Ageing, productivity and wages in Austria[1]

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Abstract

The current demographic developments 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. In order to study the relation between the age structure of employees and labour productivity at the firm level, we use a new matched employer-employee panel data set for Austrian firms spanning the period 2002-2005. These data allow us to account simultaneously for socio-demographic characteristics of the employees as well as firm heterogeneity to explain labour productivity. Our results clearly show that the age-productivity as well as age-wage profile have a strong industry-specific component. In the service sector, an ageing workforce does not necessarily imply a negative productivity effect. Moreover, we cannot find any evidence for an overpayment of elderly employees.

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Key-Words: age-productivity/ -wage profile, employer-employee data, sector affiliation

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1. Motivation

Demographic change in industrialised countries will have profound consequences for economic sustainability in the years to come. Low levels of fertility and increasing survival to 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 may be associated with negative consequences for the financial sustainability of social security systems. The process of ageing becomes apparent when having a look at the figures for Austria in 2009 as well as the projections until 2030 (VID, 2010): The median age of the population is expected to increase from 41.3 to 45.4 years and the proportion of the population aged 65+ will rise from 17.4 to 24.1 percent. Thus, half of the Austrian population will be older than 45.4 years and about one quarter will be at least 65 years old in less than 20 years from now. Moreover, the old-age dependency ratio (population aged 65+ years divided by population aged 15 to 64 years) will rise from 25.7 to 39.4 percent; meaning that instead of four persons at working age it will be no more than two and a half taking economically care of one "old" individual. But what are the consequences of aging of the labour force itself, i.e. the economically supporting entity? The question boils down to whether an ageing workforce – in the light of shrinking size – will 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 of our former analysis (Prskawetz et al., 2007, Mahlberg et al., 2009) rather confirmed a hump-shaped productivity profile over age at the firm level. On the contrary, recent studies at the firm level, which is the decisive output producing unit within an economy, provide evidence against this hump-shaped age-productivity pattern. Studies such as Aubert and Crépon (2006) as well as Göbel and Zwick (2009) show that the age-productivity relation is quite sensitive to the estimation method applied and indicate that controlling for unobserved time-invariant individual heterogeneity as well as endogeneity leads to a flattening of the curve at higher ages. As - depending on the respective work environment – single workers (at different ages) may act as complements or substitutes, various cumulative as well as compensatory effects may appear and assuming that we deal with a pure aggregate over homogeneous individual skills may not necessarily be enlightening.

Based on a yearly, balanced panel data set for Austrian firms ranging from 2002 to 2005, we analyse whether the employees' age distribution is related to labour productivity in an average firm. The data set was 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") and wage tax data of Austria. It thus allows for simultaneously assessing employee characteristics in combination with firm heterogeneity.

Since seniority wage schemes are prevalent in certain sectors of the Austrian economy, wages might not be an appropriate measure of labour productivity as some (age) groups of employees may be under- or overpaid in this regard. Evidence in the literature is ambiguous (see e.g. Hellerstein et al., 1999, Crépon et al., 2002, Dostie, 2006). Thus, we additionally aim at a complementary comparative investigation of the age-wage relationship.

The division of our firm sample into the service as well as the industry and construction sector is crucial, since physically demanding jobs, which are assumed to be more prevalent in the latter, will lose, while service sector jobs[2] that rather require mental abilities and experience will gain weight in the future economic landscape. Hence, against the background of population and workforce ageing insights into the respective age-productivity as well as age-wage patterns may be of great economic, societal and political interest.

Based on these two subsamples with respect to the sector affiliation, our analysis leads to the result that, while a negative labour productivity impact of young workers (≤ 29 years) is prevalent in firms belonging to the industry and construction sector, the respective productivity effect of old workers (50+ years) turns out to be positive within firms of the service sector. In addition, we find a hump-shaped age-wage pattern across all firms, which loses significance for firms being affiliated in the industry and construction sector.

The paper is structured as follows: We review recent literature on ageing, productivity and wages in section 2. Section 3 introduces the theoretical framework, which will be the basis for the empirical analysis. The data set is presented in section 4, before we proceed with the empirical analysis in section 5. Section 6 concludes.

[2] This line of argument should hold, since we do not include physically demanding labour tasks like elderly care, for instance.

2. Previous studies on age, wages and productivity

During recent years the interest in the relationships between the age structure of the workforce and productivity as well as wages within firms has grown. Hence, several attempts have been undertaken to estimate the age-productivity profile and age-wage profile based on firm level data, as well as data measured at the level of an establishment and plant. This section provides a brief overview of selected studies. For comprehensive reviews of contemporary literature we refer to Börsch-Supan et al. (2005), Gelderblom (2006), and Skirbekk (2008).[3]

A study on the relationship between age and productivity as well as wages requires data at the level of the firm rather than at the individual level. Firstly, productivity is a firm-level phenomenon. Secondly, productivity is difficult to observe at the individual level. Thirdly, the aim is to achieve a high degree of direct comparability of productivity and wage effects. For a proper examination it became internationally common to make use of so-called matched employer-employee data are used. These data sets contain firm characteristics as well as attributes of employees working for the respective enterprises.

Several empirical studies 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). Many of these studies are based on cross-sectional data sets and estimate the relationship by means of ordinary least squares. The more recent literature (e.g. Malmberg et al., 2008, Göbel and Zwick, 2009) questions the accuracy of these results and argue that many studies suffer from using poor data with respect to the number of observations, explanatory variables or missing time dimensions. Moreover, reverse causality between firm-specific age structure and productivity does not tend to be explicitly taken into account by the estimation methods used. The point is that reliable statements on the unambiguous direction of causality between a (potentially independent) explanatory variable on the right hand-side and the explained variable on the left hand-side of a regression equation can hardly be made just being based on data at one and the same point in time. On the contrary, the availability of at least two different time points and thus the ability of making use of the given time structure within the data allows for the exclusion of reverse causality, i.e. productivity impacting the employees' age structure, to a certain extent. Hence, more modern studies are based on

[3] For an early survey on the economic impact of an older population see Ashenfelter (1981).

longitudinal matched employer-employee data sets and try to remove the potential bias associated with least square estimation of production functions. The results of this literature tend to indicate that a larger share of old workers does not necessarily affect firm productivity.

Malmberg et al. (2008) aim to answer the empirical question concerning how labour productivity at the plant level is related to the age composition of the labour force without imposing any given theoretical structure. The data are sourced from the Swedish Manufacturing and Mining Surveys and Regional Labour Market Statistics and consist of 8,000-9,000 establishments observed over the period 1985-1996. The estimates are obtained using instrumental variable methods. According to their estimates, an accumulation of high shares of older adults in a manufacturing plant does not have a negative effect on productivity. On the contrary, when plant-specific effects are controlled for, high shares of older adults are associated with higher productivity than high shares of young adults. Göbel and Zwick (2009) analyse German data and find considerable differences in parameter estimates depending on the estimation strategy. The results of their preferred estimates depict an increase in productivity until the age 40-45, but no considerable decline until the age of 60.

The studies referred to so far have purely concentrated on the productivity side. None of them focuses on a direct comparison of productivity and wage profiles in order to test whether the age-wage slope diverging from the age-productivity slope or not. An early study on this issue is the work of Medoff and Abraham (1980), who document a positive association between pay and experience, not or negatively related to individual performance on the job (as rated by the supervisors). Their results are interpreted as evidence against the human capital on-the-job training model and are consistent with Lazear's model of deferred compensation (Lazear, 1979). In this theoretical framework age-earnings profiles are thought to be upward sloping because this will discourage workers from shirking. Workers and firms engage in long-term relationships, in which the worker is initially underpaid - the wage is lower than the value of the marginal product, while later on in life the worker is overpaid. Such delayed-compensation contracts will discourage the worker from shirking, but at the same time require mandatory retirement to avoid firms paying more than the value of the marginal product (averaged over the working life i.e. over the duration of the working contract between workers and firms). The theory of Lazear (1979) assumes that workers and firms want to be engaged in long-term relationships and concludes that rising earnings do not fully reflect increased productivity.

The first study focusing entirely on comparing age-productivity and age-wage profiles was Hellerstein and Neumark (1995). They initiated a new track in the literature by proposing a simple method to test, whether wage differentials traditionally captured by wage regressions are rooted in productivity differentials captured by production functions. The procedure relies on matched employer-employee data and consists of estimating a production function and a wage function at the plant level, thereby using a common specification, and finally comparing the estimated coefficients across equations. Based on firm level data from Israel, they estimate Cobb-Douglas production functions augmented by the inclusion of the worker shares in the young, prime-age and old age groups, finding 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) found that the wage premium for workers with higher experience (more than 15 years) exceed their relative productivity, whereas the opposite is true for workers with 8 to 15 years of experience.

Both the representativeness and the validity of these results are currently subject to intense debate. The need to ground 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). Firm-productivity shocks (which are, by definition, time-varying and therefore not captured by firm fixed-effects or similar methods) might as well bias the results. Some firms may have more difficulties in adjusting some types of labour than others due to the adoption of inverse seniority rules for instance. In such cases, the bias in the estimation of older workers' productivity would arise from the fact that changes in input shares are endogenous. Attempts to overcome this problem include the use of dynamic panel data methods such as those proposed by Arellano and Bond (1991) (e.g. Aubert and Crépon, 2006, Cardoso et al, 2010, van Ours and Stoeldraijer, 2010) and two-stage regression methods (Dostie, 2006).

Aubert and Crépon (2006) find that productivity, defined as the average contribution of particular age groups to the productivity of firms, increases with age until age 40 to 45 and remains constant afterwards. These results are stable across industries. They also 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. The evidence with regard to ages above 55 remains inconclusive due to data and precision issues. Ilmakunnas and Maliranta (2007) examine the connection of an ageing workforce and firm performance by using information on the hiring and separation of employees. They show that the change in firm level labour productivity can be decomposed into the effects of hiring and separation rates of the age groups as well as the effect of productivity growth for those workers in different age groups who are staying in the firm. The evidence shows that separations from older workers are profitable to firms, especially in the manufacturing ICT-industries, since there are indeed age group dependent differences in relative productivity and wage levels.

Dostie (2006) use Canadian matched employer-employee data at the workplace level to estimate production functions taking into account the age composition of the firm's workforce. He estimates wage equations at the employee level distinguishing workers based on their age. He applies a method similar to Hellerstein et al. (1999) and Aubert and Crépon (2006), but improves along two lines. First, he estimate wage equation taking into account individual as well as firm unobserved heterogeneity using a mixed model of wage determination (as suggested by Abowd and Kramarz, 1999b). Second, he also control for unobserved time varying productivity shocks in the production function using a method suggested Levinsohn and Petrin (2003). Dostie (2006) 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 (2010) perform their analysis using a matched employer-employee data set from Dutch manufacturing covering the period 2000-2005. Their findings are in line with Aubert and Crépon (2006) and Dostie (2006). They find a flat age-productivity profile at higher ages and do not attain any evidence of a wage-productivity gap for this group of employees.[4]

Cardoso et al. (2010) use a longitudinal matched employer-employee data set covering the entire workforce in manufacturing and the private service sector in Portugal spanning over a 22-year period. They 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, older workers are, in fact, worthy of their pay, in the sense that their contribution to firm level productivity even exceeds their contribution to the wage bill.

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

3. The Theoretical Framework

This section presents a simple theoretical framework to frame our empirical analysis. We start by specifying a production function with differentiated labour input and arrive at an empirical model which is confronted with the data set on matched employer-employee information for Austria.

Let us assume that production in a given firm can be represented by a Cobb-Douglas production function with the input factors capital and labour. The latter factor is differentiated by age and other labour force characteristics such as gender, occupation, etc.

In the basic model capital K_i and labour L_i^* of firm i are combined with technology level A resulting in the level of output Y_i:[5]

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

Initially, following Crépon et al. (2002) we decompose total labour input L_i^* of a firm into a weighted sum of various types of employees k, which are perfectly substitutable, such that $L_i^* = \sum_{k=0}^{m} \lambda_{ik} L_{ik}$.[6] The weights are represented by an individual productivity parameter λ_{ik}. This implies that

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

and thus

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

where λ_{i0} is 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 of employees.[7] We assume the productivity

[5] For simplification we abstain from time subscripts in the following.

[6] An alternative way in order to abstain from the assumption of perfect substitutability would be to implement a Cobb-Douglas type aggregate of labour, see e.g. Prskawetz and Fent (2007) and Prskawetz et al. (2008).

[7] This term is similar to the "relative (marginal) productivity differential" of a trained worker compared to an untrained worker in Konings and Varnomelingen (2009, p. 5).

differential to be constant across firms, i.e. $\gamma_{ik} \equiv \gamma_k$. In a next step we postulate constant returns to scale, i.e. $\alpha + \beta = 1$. Taking logs of equation (1) and substituting L_i^* (equation (2)) into equation (1) yields:

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

Considering that the expression for $\ln(\lambda_{i0})$ is captured within the constant term *c*, subtracting $\ln(L_i)$ from both sides and implementing the approximation *ln(1+x)≈x*, which in fact holds for x<<1, leads to the equation of output per employee for each firm that will be estimated below:

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

where u_i represents the usual error term, assumed to contain both a firm-specific and a time fixed effect. The error term captures the part of *A* that cannot be explained with the help of further firm-specific explanatory variables X_j. Note that from equation (4) it follows that the estimated (age) share coefficients are composed of the Cobb-Douglas parameter α as well as the relative productivity differentials γ_k.

The empirical analysis of the age-wage correlation[8] follows analogously to the productivity estimation. Gross wages and salaries per employee W_i/L_i are modelled as a function of capital intensity K_i/L_i, share of different types of labour L_{ik}/L_i and further explanatory variables X_j. In this case the empirical estimation is based on the following equation:

$$\ln\left(\frac{W_i}{L_i}\right) = c + \alpha \ln\left(\frac{K_i}{L_i}\right) + (1-\alpha)\sum_{k=1}^{m} \gamma_k \frac{L_{ik}}{L_i} + \sum_{j=1}^{n} \delta_j X_{ij} + u_i \quad (5)$$

Our wage regression explains the average wage at the firm level by exactly the same variables that enter the production function. Based on the respective coefficients this specification permits to compare the impact of age on wages per employee and productivity in order to test whether old employees are overpaid or not. One could argue that firm characteristics such as capital intensity should be excluded from the wage equation in competitive labour markets. However, these variables are typically quite informative in wage

[8] Although average wages rather present an approximate measure, we prefer these as opposed to individual wages especially at the present level of analysis in order to achieve best possible comparability with the productivity outcome.

equations, either because they are picking up some measure of unobserved labour quality (Hellerstein and Neumark, 1999) or because of “real world” departures from perfect competition. In either case, omitting such variables is likely to cause bias on the age variables which is why our specifications will include them (cf. Dearden et al., 2006).

4. Data

4.1. Data Sources

The novel panel data set constructed for this study contains yearly employer-employee data for Austria sourced from Statistics Austria ranging over the years 2002-2005. The data set 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”) and *wage tax data* (Statistics Austria).[9]

The structural business survey as well as social security and wage tax data contain a firm identifier that allows linking these three data sets. As the assignment of self-employed persons to their firms is ambiguous, individual data of this kind of workers is excluded from the data set[10]. Temporary agency workers (“*Zeitarbeiter*”) are assigned to temporary employment companies and not to the firms they actually work for. All persons with other atypical employment relationships like service contracts (“*Werkvertrag*”) are also not linked to their employer. The matched data set contains data on 19,633 firms and approximately 1.9 million employees per year.[11] The data set covers around 7% of the Austrian firm population in the investigated sectors, which produce

[9] In recent years similar data sets have been created for several countries. See Abowd and Kramarz (1999a) for an excellent review on the availability and analysis of such data and Abowd and Kramarz (1999b) for an econometric analysis of these types of data. Applications based on these data sets include studies on labor mobility, unemployment, wage compensation, productivity, etc. An excellent review of potential applications is given in Hamermesh (2007).

[10] 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. This in turn should not lead to any bias, as we assume, that the self-employees in our sample are equally distributed across the age groups used.

[11] 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. Thus, the final data set is a balanced panel.

around 66% of value added and employ around 56% of the active workforce. Our panel data set is constructed to be balanced over the period under consideration.

The *firm characteristics* are collected from the structural business survey, sourced by Statistics Austria. 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 with OeNACE.[12] 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. The structural business survey encompasses economic indicators of 29,371 enterprises in 2002, 31,966 enterprises in 2003, 32,891 enterprises in 2004, and 34,312 enterprises in 2005, respectively. 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, white-collar workers, blue-collar workers, apprentices, home workers and part-time workers. In addition, legal form and year of foundation are taken from the enterprise register of Statistics Austria.

Data on net fixed capital emanate from the national accounts dataset of Statistics Austria.[13] These data are valued at replacement costs of 2005 and available only

[12] 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-classes – 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). In this article we use the OeNACE version of 2003, because in our data, which encompass the years 2002-2005, the firms are classified according to this version.

[13] For details on the computation procedure of net fixed capital see Schwarz (2002) and Statistics Austria (2009, p. 154).

at the industry level. Therefore, they had to be disaggregated to firm level before they could be included in our analysis. As in Harhoff (1998), net fixed capital 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[14] was used exploiting firm specific investment data from the structural business survey and industry specific depreciation rates from the national accounts.

The *workforce characteristics* are taken from the workforce statistics, which in turn are sourced 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[15] ("*Sonderzahlungen*"), location of residence, citizenship and job tenure (length of stay in a firm) of individuals employed in firms. Principally, this survey contains all employees (white-collar and blue-collar workers, home workers, apprentices, full-time and part-time workers) and most self-employed persons.[16] The Main Association of Austrian Social Security Institutions provides individual data of employees to Statistics Austria, which in turn is responsible for calculating the workforce statistics.[17]

The wage tax data contain wages and salaries at the individual level, social status (apprentice, blue-collar worker, white-collar worker, public servant, pensioner, etc.) and information concerning whether a person is full-time or part-time employed. Data of wage tax in 2005 are based on approx. 7.8 million pay slips ("*Lohnzettel*") issued to employees and pensioners. These data are collected by the Austrian tax authorities and also used for the set-up of the workforce statistics. Wage tax is a special form of income tax and is collected via deductions from the taxpayer's wages or pension. 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 in one of the included firms. This issue is of special importance, as these two data sets are related to one another for analytical purposes.

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[14] 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).

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

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

[17] The data set provides no information on educational attainment of employees. Therefore information on human capital in the workforce of the firms is not available.

From the firm and worker characteristics mentioned above we constructed the key variables for firms as well as individual workers aggregated at the firm level. These are presented in Table 1. All indicators measured in monetary terms (except for net fixed assets) are deflated to constant prices of 2005 by the harmonized consumer price index taken from Statistics Austria.

4.2. Descriptive Statistics

We divide our sample into two subsamples of the industry and construction sector (NACE C to NACE F) on the one hand and the service sector (NACE G to NACE K) on the other. The former subsample is identical to the secondary sector whereas the later 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 selected characteristics) is presented in Table 1 below. As can be seen from the quite large values of standard deviation, the discrepancy between firms is considerable for most of the examined characteristics, whereby the industry and construction sector is less heterogeneous than the service sector.[18]

As we analyse both of our dependent variables, i.e. mean value added per employee (labour productivity) and mean gross wages and salaries per employee, over the complete time horizon, the table actually displays the descriptive statistics based on their respective mean values over the observation period 2002-2005. 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.

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

Table 1: Descriptive statistics

Variable	All firms		industry and construction		Service sector	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Firm Characteristics						
Mean value added per employee 2002-2005 (in TEUR)	72.32	536.39	49.92	34.24	87.62	694.89
Mean gross wages and salaries per employee 2002-2005 (in TEUR)	28.72	22.30	27.18	8.46	29.77	28.03
Value added per employee 2002 (in TEUR)	73.60	669.63	50.48	42.16	89.39	867.70
Size of firm (in persons employed)	69.45	377.17	79.77	252.03	62.39	442.64
Age of firm (in years)	18.34	16.21	18.45	15.05	18.26	16.97
Multiplant (0, 1)	0.28	0.45	0.27	0.44	0.29	0.45
Investment in fixed assets per employee (in TEUR)	19.39	432.35	5.94	17.87	28.58	560.54
Net fixed assets per employee (in TEUR)	498.18	9,723.77	97.00	367.51	772.04	12,602.57
Sector affiliation (shares)						
NACE C (mining and quarrying)	0.00	0.07	0.01	0.10	-	-
NACE D (manufacturing)	0.23	0.42	0.58	0.49	-	-
NACE E (electricity, gas and water supply)	0.00	0.07	0.01	0.10	-	-
NACE F (construction)	0.16	0.37	0.40	0.49	-	-
NACE G (wholesale and retail trade;…)	0.30	0.46	-	-	0.51	0.50
NACE H (hotels and restaurants)	0.06	0.25	-	-	0.11	0.31
NACE I (transport, storage and communication)	0.08	0.27	-	-	0.13	0.34
NACE J (financial intermediation)	0.01	0.12	-	-	0.03	0.16
NACE K (real estate, renting & business activities)	0.14	0.34	-	-	0.23	0.42
Region (shares)						
NUTS 11 (Burgenland)	0.03	0.16	0.04	0.19	0.02	0.14
NUTS 12 (Lower Austria)	0.17	0.37	0.19	0.40	0.15	0.36
NUTS 13 (Vienna)	0.22	0.41	0.12	0.33	0.28	0.45
NUTS 21 (Carinthia)	0.06	0.23	0.06	0.25	0.05	0.22
NUTS 22 (Styria)	0.12	0.32	0.14	0.35	0.10	0.31
NUTS 31 (Upper Austria)	0.18	0.38	0.21	0.41	0.15	0.36
NUTS 32 (Salzburg)	0.08	0.28	0.07	0.26	0.09	0.29
NUTS 33 (Tyrol)	0.10	0.30	0.09	0.29	0.10	0.30
NUTS 34 (Vorarlberg)	0.06	0.23	0.06	0.24	0.05	0.22

Employee-characteristics						
Proportion of employees						
Aged under 30 (‘young’)	0.31	0.18	0.32	0.17	0.30	0.18
Aged 30 to 49 (‘prime-aged’)	0.54	0.16	0.52	0.14	0.55	0.17
Aged over 49 (‘old’)	0.16	0.13	0.16	0.11	0.16	0.14
Herfindahl index (of age concentration)	0.48	0.11	0.46	0.08	0.49	0.12
Proportion of employees						
Tenure 1 (tenure ≤ ¼ year)	0.12	0.12	0.10	0.09	0.13	0.14
Tenure 2 (¼ year > tenure ≤ ½ year)	0.08	0.09	0.07	0.07	0.09	0.10
Tenure 3 (½ year > tenure ≤ ¾ year)	0.07	0.09	0.07	0.10	0.06	0.08
Tenure 4 (¾ year > tenure ≤ 1 year)	0.08	0.12	0.09	0.13	0.08	0.11
Tenure 5 (1 year > tenure ≤ 2 years)	0.17	0.15	0.17	0.13	0.18	0.16
Tenure 6 (2 years > tenure ≤ 3 years)	0.10	0.10	0.11	0.08	0.10	0.11
Tenure 7 (3 years > tenure ≤ 4 years)	0.08	0.09	0.08	0.08	0.08	0.10
Tenure 8 (4 years > tenure ≤ 5 years)	0.05	0.08	0.05	0.07	0.05	0.09
Tenure 9 (5 years > tenure ≤ 10 years)	0.14	0.14	0.14	0.12	0.14	0.15
Tenure 10 (10 years > tenure ≤ 20 years)	0.08	0.10	0.09	0.10	0.07	0.11
Tenure 11 (20 years > tenure ≤ 30 years)	0.02	0.05	0.02	0.04	0.02	0.05
Tenure 12 (30 years > tenure ≤ 40 years)	0.00	0.01	0.00	0.01	0.00	0.01
Tenure 13 (tenure > 40 years)	0.00	0.00	0.00	0.00	0.00	0.00
Proportion in occupation						
Self-employed	0.03	0.07	0.02	0.04	0.04	0.08
White-collar	0.45	0.33	0.26	0.18	0.59	0.34
Blue-collar (incl. home workers)	0.45	0.32	0.64	0.18	0.33	0.32
Apprenticeship	0.06	0.09	0.09	0.10	0.04	0.07
Proportion of						
Male employees	0.66	0.26	0.77	0.20	0.58	0.26
Female employees	0.34	0.26	0.23	0.20	0.42	0.26
Proportion of						
Part-time	0.13	0.17	0.09	0.11	0.16	0.20
Full-time	0.87	0.17	0.91	0.11	0.84	0.20

Note: Value added per employee and gross wages and salaries per employee are average values over the whole observation period. Further figures accord to the year 2002.

Notwithstanding the fact that firms are quite heterogeneous with respect to size and age throughout the sample, an average enterprise employs around 80 persons in the industry and construction sector and 62 persons in the service sector. The average age of a firm is roughly 18 years in 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 investment in fixed assets per employee (a flow variable) and net fixed assets per employee (a stock variable), presents particularly large differences between sectors. Our data indicate that firms belonging to the service sector produce by far more capital intensively than industry and construction firms. However, with respect to this characteristic the diversity within the service sector is particularly pronounced. The reason is that the housing stock as well as investments into buildings are attributed to the real estate business[19]. Facilities are owned by firms belonging to this sector, which in turn provide services to firms of other sectors. Based on leasing contracts or rental agreements the latter incorporates the respective buildings into their production process.

Across industrial sectors considered in terms of NACE 1-digit categories, the largest group of firms in the complete samples, i.e. 30 percent, carries out its business in wholesale and retail trade (NACE G) followed by manufacturing (NACE D) with 23%, 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 emanates from the service sector (NACE G-K), as opposed to approximately 40% stemming from the industry and construction sector (NACE C-F) of the Austrian economy.

Regarding the geographical distribution of all firms in the complete sample we observe that roughly a quarter (22%) of all enterprises is located in Vienna followed by Upper (18%) and Lower Austria (17%), while Burgenland (3%) is structurally rather weak in this respect. In the industry and construction sector the firms are clustered within Upper Austria and Lower Austria. The service sector, however, is rather concentrated in Vienna.

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

The most interesting employee characteristic for our purpose is age[20]. 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. Austria's comparably low retirement age (D'Addio et al., 2010, OECD, 2011) might partially compensate for population ageing effects within the labour force here but could lead to a selection bias at higher ages. The mean age concentration[21] across all firms amounts to around 0.5[22], which in our case means that the average firm is rather unconcentrated in terms of the employees' age structure. The age distribution and age concentration variables show almost no systematic differences between the sub-samples.

With the aim to disentangle tenure from pure age effects, which may be particularly important against the background of senior wage schemes, we created a continuous tenure variable, in turn being cut into various intervals of irregular length. We define tenure as the time spent working in the current company (job experience[23]) , which we construct from three original variables in the data set: These in turn exist of i) the length (= number of days) of a certain kind of employment relationship being upright during the current year, ii) the length of the current kind of employment relationship having been upright until the end of the previous year, and iii) the length of an earlier kind of employment relationship 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 a certain firm. Unfortunately the tenure variable is systematically left-censored before 2002, as we cannot track changes which have taken place before that date.[24] In all three samples, the highest share of employees (around 17%) can be found within the tenure interval between 1 and 2 years (Tenure 5) followed by the intervals 5 to 10 years and below a quarter of a year. Within-

[20] We are able to account for yearly working time insofar as we construct weights according to the number of days, which an employee in fact is occupied in a certain firm and hence contributes to its value added over the given time span and not necessarily for a year as a whole.

[21] The Herfindahl index H 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.

[22] In our application the Herfindahl can be between 0.3 and 1, in which 1 indicates full concentration and 0.3 full diversification.

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

[24] For further details please see the Appendix, p. 31.

sector diversity is considerable as can be seen from the values of standard deviations which are almost as high as the mean values.

Having a closer look at the type of occupation in the complete sample this characteristic is more or less shared between the white-collar and blue-collar working status with 45% each. The differences between sectors are noteworthy. 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 the average firm in the industry and construction sector employs three quarter men, only 58 percent males can be found in a typical firm of the service sector. The high share of male in the former sector corresponds to the high share of blue-collar workers. On average, more part-time workers can be found in the latter sector than in the former, which may be closely related to a higher share of female employees.

5. Regression Analysis

In our empirical study we extend the work in Prskawetz et al. (2007) and Mahlberg et al. (2009), which was originally based on a contemporaneous cross-section of employer-employee data. Since now we can exploit the time dimension of the data, we are able to control for starting conditions and thus for productivity convergence. The possibility of including regressors evaluated at the beginning of our time period should also at least partly alleviate the potential endogeneity problems mentioned above. In addition, we aim at comparing age-productivity with age-wage profiles in order to draw conclusions concerning their similarities and/or differences.

We first present the results for the full matched employer-employee sample. Afterwards, we show outcomes for the two sub-samples corresponding to industry and construction, on the one hand, and services on the other. The dependent variables are the natural logarithm of mean value added per employee, i.e. labour productivity (productivity regression) and wages per employee (wage regression) over the 2002-2005 period. All independent variables are taken as values in the year 2002 and ordinary least squares estimation is used to obtain the parameter estimates. The lack of sufficient time variation in the data, which particularly holds for the age structure within firms, does not allow us to further exploit the panel structure of the data. Our procedure ensures the mitigation of endogeneity in terms of reverse causality to a certain extent, as the timing of events is marked by a clear direction.

In order to guarantee the highest possible comparability, we include the same set of regressors in both estimations. Mean value added per employee as well as mean wages per employee are regressed on three age-share variables, the Herfindahl index for age shares, twelve tenure-share variables, gender shares, firm-specific variables such as the natural logarithm of value added per employee in 2002, 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, the natural logarithm of investment in fixed assets (both linearly and squared) 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. In this way, we account for the heterogeneity among firms as effectively as possible in order to mitigate the bias which 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 two to three years (Tenure 6), 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.

Table 2: Estimation results on labour productivity as compared to average wages.

Variable	All firms Productivity	All firms Wages	Industry and construction Productivity	Industry and construction Wages	Service sector Productivity	Service sector Wages
Proportion of employees						
Aged under 30	-0.04*	-0.28***	-0.07***	-0.15***	-0.02	-0.33***
Aged 30 to 49 (ref.cat.)	-	-	-	-	-	-
Aged over 49	0.05*	-0.09***	-0.04	0.04	0.07*	-0.14***
Herfindahl index	0.20***	-0.08***	0.08**	0.03	0.22***	-0.13***
Proportion of						
Tenure 1	-0.12***	-0.08***	0.03	-0.01	-0.17***	-0.10***
Tenure 2	-0.04	-0.05*	-0.13**	-0.14***	-0.01	-0.02
Tenure 3	-0.06	-0.06**	-0.04	-0.07**	-0.04	-0.03
Tenure 4	-0.08***	-0.01	0.01	0.05**	-0.15***	-0.06*
Tenure 5	0.01	0.02	0.03	0.04	-0.02	0.01
Tenure 6 (ref. cat.)	-	-	-	-	-	-
Tenure 7	0.00	0.05**	0.06	0.04	-0.04	0.05
Tenure 8	-0.01	-0.00	0.02	0.07*	-0.04	-0.03
Tenure 9	-0.02	0.07***	0.06	0.07**	-0.06	0.07**
Tenure 10	-0.03	0.9***	-0.06	0.03	-0.02	0.13***
Tenure 11	-0.15**	0.06	-0.16**	0.03	-0.06	0.11
Tenure 12	0.20	0.10	0.03	0.46**	0.28	-0.02
Proportion of						
Male employees (ref. cat.)	-	-	-	-	-	-
Female employees	-0.17***	-0.35***	-0.19***	-0.39***	-0.14***	-0.35***
Ln (value added per employee) in 2002	0.59***	0.16***	0.58***	0.17***	0.59***	0.15***
Ln (size of firm)	-0.11***	0.10***	0.04***	0.13***	-0.15***	0.11***
Ln (size of firm)^2	0.01***	-0.01***	-	-0.01***	0.01***	-0.01***
Ln (age of firm)	-0.00	-0.01**	-0.00	-0.00**	0.00	-0.00
Multiplant	-0.04***	-0.06***	-0.03***	-0.02***	-0.04***	-0.07***
Ln (investment in fixed assets per employee)	0.01**	0.01***	0.01**	0.02***	0.01**	0.02***
Ln (investment in fixed assets per employee)^2	0.01***	-	0.01***	0.00*	-	-0.00***

Ln (fixed assets per employee)	0.01***	0.01***	0.03**	-0.02***	0.03***	-0.01*
Ln (fixed assets per employee)^2	-	-0.00***	0.00***	-	-	-
Proportion in occupation						
Self-employed	-0.30***	-1.50***	-0.73***	-1.64***	-0.32***	-1.50***
White-collar (ref. cat.)	-	-	-	-	-	-
Blue-collar (incl. homeworkers)	-0.26***	-0.56***	-0.28***	-0.44***	-0.21***	-0.58***
Apprenticeship	-0.69***	-0.99***	-0.58***	-0.86***	-0.61***	-1.01***
Proportion of						
Part-time	-0.22***	-0.52***	-0.18***	-0.36***	-0.20***	-0.54***
Full-time (ref. cat.)	-	-	-	-	-	
Sector affiliation						
NACE C	-0.08	0.00	-	-	-	-
NACE D	-0.13***	-0.04	-0.08***	-0.02	-	-
NACE E (ref. cat.)	-	-	0.08**	-0.04	-	-
NACE F	-0.13***	-0.02	-0.07***	-0.01	-	-
NACE G	-0.12***	-0.12***	-	-	0.03*	-0.06***
NACE H	-0.13***	-0.06**	-	-	-	-
NACE I	-0.15***	-0.10***	-	-	0.01	-0.04***
NACE J	0.08*	0.02	-	-	0.25***	0.10***
NACE K	-0.09**	-0.04	-	-	0.10***	0.01
Region						
NUTS 11	-0.08***	-0.09***	-0.06***	-0.07***	-0.11***	-0.10***
NUTS 12	-0.03**	-0.04***	-0.04***	-0.04***	-0.02	-0.05***
NUTS 13	0.00	0.02***	-0.02	0.03***	0.02	0.02
NUTS 21	-0.02	-0.05***	-0.03*	-0.04***	-0.02	-0.07***
NUTS 22	-0.04***	-0.06***	-0.04***	-0.05***	-0.05**	-0.08***
NUTS 31	-0.02	-0.05***	-0.02*	-0.04***	-0.01	-0.06***
NUTS 32	-0.01	-0.03***	-0.01	-0.03***	0.00	-0.04***
NUTS 33	0.00	-0.04***	-0.02*	-0.05***	0.01	-0.04***
NUTS 34 (ref. cat.)	-	-	-	-	-	-
Constant	2.12***	3.23***	1.79***	2.87***	1.97***	3.31***
Adjusted R^2	0.75	0.69	0.77	0.75	0.74	0.67
F-test	1168.70***	846.53***	614.77***	549.66***	722.97***	517.66
Number of observations	16,742	16,742	6,958	6,958	9,784	9,784

Significance levels: * 10%, ** 5%, *** 1%

Table 2 shows the results of the estimation for labour productivity as compared to wages. It includes regression results for the complete sample (column 2), as well as for the sample subdivided into the industry and construction sector (column 3) and the service sector (column 4). The regression coefficients on the age categories presented indicate the marginal effect of an increase in the respective share, assuming that the omitted share adjusts.

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 for the complete sample. Our results indicate a negative relationship between productivity and the share of young aged workers as usually found in the literature., but the coefficient of the share of old workers shows a positive sign. Hence, labour productivity appears to be fostered by employing a high share of old workers. For the sample of all firms the coefficient is even significantly positive, in contrast to other studies (e.g. Aubert and Crépon, 2006, Göbel and Zwick, 2009), who rather find a flat profile for old employees. Although our finding of a positive impact of the old age group is less common, similar results can be found in the literature. Van Ours and Stoeldraijer (2010) also obtained an upward sloping age-productivity profile in some estimates using instrumental variables. They trace this result back to an issue of selective attrition. It could be the case that the most productive old employees remain while the least productive older workers leave the firms (and perhaps even the labour force) through, for instance, early retirement. This effect might be even stronger within the Austrian economy, as the domestic labour market is marked by a comparably low retirement age on average. Picking up this idea, we compare the wage profiles for a certain cohort at different ages, i.e. at two different points in time and find that wages for those who remain in the labour force at higher ages, also tended to be higher on average in the past as compared to those employees leaving the labour force earlier.[25] This finding can be interpreted as confirming the intuition behind Van Ours and Stoeldraijer's (2010) explanation. Our findings complement and expand previous estimates obtained for Austria (Prskawetz et al., 2007, Mahlberg et al., 2009), as we are now equipped with the possibility to (at least partly) take into account endogeneity of the age share and unobserved heterogeneity between firms.

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 older than 49 years. Due to seniority wage schemes being in place, a positive partial correlation was expected. While – as compared to the share of prime-aged employees – the firms with a high share of young employees exhibit an even more negative

[25] We are very grateful to René Böheim, who provided these results for us.

correlation with wages than with productivity, firms with a high share of old employees tend to be more productive than those with employees at middle ages, but pay lower wages. From the differences of the age pattern for wages per employee compared to that for labour productivity it can be concluded that wages per employee are not an appropriate measure of labour productivity as the results significantly differ.[26] In addition, these results indicate that on average elderly employees do not tend to be over-paid in Austria as compared to their productivity levels.

In order to test the impact of sector specific heterogeneity, we divide our sample into two parts representing the economic segmentation according to the entirety of the industry and construction (NACE C to NACE F) as well as service (NACE G to NACE K) sector. 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 main sectors. The most central findings are related to our variables of interest: While the negative wage impact emanating from the share of young employees is rather robust, the results with regard to the share of old aged employees are quite different and insightful. The positive productivity contribution of employees aged 50 years and above predominantly arises from service sector firms, whereas we cannot find any hints on seniority wage payments[27]. Considering that the service sector comprises two thirds of overall economic activity and still expands – while the industrial and constructional sectors may be characterised as more traditional -, these results are plausible on the one hand as well as promising with regard to the ongoing demographic development on the other. While more conservative working contracts usually encompass an unlimited time period accompanied by wages rising with age and/or tenure[28], contemporary wage policy might be aware of the necessity to disentangle wages from age. Furthermore, working in the market oriented service sector does not require physical strength as a rule, which typically diminishes when getting older. On the contrary, attributes that even improve over age, like experience, may become

[26] A significant difference between the coefficients has been confirmed by a test conducting a regression on the according differences. The difference between (the natural logarithm of) labour productivity and (the natural logarithm of) aggregate wages per capita (= productivity-pay gap) are regressed on the same set of regressors as the production function and the wage equation. 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 we do reject the null-hypotheses that the coefficient for the share of old employees within the productivity-pay-gap regression is equal to zero.

[27] The according coefficient loses significance as soon as we control for actual working days during a year.

[28] In the wage equation displayed in Table 2 we observe a comparably large and positive coefficient for the share of workers in the highest tenure interval.

more important and thus, positively foster labour productivity – particularly aggregated within firms.

While a higher age concentration favours labour productivity, age diversity is positively associated with wages on average in the overall sample and in the service sector. On the one hand, employees within one age group might cooperate more efficiently due to a similar working behaviour, attitudes and way of communication. On the other hand, a more equal age distribution of employees, which may be seen as a certain scarcity of single age groups, strengthens their bargaining position, whereas a higher age concentration – being identical with the prevalence of a certain age group – would lead to lower wages for the respective employees due to competitive pressure.

As we would like to disentangle pure age from seniority effects, we additionally control for the length of employment, i.e. the tenure, of employees. These variables have to be interpreted with caution due to the above mentioned left-censoring. However, the overall picture hints towards a negative impact of a higher share of employees with a rather short tenure, while the coefficients also unveil the senior wage effect, i.e. wages rising with tenure. On the contrary, a very high tenure obviously decreases labour productivity, which may reveal the true relationship standing behind the superficial negative old age effect, if one does not separately control for the length of stay within a firm. As compared to estimations which does not include any kind of tenure control as an explanatory variable (not shown here but available from the authors upon request), we see a decrease both in the magnitude of the age coefficients as well as their significance to a plausible degree in our regression results at hand.

While mean value added per employee in the baseline year is clearly positively related to average labour productivity as well as wages over the whole period, firm age does not appear to be relevant, and the same is true for the capital and investment variables. The organisational form of being a multi-plant enterprise has a slightly negative effect; thus, decentralised ways of economic management may be less effective than pooling the complete business at one place. Firm size starts off negatively for labour productivity with a slight increase for higher values. Small-sized firms face training costs for further employees entailing opportunity costs in terms of foregone production as well as a calculative dilution effect of per employee output. From a certain threshold level onwards larger firms are able to benefit from specialisation and scale effects respectively. Labour productivity reaches a minimum at a firm size of 245 employees. For wages we obtain an inverted picture. Small firms are not able to cope with high labour costs. In order to reach a certain size and thus satisfy the contingent of labour demand, the employer has to and is more able to pay higher wages. Having obtained a specific standing in terms of firm size, labour demand eases and therewith the need for paying high wages decreases. Maximum wages are paid in firms with around 148 employees.

Relative to the reference category of white-collar workers the three further occupational groups negatively impact the dependent variables. Thereby, apprenticeships show the worst effect on labour productivity, while the coefficient on self-employed persons is of highest negative magnitude for wages. The former are costly in terms of training costs, whereas the latter rather keep their own salaries low, as a running business is of preference. As expected, given the widespread evidence of gender wage gaps, a higher share of female as opposed to male employees has a negative impact on both dependent variables with this effect being stronger for wages. The same holds for part-time as compared to full-time employees.

With regard to a firm's sector affiliation the productivity and wage effects are quite similar for some sectors. It is noticeable that manufacturing (NACE D) or construction (NACE F) business tend to show lower average labour productivity as compared to NACE E (electricity, gas and water supply), while there is no effect on wages. We see the contrary effect for financial intermediation (NACE J), where wages cannot stick with the positive labour productivity effect. Hotels and restaurants (NACE H) suffer from even lower relative labour productivity than wages.

For the regional location of firms all of the coefficients are significant in the wage regression. As compared to Vorarlberg (NUTS 34) wages are higher in Vienna (NUTS 13), but lower for instance in Carinthia (NUTS 21), Upper Austria (NUTS 31), Salzburg (NUTS 32) and Tyrol (NUTS 33) without showing hardly any effect on labour productivity.

6. Conclusions

In this study, we analyse the relationship of the age composition of the workforce and labour productivity on the one hand as well as average wage per employee on the other in a broad sample of Austrian firms. By comparing the age-productivity and age-wage profiles we test whether old workers are worth their pay. In order to investigate the rule of sector affiliation of firms, we split our sample in two parts, one with firms belonging to the industry and construction sector and another one of companies belonging to sectors of market oriented services. The analyses are based on a newly created matched employer-employee panel data set covering the years 2002-2005. Endogeneity in terms of reversed causality is taken into account by the time structure of the data.

Summing up the results of our analysis, we find a negative effect of the share of young workers (29 years and younger) and a positive effect of the share of old employees (50 years and older) on labour productivity. The negative impact of young workers appears particularly in firms of the industry and construction sector whereas the positive relationship of old workers is prevalent in firms of the service sector. This result is contrary to former studies, but accords to more recent ones. Our estimates suggest that some of the previous studies might imprecisely estimate the impact of older age employees on productivity.

This outcome might be traced back, first, to the fact that in contrast to other studies, endogeneity of the age shares as well as essential information correlated with productivity and age shares such as workforce tenure are taken into account. A positive selection effect of employees at higher ages might be a second reason. In general the Austrian labour market is characterised by a rather low effective retirement age, so that those employees older than 50 years, who are still in the labour market, may be the productive ones.

Based on our results, we do not find an indication that the ageing workforce will necessarily lead to a welfare decline in industrialised economies, since on average the age-productivity profile is flat from prime-age onwards (in the industry and construction sector) or even positive (in the service sector). Furthermore, our findings imply that there is considerable variation in the age-productivity profile amongst the firms in the Austrian economy.

Moreover, we find an inverted u-shaped age-wage profile which means a simultaneous, negative effect of the share of young employees (29 years and younger) and old employees (50 years and older) on wages per worker in the sample of all firms. Again, this pattern depends on the affiliation of firms. The negative impact of young workers can be found in the industry and construction sector as well as in the service sector. On the contrary, the negative influence of old employees is prevalent just in the service sector whereas our results do not reveal any significant effect in the industry and construction sector.

To conclude, the estimates do not yield any evidence for an over-payment of old employees as compared to their correlation with productivity. In fact, the opposite seems to be the case. In the service sector (as well as overall sample) our results indicate that productivity increases, whereas wages per employee decrease, when the share of old workers rises. From these findings we conclude that in the service sector old employees seem to be rather under-paid. For the industry and construction sector the results are not that clear-cut, since no significant evidence has been found for any kind of relationship between old workers and productivity as well as wages. Finally, we would like to add two remarks: Obviously, at least part of the expected negative old-age impact on labour productivity as well as seniority wage effect might be due to the length of stay within a firm. Moreover, also for young employees the wage and productivity effects do not coincide, indeed they rather seem to be underpaid. Thus, in the light of a growing share of an elderly workforce in the future there is not necessarily a need to catastrophise according to the results at hand.

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Appendix

Table A.1: Tenure – Examples.

Year	Duration in current year	Duration in previous years	Duration of previous employment span	Tenure
	(1)	(2)	(3)	(1)+(2)+(3)
2002	365	2,922	0	3,287
2003	365	3,287	0	3,652
2004	366	3,652	0	4,018
2005	365	4,018	0	4,383

Note: "Experience" is proxied by firm-specific tenure, which we constructed from three original variables in the data set: These in turn are
i) *Duration in current year* = number of days a person has been assigned to at least one kind of "qualification" during the current year,
ii) *Duration in previous years* = number of days until the end of the previous year this person has been assigned to that kind of "qualification", which is the first one still existing in the current year, and
iii) *Duration of previous employment span* = number of days this person has been assigned to another kind of "qualification" in the past, which has ended at the latest, before the current kind of "qualification" has started.
Thereby, "qualification" refers to a certain type of social security status.

Explanation of the example:

In general, the overall tenure (column (1)+(2)+(3)) amounts to the sum of the length of an employee's stay in a firm within a current year (column (1)) in addition to the according duration in the years before (column (2)) as well as the duration of a potentially existing previous employment span (column (3)). Thus, e.g. in the year 2004 the tenure amounts to 4,018 days and is comprised of 366 days in 2004 plus 3,652 days stemming from 2003 and years before. In the above named example there is no contribution from any duration of some previous employment span, since the considered employee has not been assigned to any further "qualification" in the same firm during the observation period. For the details to be taken into account as well as the exact definitions please see the text (p. 16) as well as table notes.