationship. Aubert and Crépon (2006) find that the average contribution of particular age groups to the productivity of firms increases with age until age 40–45, and remains constant. They show that the age–productivity profile is similar to the age-labour cost profile, which does not support the idea of overpayment of older workers, although the evidence with regard to ages above 55 is inconclusive. Ilmakunnas and Maliranta (2007) examine the connection of an ageing workforce and firm performance using information on hiring and separation of employees. Their evidence shows that separations from older workers are profitable to firms, especially in the manufacturing ICT-industries.

Dostie (2011) uses Canadian matched employer–employee data at the workplace level to estimate production functions which explicitly take into account the age composition of the workforce. Using similar methods as Hellerstein et al. (1999) and Aubert and Crépon (2006) but controlling for individual and firm unobserved heterogeneity, as well as for unobserved time-varying productivity shocks, Dostie (2011) finds that both wage and productivity profiles are concave, but productivity is diminishing faster than wages for workers aged 55 and over. Van Ours and Stoeldraijer (2011) perform their analysis using a matched employer–employee dataset from Dutch manufacturing covering the period 2000–2005. Their findings are closely related to Aubert and Crépon (2006) and Dostie (2011).

They find a flat age–productivity profile at higher ages and no evidence of a wage–productivity gap.[1]

Using a longitudinal matched employer–employee dataset covering the entire workforce in manufacturing and the private service sector in Portugal over a 22-year period, Cardoso et al. (2011) find that productivity increases until the age range of 50–54, whereas wages peak around the age 40–44. At younger ages, wages increase in line with productivity gains but, as prime-age approaches, wage increases lag behind productivity gains. As a result, the average contribution of older workers to firm-level productivity may even exceed their contribution to the wage bill.

3. The theoretical framework

We assume that production in a given firm can be represented by a Cobb–Douglas production function with technology, capital and differentiated labour as factors of production. Capital (K_i) and total labour input (L_i^*) of firm i are combined with technology level A to produce output Y_i[2]:

$$Y_i = AK_i^{\alpha} L_i^{*\beta} \tag{1}$$

Similar to Crépon et al. (2002), we decompose total labour input L_i^* of a firm into the weighted sum of various types, k, of employees (indexed by some individual characteristics), which are perfectly substitutable: $L_i^* = \sum_{k=0}^{m} \lambda_{ik} L_{ik}$[3] with λ_{ik} denoting the individual productivity parameters. Rearranging terms yields the following expression of total labour input in firm i:

$$L_i^* = \sum_{k=0}^{m} \lambda_{ik} L_{ik} = \lambda_{i0} L_{i0} + \sum_{k=1}^{m} \lambda_{ik} L_{ik} = \lambda_{i0} L_i \left(1 + \sum_{k=1}^{m} \left(\frac{\lambda_{ik}}{\lambda_{i0}} - 1\right) \frac{L_{ik}}{L_i}\right),$$

and thus,

$$\ln\left(L_i^*\right) = \ln(\lambda_{i0}) + \ln(L_i) + \ln\left(1 + \sum_{k=1}^{m} \gamma_{ik} \frac{L_{ik}}{L_i}\right) \tag{2}$$

where λ_{i0} denotes the productivity of the reference group of employees and $\gamma_{ik} = \frac{\lambda_{ik}}{\lambda_{i0}} - 1$ denotes the relative productivity difference between an employee of type k and the reference group. We assume the productivity differential to be constant across firms, i.e. $\gamma_{ik} \equiv \gamma_k$ and assume constant returns to scale, $\alpha + \beta = 1$. Taking logs of Eq. (1) and substituting L_i^* (Eq. (2)) into Eq. (1) yields:

$$\begin{aligned} \ln(Y_i) = {} & \alpha \ln(K_i) + (1-\alpha)\ln(\lambda_{i0}) + (1-\alpha)\ln(L_i) \\ & + (1-\alpha)\ln\left(1 + \sum_{k=1}^{m} \gamma_k \frac{L_{ik}}{L_i}\right) + \ln(A). \end{aligned} \tag{3}$$

Denoting $\ln(\lambda_{i0})$ as the constant term c, subtracting $\ln(L_i)$ from both sides and applying the approximation $\ln(1+x) \approx x$, which holds for $x \ll 1$, leads to the following equation of output per employee for each firm,

$$\ln\left(\frac{Y_i}{L_i}\right) = c + \alpha \ln\left(\frac{K_i}{L_i}\right) + (1-\alpha) \sum_{k=1}^{m} \gamma_k \frac{L_{ik}}{L_i} + \sum_{j=1}^{n} \delta_j X_{ij} + u_i \tag{4}$$

where u_i represents the firm-specific error term, assumed to contain both a firm-specific and a time-fixed effect. The error term also captures the part of technology A that cannot be directly explained with the help of further firm-specific explanatory variables X_j. Note that the estimated parameters corresponding to the age share in Eq. (4) are the product of the parameter (1 - α) with the relative productivity differentials γ_k.

The empirical analysis of the age–wage link at the firm level follows analogously to the estimation of the productivity equation above. Gross wages and salaries per employee W_i/L_i are modelled as a function of capital intensity K_i/L_i, the share of different types of labour L_{ik}/L_i and further explanatory variables X_j. Our empirical estimation will thus be based on the following specification

$$\ln\left(\frac{W_i}{L_i}\right) = c^W + \tilde{\alpha} \ln\left(\frac{K_i}{L_i}\right) + (1-\tilde{\alpha}) \sum_{k=1}^{m} \tilde{\gamma}_k \frac{L_{ik}}{L_i} + \sum_{j=1}^{n} \tilde{\delta}_j X_{ij} + u_i^W \tag{5}$$

For the corresponding empirical implementation we use a comparable set of explanatory variables in the production function specification for the wage equation. For the wage equation, lagged productivity is also used as part of the explanatory variables. In addition, we expand our set of explanatory variables in both specifications by including the lagged dependent variable, which accounts for persistence and convergence patterns in productivity and wages.

4. Data

4.1. Data sources

We make use of a recently generated employer–employee dataset for Austria for the time period 2002–2005. The dataset emerged from linking firm-level data from the *structural business survey* (Statistics Austria) with data from the *Main Association of Austrian Social Security Institutions* (Hauptverband der Sozialversicherungsträger).[4]

The structural business survey, as well as social security and wage tax data, contains a firm identifier that allows the linkage of these three datasets. As the assignment of self-employed persons to their firms is ambiguous, we exclude those persons.[5] Temporary agency workers (*Zeitarbeiter*) are assigned to temporary employment companies and not to the firms they actually work for. Neither are all persons with other 'atypical' employment relationships, such as those with service contracts (*Werkvertrag*) linked to their employer. Therefore they are not included in our dataset. The matched dataset contains data on 19,633 firms and approximately 1.9 million employees per year. It covers around 7% of the Austrian firm population in the investigated sectors, in terms of number of firms, which produce around 66% of value-added and employ around 56% of the active workforce. Our dataset constitutes a balanced panel[6] over the period 2002–2005.

Firm characteristics are taken from the structural business survey. This survey is conducted yearly and provides data concerning the structure (single-plant vs. multi-plant firm), sector affiliation, employment, investment activities and performance of enterprises at the national and regional level in a breakdown by economic branches in accordance

[1] For further empirical evidence based on Dutch data, see also van Ours (2009).

[2] For the sake of simplicity, we omit time subscripts in the rest of the section.

[3] Cobb–Douglas type aggregate of labour could also be used to abstain from the assumption of perfect substitutability as in Prskawetz and Fent (2007) and Prskawetz et al. (2008).

[4] In recent years similar datasets have been created for several countries. See Abowd and Kramarz (1999a) for a comprehensive review on the availability and analysis of such data, and Abowd and Kramarz (1999b) for the econometric analysis. Applications based on these datasets include studies on labour mobility, unemployment, wage compensation, productivity, etc. Another extensive review of potential applications is given in Hamermesh (2008).

[5] Thus, self-employed persons contribute to the production of value-added, which is our dependent variable, while they are not covered by the age share variables on the right hand-side of the regression equation. As long as self-employees in our sample are not decisively differently distributed across age groups from all other employees this should not affect our results.

[6] In the matching process firms (a) for which we did not find any employees in the workforce statistics, or (b) which could not be observed in each year, or (c) where the number of employees in the structural business statistics and in the workforce statistics differed too much, or (d) where distinctive reorganisation took place during the observation period are excluded.

with OeNACE.[7] Its scope covers the economic branches of the industry and construction sector (NACE-section C "Mining and quarrying", NACE-section D "Manufacturing", NACE-section E "Electricity, gas and water supply" and NACE-section F "Construction") and selected sections of the service sector (NACE-section G "Wholesale and retail trade; repair of motor vehicles and motorcycles, personal and household goods", NACE-section H "Hotels and restaurants", NACE-section I "Transport, storage and communication", NACE-section J "Financial intermediation" and NACE-section K "Real estate, renting and business services"). The sectors "Agriculture, hunting and forestry" and "Fishing" (NACE sections A and B) as well as "Education", "Health and social work", "Other community, social and personal service activities", "Activities of households" and "Extra-territorial organizations and bodies" (NACE sections L to Q) are not included in the survey. In particular, the following indicators are contained in the dataset: type of firm (single-plant vs. multi-plant), location of firm (municipality), industry/sector affiliation, value-added, number of workers, turnover, personal costs, intermediate inputs, investments, sum of wages, number of self-employed persons, white-collar workers, blue-collar workers, apprentices, home workers and part-time workers.

The year of a firm's foundation is taken from the enterprise register of Statistics Austria. Data on net fixed assets are taken from the national accounts dataset of Statistics Austria. These data are valued at replacement costs of 2005, and available only at the industry level. Therefore, we disaggregated those data to the firm-level before including them in our analysis. As in Harhoff (1998), for the first year (2002) net fixed assets of each firm was computed by dividing the aggregate industry capital stock among firms according to their share in total industry investment in order to obtain a starting value for the capital stock time series. For subsequent years, the usual perpetual inventory method[8] was used exploiting firm-specific investment data from the structural business survey and industry-specific depreciation rates from the national accounts.

Workforce characteristics are taken from the workforce statistics, which in turn emanate from social security and wage tax data. The social security data are collected by the Main Association of Austrian Social Security Institutions and provide information on date of birth, gender, assessment base for social security contributions (*Bemessungsgrundlage*) and remunerations[9] (*Sonderzahlungen*), location of residence, citizenship and job tenure (defined as the length of stay in a firm) of individuals employed in firms. In principle, social security data contain all employees (white-collar and blue-collar workers, home workers, apprentices, full-time and part-time workers) and most self-employed persons.[10] The Main Association of Austrian Social Security Institutions provides individual data of employees to Statistics Austria, which in turn is responsible for the final calculation of the workforce statistics.

One limitation of our dataset – similar to other studies (e.g. Aubert and Crépon, 2006; Ilmakunnas and Maliranta, 2007; Van Ours, 2009; Van Ours and Stoeldraijer, 2011) – is the missing information on the employees' education. Particularly against the background of population ageing, the changing human capital structure within successive workforce cohorts may have a decisive impact on a firm's value-added. More recent cohorts of young people entering the labour market are characterised by higher levels of education, which may be beneficial for labour productivity.

While the structural business survey is based on yearly averages (with regard to the number of employees), social security data covers every single employee who has ever been working. For our empirical analysis individual data for workers are also aggregated at the firm level. Except for the data on net fixed assets, which were already provided at the corresponding price level, we deflated all indicators measured in monetary terms to constant prices of 2005 by the harmonised consumer price index taken from Statistics Austria.

4.2. Descriptive statistics

We divide our sample into two subsamples: the industry and construction sector (NACE C to NACE F) versus the service sector (NACE G to NACE K).[11] The former subsample is identical to the secondary sector, whereas the latter one covers all market-oriented services and represents the core of the tertiary sector.

A summary of descriptive statistics (mean values and standard deviations for relevant variables) is presented in Table 1 below. As can be inferred from the relatively large values of the standard deviation, the discrepancy among firms is considerable for most of the examined characteristics, whereby the industry and construction sector is less heterogeneous than the service sector.[12]

Table 1 displays the descriptive statistics of our data. While the dependent variables value-added per employee (labour productivity) and gross wages and salaries per employee,[13] refer to the year 2005, the descriptive statistics for all other independent variables refer to 2002. On average, labour productivity (72 TEUR) is approximately two and a half times larger than gross wages (29 TEUR) in the sample of all firms. The spread between productivity and wages per employee is clearly more pronounced in the service sector than in the industry and construction sector. Value-added per employee in the industry and construction sector is around half of that in the service sector.

Notwithstanding the fact that firms are quite heterogeneous with respect to size and age throughout the sample, an average enterprise employs around 83 persons in the industry and construction sector, in comparison to 66 persons in the service sector. The average age of a firm is roughly 19 years throughout all samples. In terms of firm organisation (multi-plant vs. single-plant) the two subsamples are very similar. Slightly more than a quarter of the firms are structured as multi-plant enterprises in both sectors of the Austrian economy.

Capital intensity, measured by net fixed assets per employee, presents particularly large differences between sectors. Our data indicate that firms belonging to the service sector are characterised by a higher stock of net fixed assets per employee as compared to firms in the industry and construction sectors. However, this seems to be due mainly to the inclusion of certain capital intensive NACE divisions, like the real estate business, which both the housing stock and investments into buildings are attributed to.[14] Facilities are owned by firms belonging to this sector, which in turn provide services to firms of

[7] NACE (Nomenclature of economic activities) is a code that represents the classification of economic activities within the European Union. The OeNACE is the Austrian version of NACE, and therefore the Austrian Statistical Classification of Economic Activities. An additional hierarchical level – the national sub-divisions – was added in order to represent the Austrian economy in a more detailed and specific way. All other levels of OeNACE are identical with the corresponding levels of NACE. For details see European Commission (2002) and Statistics Austria (2003). For our analysis the OeNACE version from the year 2003 is relevant.

[8] For details on the computation procedure of net fixed capital see Schwarz (2002) and Statistics Austria (2009, p. 154). The perpetual inventory method (PIM) produces an estimate of the stock of fixed assets in existence and in the hands of producers by estimating how many of the fixed assets installed as a result of gross fixed capital formation undertaken in previous years have survived to the current period. For details see OECD (2001).

[9] Remunerations comprise among others vacation pay, Christmas pay, balance sheet pay, etc.

[10] In Austria all employees and most self-employed persons are obliged by law to register to Austrian Social Insurance independently of their salary.

[11] From our descriptive statistics and our regression analysis we excluded the temporary employment agencies (NACE division 745, "Labour recruitment and provision of personnel") since temporary workers are counted as employees of these firms and not of the firms where they are actually active. Including them may cause a small bias.

[12] Further details about the dataset and more descriptive statistics can be found in Freund et al. (2011).

[13] Labour productivity as well as wage per employee are computed taking the number of employees from Structural Business Statistics.

[14] The real estate business (NACE division 70) is part of "Real estate, renting and business services" (NACE-section K).

Table 1
Descriptive statistics.

Variable	All firms		Industry and construction		Service sector	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Employee characteristics						
Proportion of employees						
Aged under 30 (‘young’)	0.31	0.18	0.32	0.17	0.30	0.18
Aged 30–49 (‘prime-aged’)	0.54	0.15	0.52	0.14	0.55	0.16
Aged over 49 (‘old’)	0.15	0.12	0.16	0.10	0.15	0.13
Herfindahl index (of age concentration)	0.48	0.10	0.46	0.08	0.49	0.12
Proportion of employees						
Tenure ≤ ¼ year	0.12	0.12	0.10	0.09	0.13	0.13
¼ year > Tenure ≤ 1 year	0.23	0.18	0.23	0.19	0.22	0.17
1 year > Tenure ≤ 2 year	0.18	0.14	0.17	0.13	0.18	0.16
2 year > Tenure ≤ 5 year	0.24	0.16	0.24	0.14	0.23	0.17
5 year > Tenure ≤ 10 years	0.14	0.13	0.14	0.12	0.14	0.14
Tenure > 10 years	0.10	0.13	0.11	0.12	0.09	0.13
Proportion in occupation						
Self-employed	0.03	0.06	0.02	0.04	0.04	0.08
White-collar	0.45	0.33	0.26	0.18	0.58	0.34
Blue-collar (incl. home workers)	0.46	0.31	0.64	0.18	0.34	0.32
Apprenticeship	0.06	0.09	0.09	0.10	0.04	0.07
Proportion of						
Male employees	0.66	0.25	0.77	0.20	0.58	0.26
Female employees	0.34	0.25	0.23	0.20	0.42	0.26
Proportion of						
Part-time	0.13	0.17	0.09	0.11	0.16	0.19
Full-time	0.87	0.17	0.91	0.11	0.84	0.19
Firm characteristics						
Value-added per employee in 2005 (in TEUR)	71.66	459.97	50.20	41.60	87.08	601.44
Gross wages and salaries per employee in 2005 (in TEUR)	28.57	13.44	27.62	8.82	29.25	15.91
Value-added per employee (in TEUR)	73.73	723.44	50.55	40.07	90.38	947.31
Gross wages and salaries per employee (in TEUR)	28.25	13.18	26.79	8.66	29.29	15.56
Size of firm (in persons employed)	73.07	404.05	82.52	261.57	66.28	480.91
Age of firm (in years)	18.70	16.19	18.72	14.90	18.68	17.06
Multi-plant (0, 1)	0.29	–	0.27	–	0.30	–
Net fixed assets per employee (in TEUR)	534.86	10,177.04	101.62	363.07	828.84	13,328.51
Variable	Share		Share		Share	
Firm characteristics						
Sector affiliation						
NACE C (mining and quarrying)	0.00		0.01		–	
NACE D (manufacturing)	0.24		0.58		–	
NACE E (electricity, gas and water supply)	0.00		0.01		–	
NACE F (construction)	0.16		0.40		–	
NACE G (wholesale and retail trade, …)	0.30		–		0.52	
NACE H (hotels and restaurants)	0.07		–		0.12	
NACE I (transport, storage and communication)	0.08		–		0.14	
NACE J (financial intermediation)	0.01		–		0.02	
NACE K (real estate, renting and business activities)	0.12		–		0.20	
Region						
NUTS 11 (Burgenland)	0.03		0.03		0.02	
NUTS 12 (Lower Austria)	0.17		0.19		0.15	
NUTS 13 (Vienna)	0.21		0.12		0.27	
NUTS 21 (Carinthia)	0.06		0.06		0.05	
NUTS 22 (Styria)	0.12		0.15		0.11	
NUTS 31 (Upper Austria)	0.18		0.22		0.15	
NUTS 32 (Salzburg)	0.08		0.07		0.09	
NUTS 33 (Tyrol)	0.10		0.09		0.11	
NUTS 34 (Vorarlberg)	0.06		0.06		0.05	

Notes: All indictors are presented in values of 2002 unless otherwise specified.
NACE division 745 (“Labour recruitment and provision of personnel”) has been excluded.

other sectors. Based on leasing contracts or rental agreements the latter incorporate the respective buildings into their production process.[15]

Across industrial sectors considered in terms of NACE 1-digit categories, the largest group of firms in the complete sample, i.e. 30%, carries out its business in wholesale and retail trade (NACE G) followed by manufacturing (NACE D) with 24%, while a diminishing share of firms is affiliated to the mining and quarrying (NACE C) as well as electricity, gas and water supply (NACE E) sector and financial intermediation (NACE J). Thus, the majority of enterprises (60%) within our sample belong to the service sector (NACE G-K), in comparison to approximately 40% belonging to the industry and construction sector (NACE C-F) of the Austrian economy. Within our subsamples manufacturing (NACE D) and wholesale and retail trade (NACE G) capture the majority of firms respectively.

[15] Excluding firms belonging to real estate activities (NACE division 70) indeed reduces the mean productivity and capital intensity of service sector firms from 82.2 and respectively 842.9–78.6 and 305.7. The exclusion of firms from the financial intermediation sector (sector J) leads only to small changes.

Regarding the geographical distribution of all firms in the complete sample, we observe that roughly a fifth (21%) of all enterprises is located in Vienna, followed by Upper (18%) and Lower Austria (17%), while only 3% are located in Burgenland. In the industry and construction sector the firms tend to be clustered within Upper and Lower Austria, whereas the service sector is more concentrated in Vienna.

The most interesting employee characteristic for our purpose is age.[16] On average, in all three samples the majority of the employed population, i.e. more than half of the labour force, is in prime-age, while a bit less than one third is younger than 30 years and only 16% are older than 49 years reflecting Austria's comparably low retirement age (D'Addio et al., 2010; OECD, 2011). Our age-share variables are characterized by a high variation across firms and a low variation over time. The mean age concentration[17] across all firms is about 0.5 implying a quite diverse age structure of employees. The age distribution and age concentration variables show almost no systematic differences between the subsamples.

With the aim to disentangle tenure from pure age effects, which may be particularly important against the background of seniority wage schemes, we set up a continuous tenure variable. We define tenure as time spent working in the current firm (job experience[18]).[19] The variable is constructed making use of three variables in the data set: i) the length (in number of days) of employment during the current year, ii) the length of (the same) employment until the end of the previous year, and iii) the length of an earlier employment having ended before the current year (but after the beginning of 2002) and being upright until the current kind of employment relationship has started - within the same firm. Unfortunately the tenure variable is systematically left-censored before 2002, as we cannot track changes that have taken place before that date. In all three samples, the highest share of employees, around a quarter of a firm's labour force, can be found within the tenure intervals of between ¼ and 1 year, and also 2 to 5 years. Within-sector diversity is considerable as can be seen from the values of standard deviations, which are almost as high as the mean values.

The type of occupation in the complete sample is more or less shared between the white-collar and blue-collar working status. In the industry and construction sector two thirds of employees in an average firm are blue-collar workers, whereas in the service sector the majority are white-collar workers.

In the full sample, two thirds of the labour force consists of men. While an average firm in the industry and construction sector employs around three quarters of men, only 58% men can be found in a typical firm of the service sector. The high share of males in the former sector corresponds to the high share of blue-collar workers. On average, more part-time workers can be found in the service sector, which may be closely related to a higher share of female employees. All three characteristics are probably also an expression of the degree of physical work intensity in the specific sectors.

5. Regression analysis

In our empirical study we extend the work from Prskawetz et al. (2007) and Mahlberg et al. (2009), which was based on a pure cross-section of employer–employee data in 2001. In that setting we have found a hump-shaped age–productivity pattern, i.e. a negative association between labour productivity and the share of young aged as well as old aged employees as compared to prime-aged workers.

Besides a pure labour productivity analysis, we additionally aim at comparing age–productivity with age–wage profiles at the firm level in order to draw conclusions concerning their similarities and/or differences. We present the results for the complete sample and show the outcomes separately also for the industry and construction sector as well as the service sector.[20]

The time dimension of the data allows us to control for productivity convergence by including the productivity level for the starting period in the corresponding regression.[21] Within the wage regression we not only take the lagged level of value-added into account, but also control for a corresponding "convergence" effect with regard to wages. Hence, the dependent variables are the natural logarithm of value-added per employee, i.e. labour productivity (productivity regression) and, alternatively, the wage per employee (wage regression). In case of the ordinary least squares (OLS) regressions, these values are taken from the year 2005, which is the end of our observation period, while all independent variables refer to values in the starting year of the period, i.e. 2002. Thus, the panel structure of our data allows us to account for a potential endogeneity problem – emanating from reverse causality – by running regressions of the dependent variable based on data from 2005 on independent variables based on data from 2002.

In order to guarantee comparability between the age–productivity and age–wage regressions, we include a comparable set of regressors in both estimations. The set of independent variables include three age-share variables, the Herfindahl index for age shares, six tenure-share variables, gender shares, firm-specific variables such as the natural logarithm of value-added per employee in 2002, the natural logarithm of wages per employee in 2002 (only in the wage regression), the natural logarithm of the size of the firm (both linearly and as a squared variable), the natural logarithm of the firm's age, a dummy controlling for multi-plant firms and the natural logarithm of the stock of net fixed assets (both linearly and squared). A further set of variables contains the share of workers in various occupations as well as the share of part-time workers, nine sector dummies (NACE-categories) as well as nine regional dummies (NUTS-categories) for Austria. By including a rather broad set of independent variables, we account for heterogeneity among firms, in order to mitigate the bias that could be caused by omitted variables.

As reference categories we choose: the share of prime-aged employees, the share of employees with job tenure of 1–2 years, the share of male employees as well as the shares of white-collar and full-time workers, NACE E (energy and water supply) in the full sample regression, NACE C (mining and quarrying) in the industry and construction sample, NACE H (hotel and restaurants) in the service sector regression, and NUTS 34 (Vorarlberg) for the regional level.

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[16] In accordance to our tenure variable we are able to account for yearly working time insofar as we construct weights according to the number of days, which an employee has been occupied in a certain firm and hence in fact contributes to its value added over the given time span and not necessarily for a year as a whole. Thus, we deal with weighted age shares.

[17] The Herfindahl index H – based on age shares – with regard to the age concentration of employees within a firm is computed as follows: $H = \frac{\sum_{i=1}^{N} a_i^2}{\left(\sum_{i=1}^{N} a_i\right)^2}$ where $a_i =$ age shares and $N =$ number of age groups. In our application the Herfindahl can be between 0.3 and 1, in which 1 indicates full concentration and 0.3 full diversification.

[18] Since data on educational attainment of employees are not available, potential work experience (= age minus years of education minus six) cannot be computed.

[19] For details about the construction of the tenure variable see Freund et al. (2011).

[20] Due to reasons mentioned above we have excluded all firms of NACE division 745 ("Labour recruitment and provision of personnel").

[21] The specification estimated is of the form

$$\ln(Y/L)_{2005} = \alpha + \beta_1 \ln(Y/L)_{2002} + \beta_2 X + \varepsilon$$

and we interpret values of β_1 in the interval (0,1) as evidence for (conditional) convergence. The relationship between this model and the standard β–convergence specifications can be seen immediately by subtracting $\ln(Y/L)_{2002}$ from both sides of this equation, thus leading to

$$\ln(Y/L)_{2005} - \ln(Y/L)_{2002} = \alpha + (\beta_1 - 1)\ln(Y/L)_{2002} + \beta_2 X + \varepsilon$$

As can be easily seen, a negative coefficient associated with the initial level of productivity in this specification implies $\beta_1 \in (0,1)$. It should be noticed that in our regression setting, where other controls are included in the specification, (conditional) convergence takes place to a firm-specific equilibrium which can differ across firms.

Table 2 shows the results of the estimation for labour productivity as compared to wages for the complete sample and applying alternative cross-section and panel data estimation methods. In addition to OLS, we estimated a random effects specification,[22] a fixed effects specification and a dynamic panel data model which we estimate using the difference GMM (Arellano and Bond, 1991) procedure. However it should be noticed that due to the very limited time dimension of our panel, dynamic panel estimation methods may not work optimally.

From OLS estimations we find no significant relationship between the age structure and labour productivity but a significantly negative correlation between wages and the share of young workers. Furthermore, the OLS results do not show any link between average wages and old age share. The estimation using the full panel strengthens our results concerning the negative correlation of the young age-share variable and wages. The random effects model also finds similar relationships with productivity, but these do not appear robust across panel specifications. The same applies to the positive link between older age shares and wages, which is only significant if GMM estimation is used. The fact that wages tend to be lower in firms with a relatively higher share of young workers is thus the only result which appears systematically robust across estimation methods and data structures (cross-section versus panel data).[23] The lack of sufficient time variation in the data – especially for the age structure within firms – makes panel estimation techniques particularly fragile for our dataset, which spans a relatively short period of time. We therefore stick to cross-sectional OLS regressions in the rest of our analysis.[24]

Table 3 includes regression results for the complete sample as well as for the sample subdivided into the industry and construction sector (NACE sections C to F) and the service sector (NACE sections G to K). We expect different age–productivity and age–wage profiles because of the differences in production processes, as well as required work abilities (i.e. physical vs. mental) of the employees between these two sectors.

The parameter corresponding to the value-added per employee in the baseline year indicates that labour productivity across firms in a given sector tends to converge to a firm-specific steady state that depends on the characteristics of the firm. Initial productivity levels also tend to be positively related to average wages, but the effect is reduced, when we additionally control for "stickiness" of wages. A comparison between the coefficients on the lagged values of wages and productivity indicates that the wage variable is more persistent over time than the changes in labour productivity would imply.

Contrary to several other studies in the literature (e.g. Haltiwanger et al., 1999; Lallemand and Rycx, 2009), we do not find a hump-shaped pattern of the age variables in the productivity regression. The regression coefficients on the age categories indicate the marginal effects of an increase in the respective share, assuming that the omitted share adjusts. For the overall sample our results do not show any significantly different relationship between productivity and the share of younger or older workers as compared to prime-aged employees. Hence, labour productivity appears not to be fostered to a different degree by employing a high share of young or old, rather than middle-aged workers.

While the coefficient for the share of younger employees is significantly negative for the industry and construction sector, the coefficient for the share of old employees turns out to be insignificant in any case. Our results are in accordance with more recent studies (e.g. Aubert and Crépon, 2006, Göbel and Zwick, 2009) that also find a flat age–productivity profile for higher age groups. Interestingly, though, we also cannot find a negative correlation between the share of young employees and labour productivity for the overall sample (as well as service sector industries) as it is common in the literature. As we do not find a link between labour productivity and the share of old employees, we cannot confirm our formerly found hump-shade age–productivity pattern. The large standard errors point to considerable variation in the age–productivity profile amongst the firms in the Austrian economy.

In contrast to the findings with regard to labour productivity, the results of the wage regression for all firms show a negative coefficient of the share of employees aged younger than 30. Hence, firms with high shares of young employees tend to pay lower wages as compared to firms with a higher share of employees at middle ages. Since the coefficients on the young age shares are quite low and similar across the productivity and wage regression in the overall sample and the service sector, the negative sign in the wage regressions may indicate a certain degree of underpayment. In the industry and construction sector, the relationship between the share of young employees and labour productivity is lower as compared to the correlation with average wages. Hence, in this sector lower wages for younger employees may indeed reflect their lower productivity. Overall, our results do not indicate any significantly different relationship for the share of employees aged older than 49 years as compared to middle-aged workers, neither for labour productivity, nor for average wages and neither for the industry and construction, nor for the service sector.[25] Furthermore, it seems that wages per employee are not an appropriate measure for labour productivity.[26]

With respect to the tenure variable – which allows us to disentangle 'pure' age effects from the length of stay within a firm – the coefficients rather weakly indicate that the higher share of employees in shorter tenure intervals (as compared to a share of employees within a tenure interval of 1 to 2 years) is negatively associated with labour productivity, together with a negative link with wages in the industry and construction sector. A lower tenure usually goes along with young – and thus rather inexperienced – employees at the beginning of their career. Interestingly, a high worker share with a tenure of more than 10 years is associated with a more negative labour productivity in the industry and construction sector.

Due to left-censoring, our tenure variable is indeed an imperfect proxy for job experience, in particular for older workers. The identification of its effect is mostly based on the experience of young workers and those older workers which were incorporated to the firms in our sample in the years that our dataset covers. The estimation results when the model is specified without the tenure variable (Table 4) make us confident of the robustness of our estimates. The young

[22] A random effects estimator can account for the relatively small within variation but may cause problems since it assumes the random effects to be uncorrelated with the explanatory variables. This assumption might be violated in our case since we include a lagged dependent variable in all models.

[23] In the literature we could not find any consensus on the classification of age groups. Therefore, we tested for the robustness of the age variable by applying cross-section and panel data methods (fixed effects and random effects) based on narrow age shares (5-year age groups from 15 to 60 years and 65 + similar to Göbel and Zwick, 2009; Van Ours and Stoeldraijer, 2011) and on the whole sample (all firms). The fixed and random effect specification results are not particularly enlightening, with single age groups appearing significant and partly confirming our results, although the estimates of the coefficients of groups corresponding to the older age intervals are sometimes counterintuitive. Given the high degree of correlation across variables based on narrow age groups, multicollinearity appears to be having a strong effect on the estimation results.

[24] Although we impose a time structure in the cross-sectional regressions by evaluating the covariates in the initial year, it should be noted that the OLS regressions make a causal interpretation difficult in this setting.

[25] Some related studies (e.g. Göbel and Zwick, 2009) exclude the financial sector (NACE-section J) or the sector real estate, renting and business services (NACE-section K). Excluding these sectors did not change our estimation results. From this outcome we conclude that the results do not depend much on the composition of the sample.

[26] A significant difference between the coefficients has been confirmed for the overall sample as well as for the industry and construction sector by the following test: The difference between (the natural logarithm of) labour productivity and (the natural logarithm of) average wages per capita (= productivity-pay gap) at the firm level is regressed on the same set of independent variables as the production function and the wage equation separately. The estimated coefficients for the age shares correspond to the difference between the coefficients of the production function and the wage equation. Based on this proceeding for the sample of all industries and for the sample of service sector firms we do reject the null-hypotheses that the coefficients for the share of young as well as the share of old employees within the productivity-pay-gap regression are equal to zero. For the sample firms belonging to the industry and construction sector we cannot reject this hypothesis.

Table 2
Panel estimation results on labour productivity as compared to average wages based on all firms.

Variable	OLS with lagged regressors		Fixed effects		Random effects		GMM	
	Productivity	Wages	Productivity	Wages	Productivity	Wages	Productivity	Wages
Ln (value-added per employee, 1 year lagged)	0.46***	0.04***	−0.20***	−0.00	0.55***	0.02***	0.13***	0.03***
	(0.02)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.02)	(0.01)
Ln (gross wages and salaries per employee, 1 year lagged)	–	0.63***	–	−0.13***	–	0.73***	–	0.22***
		(0.01)		(0.02)		(0.01)		(0.03)
Proportion of employees								
Aged under 30	−0.07	−0.06**	−0.01	−0.09***	−0.05**	−0.08***	−0.05	−0.17**
	(0.04)	(0.02)	(0.05)	(0.03)	(0.02)	(0.01)	(0.18)	(0.08)
Aged over 49	0.06	−0.02	−0.07	−0.05	0.03	−0.02	0.05	0.39***
	(0.06)	(0.03)	(0.07)	(0.05)	(0.03)	(0.02)	(0.35)	(0.15)
Herfindahl index	0.18***	0.06*	0.15**	−0.08*	0.14***	0.00	0.49**	0.25**
	(0.07)	(0.03)	(0.07)	(0.04)	(0.03)	(0.02)	(0.25)	(0.12)
Proportion of								
Tenure ≤ ¼ year	−0.12**	−0.05*	−0.05	0.02	−0.09***	−0.01	−0.10**	0.02
	(0.05)	(0.02)	(0.04)	(0.02)	(0.03)	(0.01)	(0.04)	(0.02)
¼ year > Tenure ≤ 1 year	−0.10**	−0.03*	−0.02	−0.03***	−0.06**	−0.04***	−0.02	−0.04***
	(0.04)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.03)	(0.01)
2 years > Tenure ≤ 5 years	−0.01	−0.00	0.00	0.01*	−0.00	0.00	−0.02	0.01
	(0.05)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.03)	(0.01)
5 years > Tenure ≤ 10 years	−0.00	0.02	0.03	0.06***	0.04*	0.02**	0.03	0.03
	(0.05)	(0.02)	(0.04)	(0.02)	(0.02)	(0.01)	(0.05)	(0.02)
Tenure > 10 years	−0.06	−0.02	0.00	0.14***	−0.01	0.01	−0.01	0.06
	(0.05)	(0.02)	(0.06)	(0.03)	(0.02)	(0.01)	(0.09)	(0.04)
Ln (size of firm)	−0.08***	0.08***	−0.10	0.10**	−0.10***	0.05***	0.42***	0.47***
	(0.02)	(0.01)	(0.07)	(0.04)	(0.01)	(0.01)	(0.12)	(0.10)
Ln (size of firm)^2/100	1.22***	−0.63***	−1.43	−1.69***	1.24***	−0.42***	−5.65***	−3.60***
	(0.27)	(0.12)	(1.04)	(0.61)	(0.14)	(0.06)	(1.27)	(0.91)
Ln (age of firm)/100	−0.25	−0.37*	4.61**	−0.58	−0.02	−0.27**	−0.19	−3.24***
	(0.47)	(0.20)	(2.35)	(0.82)	(0.28)	(0.11)	(2.41)	(0.91)
Multi-plant	−0.07***	−0.03***	0.00	0.00	−0.05***	−0.02***	−0.01	0.00
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.02)	(0.01)
Ln (fixed assets per employee)	−0.01*	0.01**	−0.02*	0.02*	−0.01***	0.01***	−0.05*	−0.03**
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.03)	(0.01)
Ln (fixed assets per employee)^2/100	0.80***	−0.11**	0.36	−0.52**	0.71***	−0.07**	−0.67	1.66***
	(0.09)	(0.05)	(0.27)	(0.22)	(0.05)	(0.03)	(1.09)	(0.63)
Proportion in occupation								
Self-employed	−0.47***	−0.28***	−0.03	−0.11*	−0.32***	−0.23***	0.20	0.39***
	(0.10)	(0.06)	(0.11)	(0.06)	(0.05)	(0.03)	(0.12)	(0.07)
Blue-collar (incl. homeworkers)	−0.36***	−0.23***	−0.03	−0.05*	−0.27***	−0.17***	−0.04	0.08**
	(0.02)	(0.01)	(0.06)	(0.03)	(0.01)	(0.01)	(0.06)	(0.03)
Apprenticeship	−0.95***	−0.38***	−0.15*	−0.20***	−0.77***	−0.29***	0.04	0.11**
	(0.07)	(0.03)	(0.08)	(0.04)	(0.04)	(0.02)	(0.11)	(0.05)
Proportion of								
Female employees	−0.23***	−0.18***	−0.09**	−0.08***	−0.16***	−0.12***	−0.10**	−0.07**
	(0.02)	(0.01)	(0.04)	(0.02)	(0.01)	(0.01)	(0.05)	(0.03)
Proportion of								
Part-time	−0.29***	−0.16***	−0.09***	−0.08***	−0.27***	−0.15***	−0.05	−0.03*
	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.03)	(0.02)
Constant	2.67***	1.19***	5.38***	3.78***	2.24***	0.94***	−0.01***	−0.01***
	(0.13)	(0.07)	(0.26)	(0.16)	(0.07)	(0.04)	(0.00)	(0.00)
R^2	0.49	0.75	0.07	0.09	0.59	0.82	–	–
R^2: within	–	–	0.05	0.03	0.03	0.01	–	–
Between	–	–	0.10	0.11	0.84	0.95	–	–
Overall	–	–	0.07	0.09	0.59	0.82	–	–
F-test/Wald chi2-test	300.39***	1,039.52***	12.47***	6.58***	38,344***	160,851***	107***	163***
Arellano–Bond test for AR(1)	–	–	–	–	–	–	−14.81***	−11.06***
Number of observations	16,639	16,639	49,818	49,818	49,818	49,818	33,072	33,072

Significance levels: * 10%, ** 5%, *** 1%.
Notes: Reference categories are: aged 30–49 and 1 years > Tenure ≤ 2 years, male employees, white-collar and full-time.
All estimates include sector dummies as well as region dummies.
NACE division 745 ("Labour recruitment and provision of personnel") has been excluded.
Heteroscedasticity-consistent standard errors are in parentheses.
OLS: While values for the dependent variables are taken from the year 2005, independent variables are made up of values in 2002.
Fixed effects and random effects: explanatory variables are lagged 1 year.
GMM: The residuals and the L(2) residuals have no observations in common. The AR(2) is trivially zero.

Table 3
OLS-estimation results on labour productivity as compared to average wages in different sectors.

Variable	All firms		Industry and construction		Service sector	
	Productivity	Wages	Productivity	Wages	Productivity	Wages
Ln (value-added per employee, 1 year lagged)	0.46***	0.04***	0.45***	0.05***	0.44***	0.03***
	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
Ln (gross wages and salaries per employee, 1 year lagged)	–	0.63***	–	0.48***	–	0.67***
		(0.01)		(0.02)		(0.02)
Proportion of employees						
Aged under 30	−0.07	−0.06**	−0.11**	−0.05**	−0.04	−0.06**
	(0.04)	(0.02)	(0.05)	(0.02)	(0.06)	(0.03)
Aged over 49	0.06	−0.02	−0.05	−0.00	0.07	−0.01
	(0.06)	(0.03)	(0.07)	(0.03)	(0.08)	(0.05)
Herfindahl index	0.18***	0.06*	0.13*	0.04	0.17*	0.07
	(0.07)	(0.03)	(0.07)	(0.03)	(0.09)	(0.05)
Proportion of						
Tenure ≤ ¼ year	−0.12**	−0.05*	−0.04	−0.06**	−0.13*	−0.03
	(0.05)	(0.02)	(0.06)	(0.03)	(0.07)	(0.03)
¼ year > Tenure ≤ 1 year	−0.10**	−0.03*	−0.08**	−0.03*	−0.08	−0.02
	(0.04)	(0.02)	(0.03)	(0.02)	(0.07)	(0.02)
2 years > Tenure ≤ 5 years	−0.01	−0.00	−0.02	0.01	−0.01	−0.00
	(0.05)	(0.02)	(0.04)	(0.02)	(0.06)	(0.02)
5 years > Tenure ≤ 10 years	−0.00	0.02	0.01	0.00	0.01	0.03
	(0.05)	(0.02)	(0.05)	(0.02)	(0.07)	(0.03)
Tenure > 10 years	−0.06	−0.02	−0.14***	−0.02	0.02	−0.02
	(0.05)	(0.02)	(0.05)	(0.02)	(0.07)	(0.03)
Ln (size of firm)	−0.08***	0.08***	0.07***	0.11**	−0.10***	0.09***
	(0.02)	(0.01)	(0.03)	(0.01)	(0.03)	(0.01)
Ln (size of firm)^2/100	1.22***	−0.63***	−0.08	−0.66***	0.99***	−0.80***
	(0.27)	(0.12)	(0.31)	(0.11)	(0.32)	(0.15)
Ln (age of firm)/100	−0.25	−0.37*	−1.03**	−0.16	0.48	−0.42
	(0.47)	(0.20)	(0.52)	(0.22)	(0.71)	(0.30)
Multi-plant	−0.07***	−0.03***	−0.05***	−0.02***	−0.07***	−0.03***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)
Ln (fixed assets per employee)	−0.01*	0.01**	0.01	0.00	−0.01	0.01*
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Ln (fixed assets per employee)^2/100	0.80***	−0.11**	0.27**	0.01	0.88***	−0.12*
	(0.09)	(0.05)	(0.11)	(0.05)	(0.11)	(0.06)
Proportion in occupation						
Self-employed	−0.47***	−0.28***	−0.94***	−0.79***	−0.44***	−0.18***
	(0.10)	(0.06)	(0.13)	(0.08)	(0.12)	(0.06)
Blue-collar (incl. homeworkers)	−0.36***	−0.23***	−0.36***	−0.24***	−0.35***	−0.21***
	(0.02)	(0.01)	(0.03)	(0.02)	(0.03)	(0.02)
Apprenticeship	−0.95***	−0.38***	−0.82***	−0.43***	−0.93***	−0.40***
	(0.07)	(0.03)	(0.08)	(0.04)	(0.10)	(0.05)
Proportion of						
Female employees	−0.23***	−0.18***	−0.29***	−0.25***	−0.20***	−0.16***
	(0.02)	(0.01)	(0.03)	(0.02)	(0.03)	(0.02)
Proportion of						
Part-time	−0.29***	−0.16***	−0.20***	−0.13***	−0.29***	−0.14***
	(0.03)	(0.02)	(0.04)	(0.03)	(0.04)	(0.02)
Constant	2.67***	1.19***	2.44***	1.54***	2.91***	1.00***
	(0.13)	(0.07)	(0.14)	(0.10)	(0.16)	(0.08)
R^2	0.49	0.75	0.51	0.77	0.48	0.75
F-test	300.39***	1,039.52***	219.13***	648.78***	199.04***	723.65***
Number of observations	16,639	16,639	6,955	6,955	9,684	9,684

Significance levels: * 10%, ** 5%, *** 1%.
Notes: Reference categories are: aged 30–49 and 1 years > Tenure ≤ 2 years, male employees, white-collar and full-time.
All estimates include sector dummies as well as region dummies.
Firms belonging to NACE division 745 ("Labour recruitment and provision of personnel") has been excluded.
Method: ordinary least squares.
Heteroscedasticity-consistent standard errors are in parentheses.
While values for the dependent variables are taken from the year 2005, independent variables are made up of values in 2002.

age coefficient becomes slightly more negative and gets weakly significant in the productivity regression for all firms, while the coefficient associated with the share of old aged employees remains almost equal. Hence, it should be noted that refraining from the separate control for tenure effects leads to a small omitted variable bias for the age coefficients.

With regard to the age concentration of the employees we find that less diversity favours labour productivity but is just weakly significantly linked with wages (only in case of considering the sample of all industries). Firm age, on the other hand, does not appear to be a significant determinant of labour productivity or wages. The organisational form in terms of being a multi-plant enterprise shows a slightly negative

Table 4
Age effects for an estimation without tenure shares.

Variable	All firms		Industry and construction		Service sector	
	Productivity	Wages	Productivity	Wages	Productivity	Wages
Proportion of employees						
Aged under 30	−0.08*	−0.07***	−0.10**	−0.06***	−0.07	−0.07**
	(0.04)	(0.02)	(0.05)	(0.02)	(0.06)	(0.03)
Aged 30–49 (ref.cat.)	–	–	–	–	–	–
Aged over 49	0.07	−0.02	−0.07	0.00	0.08	−0.01
	(0.06)	(0.03)	(0.07)	(0.03)	(0.08)	(0.05)

Significance levels: * 10%, ** 5%, *** 1%.
Note: The remaining regression set up accords to the analysis shown in Table 3. Heteroscedasticity-consistent standard errors are in parentheses.

link with productivity as well as with wages. Relative to the reference category of white-collar workers the three other occupational groups are negatively related to productivity and wages. Employees in apprenticeship are less productive and earn lower wages. A higher share of female employees and part-time[27] workers has a negative impact on wages and productivity.

6. Conclusions

In this study, we analyse the relationship between the age composition of the workforce with both labour productivity and wages per employee based on a matched employer–employee dataset for the period 2002–2005. We test whether old workers are on average being rewarded according to their productivity by comparing both age–productivity and age–wage profiles. In order to investigate whether our results differ by the sector affiliation of different firms, we consider two subsamples: firms in the industry and construction sector and firms belonging to the sectors of market-oriented services.

Summing up the results of our productivity analysis, we find a negative effect of the share of young workers (29 years and younger) – mainly in firms of the industry and construction sector – and no significant effect of the share of old employees (50 years and older). While the results should be interpreted carefully in terms of inferring causality, this finding contradicts the common outcome of a hump-shaped age–productivity pattern found in former studies in Austria, but is in accordance with more recent studies from other European countries that are based on panel data methods.

In contrast to the findings with regard to labour productivity, the results of the wage regression for all firms show a negative coefficient of the share of young employees. Overall, our results do not indicate any significantly different relationship for the share of old employees aged as compared to middle-aged workers for average wages neither for the industry and construction, nor for the service sector.

Since the coefficients on the young age shares are quite low and similar across the productivity and wage regression in the overall sample and the service sector, the negative sign in the wage regressions may indicate a certain degree of underpayment. In the industry and construction sector, the relationship between the share of young employees and labour productivity is lower as compared to the correlation with average wages. Hence, in this sector lower wages for younger employees may indeed reflect their lower productivity.

Based on our results and notwithstanding the difficulty of unveiling causal relationships in our regression framework, we do not find an indication that the ageing workforce will necessarily lead to a decline in labour productivity, since on average the age–productivity profile is flat from prime-age onwards - which holds true also for the secondary and tertiary sectors. In addition we cannot confirm unjustified wage payments. Furthermore, our findings imply that there is considerable variation in the age–productivity profile amongst the firms in the Austrian economy.

[27] We do not apply full-time equivalents here, but control for full- and part-time employment separately.

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