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Work force ageing and expanding service sector: a double burden on productivity?†

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Expansion of the service sector has often been considered as a threat to aggregate productivity. We examine whether work force ageing is a cause of further concern in the service sector, using matched employer–employee data from Finland. The results show hump-shaped relationships between average age of the work force and establishment productivity. The results vary somewhat across different service industries (hotels and restaurants, trade, transportation, and business services). The conclusion is that there is some worry about a double burden from ageing of the work force and expansion of the low-productivity service sector, especially in the labour-intensive, low-skill fields.

Keywords: ageing; productivity; wages; services; Baumol's disease

Introduction

Ageing of the labour force is posing challenges to economic policies in many respects. When the baby boomers will retire, economies have to deal with higher economic dependency ratios and increasing burdens for public sector finances. Even prior to that stage, we will face the situation where the average age of the labour force is rapidly increasing. One relevant question is related to labour productivity in the era of population ageing. Ageing would have a negative effect on economic growth, if, on average, older workers were less productive than their younger counterparts. Former empirical research has given at least some support to this worry.

Population ageing is not occurring in isolation. At the same time, there are other major societal changes that are influencing the growth patterns and labour market developments. The further increasing role of the service sector in the high-income economies is one of these major changes. The employment share of the service sector has grown consistently with the economic growth for many decades, and there seems to be no end to this general trend (OECD, 2000). Accordingly, it is worthwhile to consider the effects of population ageing and the increasing role of the service sector also in interaction.

Many large service branches are labour-intensive and they are not characterized by high frequency of technological innovations, for instance. Accordingly, when employment in the low-productivity service sector is expanding more rapidly than in the industrial sector, there is a risk of aggregate productivity growth to slow down. At the same time,

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unit costs of service increase if service sector wages follow wage setting in manufacturing. The phenomenon has been labelled as Baumol's disease after Baumol (1967). The current trends imply that both the population ageing and the change in the production structure may simultaneously put pressure on the overall productivity and future growth prospects of the economy.

Additionally, it has been argued that population ageing itself can further increase the demand for labour-intensive services. This is based on the empirical observation that the elderly spend typically more on services than the rest of the population. For example, Lührmann (2005) has projected that ageing will increase especially the expenditure shares of health and leisure goods. This development could even strengthen the risk of slower productivity growth in coming years, especially in countries where population is ageing rapidly like in Japan and Finland.

On the other hand, the effect of the ageing work force on productivity may be less severe if the rising average age has less harmful effect on productivity in the service branches than in the industrial sectors. This could be the case if service sectors, on average, are characterized by tailored and differentiated products that require the work force to be more experienced than in industrial branches. In this case, the rising share of services in the economy would help to mitigate the productivity problem. On the other hand, the sectoral differences could go the other way round so that the effect on productivity could be strengthened rather than mitigated.

The above phenomena call for an analysis that looks at the interrelationships between the production structure, the age of the work force, and productivity, and these are the issues that we deal with in this paper. The focus is on the sectoral differences in age–productivity relationship. However, information on the sectoral differences in the effects of age diversity is also useful when we consider the possibilities to mitigate the effects of population ageing on productivity. Accordingly, one needs to analyse also the age composition of the work force. For example, an age-diversified work force performs better than an age-homogeneous one, if workers of different ages are complementary. This is likely to be the case, if the skills of older employees differ from those of the younger ones because of the 'vintage' of the formal education and the level of firm-specific human capital, for instance.

At the societal level, age diversity is considered as a 'social good', one element of a good society as such. This being the case, it is natural to ask whether age diversity seems to imply also economic gains. The economic gains can be measured at different levels. In this paper, we try to measure these economic gains at the level of an employer and also at the level of an employee. Economic gains at the level of the employer are measured by analysing the effects of age diversity on productivity at establishment level. If age diversity is good for establishment-level productivity, one expects this to be reflected also at the level of individual wages. This being the case, this paper deals also with sectoral differences in the effects of age and age diversity on individual earnings.

The analysis of the relationship of age and earnings is also important since the age effects on productivity would not be as much a concern if they were accompanied by corresponding effects on wage. This would leave the firms' profitability unchanged. If there is a discrepancy between the developments of productivity and wage by age, the general ageing process may lead to a deterioration of the performance of firms.

Our research is related to three different strands of literature. One is the analysis of service sector expansion and employment growth and the subsequent productivity impacts (see, e.g. Gregory, Salverda, & Schettkat, 2007; Schettkat & Yocarini, 2006). The second is the analysis of age–productivity profiles that has used various methods

and data sets, including linked employer–employee data sets (see Skirbekk, 2004, for a survey). The third area is the analysis of the effects of age diversity, which has mostly been conducted in human research management studies (e.g. Williams & O'Reilly, 1998). We use Finnish-linked employer–employee data (FLEED) at the establishment and the individual employee levels to examine the issues. We find that there is indeed some reason to be worried about the ageing process in the service sector. Fortunately, the age–productivity profile peaks earliest in business services, where this can be compensated by raising the educational level of the work force. In other services, work experience is a partly compensating factor. We observe mixed effects from increasing age diversity at the workplaces.

The structure of this paper is the following. The next section gives the background information on the role of the service sector and the share of older employees in some OECD countries. Then we present the Finnish data that are used in the empirical analysis. The following two sections present results on establishment-level productivity analysis and on individual wages. The final section concludes the paper.

Descriptive evidence on service labour markets

The increasing employment share of private services[1] is a common feature to all the high-income countries analysed in Figure 1. This is not a coincidence: the underlying forces are common to all these countries even though the relative roles of the explanatory factors differ from country to country. One crucial background factor relates to general increase in the living standards of the citizens in these countries and the high income elasticity of the demand for these services. The higher labour market participation of women has also contributed. First, it has increased the family income and thus the potential to buy services from the market sector. Secondly, higher labour force participation has also made it necessary to substitute services bought in the market for the former home work. The

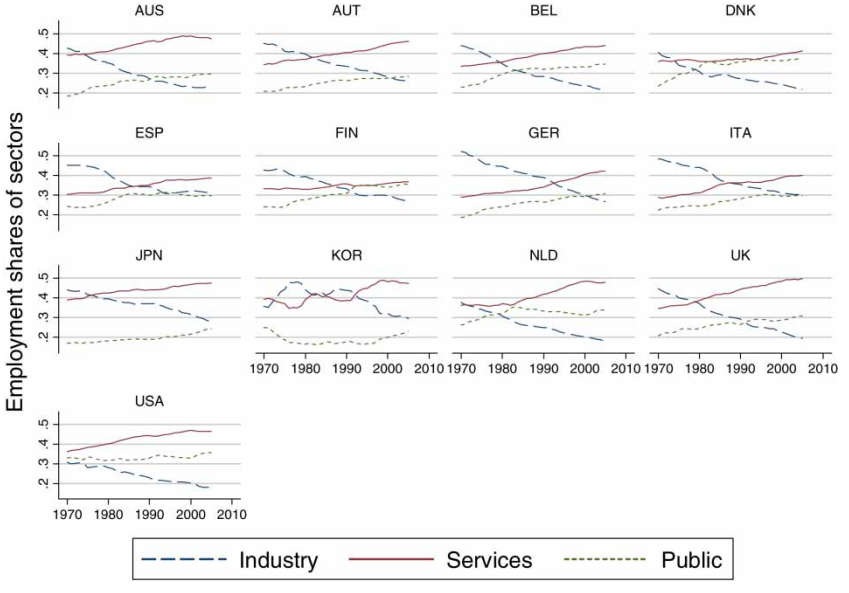

Figure 1. Employment shares of main sectors in some OECD countries.

expansion of the service sector is also related to structural changes in the ways firms organize their production. In other words, services that were previously produced within the goods-producing firm are currently bought from the market (Gregory et al., 2007). The economic rationale for these phenomena relates to the possibilities to better timing and avoiding the unnecessary fixed costs. The expansion of business services which are not final goods, but used as intermediate inputs in the production of other goods, may actually lead to faster growth, contrary to the original Baumol's disease argument (Oulton, 2001).[2]

While the increasing trend of services is common to all countries in question, there are still important differences among them, too. In some countries, the employment share of services is nearly half of the total employment (USA, UK, Austria, The Netherlands, Australia, Korea, and Japan – in Figure 1: AUT, NLD, AUS, KOR, JPN) while in the rest of them that share is clearly smaller (Belgium, Denmark, Spain, Finland, Germany, Italy – in Figure 1: BEL, DNK, ESP, FIN, GER, ITA). For some countries in the latter group, this smaller share of private services seems to stem from the noticeable employment share of public services (especially Finland and Denmark) implying some kind of trade-off between the types of service sectors.

A large difference in the sizes of the age cohorts is also a common feature of many of these countries. The large baby boom cohorts were born during somewhat different time periods and accordingly the ageing of the work force is also taking place at different speeds. Figure 2 indicates that in the countries where population is ageing most rapidly (Japan and Finland), this has already been reflected in the distribution of working hours by the age of the employees. In these countries, a quarter of the total working hours come from the labour input of those over 50 years old.

In many countries, there are only minor sectoral differences in the amount of work carried out by those over 50 years old. In the Nordic countries Finland and Denmark, and also in Germany, public services seem to employ somewhat older employees than the two other sectors. Japan is a country where the share of older employees (or their

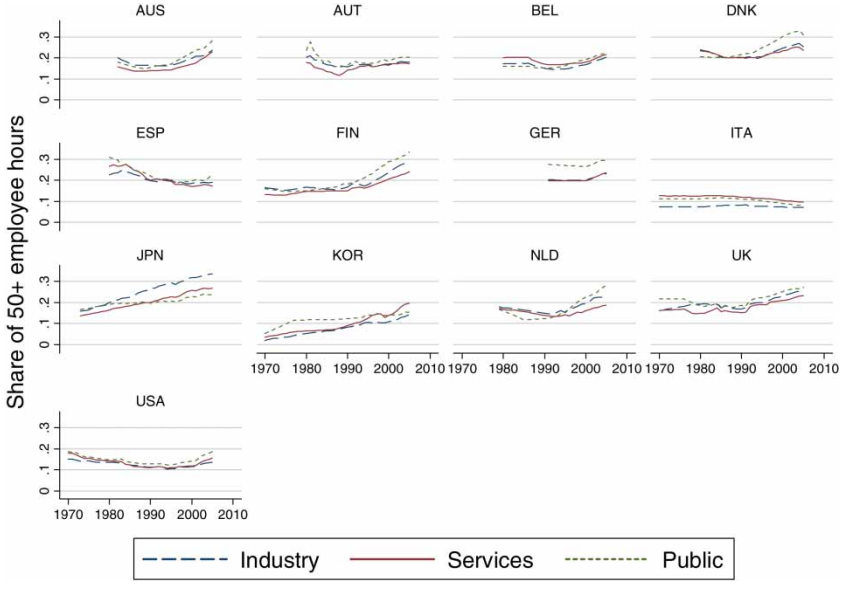

Figure 2. Share of 50+ employee hours in some OECD countries.

hours) seems to be larger in the industry sector than elsewhere in the country. In general, there does not seem to be a clear pattern of whether the work force in the service sector is typically younger or older than in the rest of the economy. Furthermore, one has to notice that the change in the amount of work carried out by older employees is not only affected by the changes in the age structure. This phenomenon is clearly dependent also on institutional arrangements, like incidence of part-time work and pension laws that have influence on the employment rates and number of hours of older employees.

Next, we take a closer look at a country that is clearly facing the situation of rapidly ageing work force, namely Finland. In Finland, the peak of the baby boom took place relatively early, around 1947, and the size of that 1947 cohort was about 40% larger than the size of the age cohorts born, e.g. in early 1970s. The baby boom cohorts are entering their retirement age around 2010, but the relative size of these cohorts has already been reflected in the increasing average age of the employees. Figure 3 shows the development of the distribution of plant average ages in the industrial and service sector establishments in Finland using kernel densities. The upper part of the figure shows the distributions in 1995 and 2004 for the aggregate service and industry sectors. In the service sector, the average age tends to be lower than in industrial establishments, and this difference has widened over time as the age distribution in the industry sector has shifted more to the right.[3] The average over all establishments has stayed constant at 37.5 in services, but increased from 38.4 to 40 in the industry sector. The distributions have flattened, which implies more variation in the age structure across establishments. The lower part of the figure disaggregates services to trade (including hotels and restaurants), transportation and communication, and business services. Also these latter two distributions have shifted to the right over time. The workforce average age is highest in the transportation industry.[4]

Finally, since the development of the employees' experience also matters, we examine the distribution of the establishment-level average tenure (Figure 4). In the industry sector, employees have more firm-specific experience than in services and the difference between

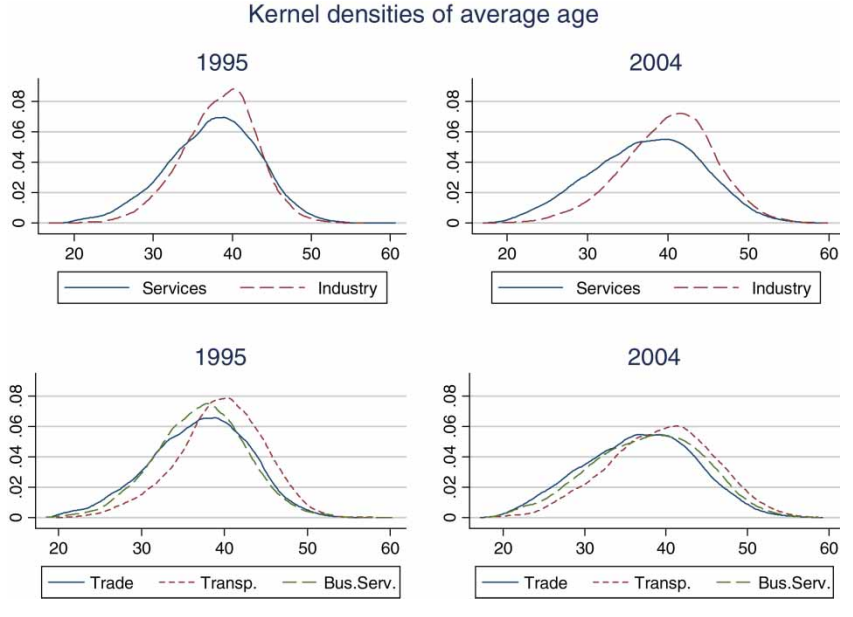

Figure 3. Distribution of average age of employees, Finnish establishments.

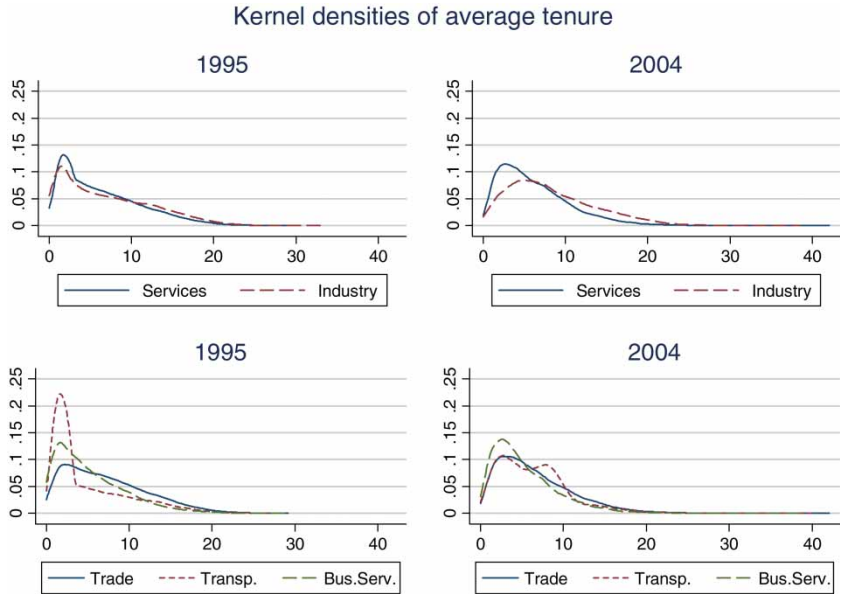

Figure 4. Distribution of average tenure of employees, Finnish establishments.

the sectors has widened over time. From 1995 to 2004, the mean of average tenures has increased from 7 years to 8.3 in the industry sector, but it has been fairly stable in services (6.4 years in 1995 and 6.2 in 2004). Among service industries, tenure has increased in the transportation and communication industry.

The data

We investigate the relationship between ageing and productivity in services in two different ways. First, we analyse how the employee age structure of establishments is reflected in their productivity. Second, we study how the earnings of individual employees depend both on the age of their own and also the establishment age structure. If wage-setting is based on productivity, we should see the same kind of age effects at both levels. In addition to age, we include some other relevant demographic variables like tenure and education in the analysis.

For the analysis of the relationships between age, productivity, and wage, we use data drawn from the FLEED. The Finnish system of registers covers the whole population and all firms and their establishments. Each individual has a personal identity code and each establishment an establishment code. In addition, the person data includes the establishment code of the person's workplace at the end of the year. The individual and establishment codes therefore allow following individuals and employers and linking data on them with near-perfect tractability over time (see Ilmakunnas, Maliranta, & Vainiomäki, 2004).

We use a sample drawn from FLEED. Every third individual in the age group 16–69 years old is randomly included in the sample in the year 1990. This sample includes circa 1 million individuals. For these individuals, all information from the subsequent years 1991–2004 is included. Starting from 1991, in each year a third of all 16 years old persons are selected for the sample and these individuals are included in the sample in all subsequent years. For each individual in each year, the data on the establishment

that she/he is working in is included. In addition, data on these establishments is included for all the years. Hence, even if an establishment appears only once as the employer of one worker in the sample it is included in all the years. As a result, the data cover practically the whole populations of establishments for all the years, but the person panel is a sample.

The person data has rich information on the individuals. We use data on age, education, tenure, gender, and earnings. From the establishment data, we use information on productivity and size (number of employees). In addition, we have data on various employee characteristics at the establishment level, like the average age and standard deviation (SD) of age. These variables have been calculated from the original FLEED data (i.e. the total data and not our sample data).

In this study, we concentrate on establishments and employees in the service sector, which we define to include (i) retail and wholesale trade, hotels and restaurants, (ii) transportation and communications, and (iii) business services. This covers most of the private service sector, except for financial intermediation, where output measurement is difficult, and personal services. Besides the whole service sector, we also analyse the three subbranches, which represent somewhat different types of services. Trade, hotels, and restaurants are traditional services which are produced for final consumption. It can be argued that they also require relatively low education. In the other extreme, business services include several high-skill activities (but also some low-skill ones) and the services are provided as intermediate inputs to other firms. Transportation and communication fall in between the other two fields. For comparison purposes, we also carry out analysis on the industrial sector, defined to include manufacturing, mining, and energy. We restrict attention to the data period 1995–2004, leaving out the early 1990s, which was a period of deep recession in the Finnish economy, and therefore not representative.[5]

The establishment data set used in the estimations includes over 340,000 establishment-year observations (over 220,000 in the service sector and close to 120,000 in the industrial sector) from over 68,000 establishments (46,000 in services and 22,000 in industry sector). The data on individuals are restricted to those who work in establishments that were included in the productivity analysis. This data have over 2,670,000 person-year observations (1,290,000 in services and 1,380,000 in the industry sector) of over 560,000 individuals (over 300,000 and 260,000 in services and industry, respectively).

Establishment productivity

The first step in our analysis is to examine how the age structure of the work force affects establishment-level productivity. The data on the establishments come mainly from the Business Register, which has relatively limited data content. In particular, there are no data on capital input or value added. We therefore measure productivity by the *logarithm of real sales per employee*.[6] The lack of capital input data may be problematic, but earlier comparative work using different kinds of data (Ilmakunnas & Maliranta, 2005) shows that reasonable estimates of the relationship of employee characteristics and productivity can be obtained even with the kind of data we have. They showed with manufacturing data that relatively similar results are obtained if value added is explained by capital, labour, and labour characteristics, if total factor productivity is explained by labour characteristics, and if real sales per worker are explained with labour characteristics. An alternative would be to use firm-level data, in which case value added and capital input could be computed from accounting information. However, as one of our purposes is to examine the role of work force age diversity, the establishment is a more relevant work unit.

To describe the structure of the work force, we use the following variables:

Average work force characteristics
- average age of employees and its square
- average years of tenure of employees and its square
- average education years of employees[7]

Dispersion of work force characteristics
- SD of employee ages
- SD of tenure years
- SD of education years

The model we estimate is the following:

$$\begin{aligned}\ln(\text{Real sales/employees})_{jt} &= \alpha_j + \beta_1 \text{average age}_{jt} + \beta_2 \text{average age}^2_{jt} \\ &+ \gamma_1 \text{average tenure}_{jt} + \gamma_2 \text{average tenure}^2_{jt} + \phi \text{average education}_{jt} \\ &+ \lambda_1 \text{SD of age}_{jt} + \lambda_2 \text{SD of tenure}_{jt} + \lambda_3 \text{SD of education}_{jt} + \delta' X_{jt} + \varepsilon_{jt}, \qquad (1)\end{aligned}$$

where the subscript j indexes the establishments and t time. Our expectation on the relationship between these variables and productivity is the following. There is a 'stylized fact' that productivity increases first with age, but its growth starts to slow down and at higher ages the productivity may fall, giving an inverted U-shaped productivity–age relationship at the individual level (Ilmakunnas, Skirbekk, van Ours, & Weiss, 2007; Skirbekk, 2004). Aggregated to establishment level, this would give the same shape for the relationship between establishment productivity and average employee age. We therefore expect the average age to have a positive ($\beta_1 > 0$) and its square a negative ($\beta_2 < 0$) relationship to productivity.

A similar relationship may appear between tenure and productivity. Typically, work experience improves productivity, but this process slows down with time spent with the same employer. Again, a similar relationship should hold at the establishment level for productivity and average length of tenure. We therefore expect average tenure to have a positive ($\gamma_1 > 0$) and its square a negative ($\gamma_2 < 0$) relationship with productivity. It is often argued that older workers can compensate their age-related productivity decline by longer experience. It is therefore important to include also tenure in the productivity equation. Note that this measures firm-specific experience, whereas age itself is closely related to total work experience over the working life (i.e. 'potential' experience is age minus education years).

The education variable is entered in a linear form to be consistent with the way in which the (wage) returns to education are usually estimated at the individual level. If these returns reflect the productivity gained through education, we expect average years of education to have a positive ($\phi > 0$) relationship to productivity at the establishment level.

The SDs of employee characteristics take into account the effects of work force diversity on productivity. Age diversity and other kinds of diversities have attracted a lot of attention in the management literature (see, e.g. Jackson, Joshi, & Erhardt, 2003; Riordan, 2000; Williams & O'Reilly, 1998, for surveys) and to some extent in labour economics (e.g. Grund & Westergård-Nielsen, 2008; Ilmakunnas et al., 2004, 2007). It is often argued that when old and young employees work together, tacit knowledge can be transferred to the younger ones. This compensates for the slowing down of productivity growth by age. Similarly, more and less experienced employees, or highly skilled (educated) and less

skilled, may benefit from working together. The management literature interprets this as diversity reducing conflicts and increasing commitment to the group. In the jargon of labour economics, this reflects complementarity of the skills of the young and old (or experienced and inexperienced, or employees with high and low education). This kind of complementarity would show up as positive coefficients of the SDs of employee characteristics in a productivity equation ($\lambda_k > 0, k = 1,2,3$). There is, however, a reverse argument. If the tasks are such that they are performed best when employees of similar age (or similar experience, or similar skills) work together, the SDs would have negative coefficients ($\lambda_k < 0,\ k = 1,2,3$). This is sometimes called the O-ring argument (Kremer, 1993).[8] Another interpretation is that when employees are of the same age (and in the same career stage), there is more competition between them and hence pressure to perform well. Thereby, diversity would be negatively related to productivity. Naturally, the effects of age, tenure, and educational diversities need not be similar. We have to interpret the diversities with some caution, however, since diversity at the establishment level can coexist with homogeneous work force at a more disaggregate level, like work teams.

As control variables (the X's in Equation (1)), we include indicators of establishment size groups (under 20 employees, 20–49, and 50–99, 100 or above is the reference group) to account for possible scale effects on productivity, and indicators for years to account for cyclical effects and productivity trends that are common to all establishments. The share of female employees is entered as control variable to take into account the fact that there may be selectivity of females to certain kinds of occupations and industries which may have low productivity not related to gender.

To take into account unobservable establishment characteristics that might be correlated with the age structure and other employee characteristics, we estimate the model by allowing for establishment-specific effects α_j in Equation (1). Since the model is then estimated using the variables as deviation from establishment means, we cannot include control variables that do not vary over time within an establishment. Therefore, we do not include indicators for industries, regions, or establishment cohorts. Since the error terms belonging to the same establishment are likely to be correlated, we correct the standard errors for clustering within establishments.

Table 1 shows the estimation results. The first column includes results for the whole service industry. The next columns show the results for three disaggregated services: trade, hotels, and restaurants (column 2), transportation and communication (column 3), and business services (column 4). Finally, the last column presents for comparison purposes the results for the industrial sector.

There is a significant age effect in the service sector, but this seems to be driven by the business services. In trade, hotels, and transportation the age terms are not estimated precisely. For the whole sector, the estimates imply an inverted U-shaped relationship with peak at 43 years of average age and in business services at 35 years. Taken at face value, the estimates for trade and transportation would imply peaks at 54 and 39 years, respectively. Given that in the whole service sector the typical establishment has the average age of employees below 40 (see the year 2004 means of the establishment-level average ages in Table 2), a considerable share of establishments would be in the increasing part of the hump-shaped age–productivity profile. However, in business services, relatively more establishments are in the declining part of the hump, which may be explained by more knowledge-intensive activity which requires more recent education.[9]

In the industrial sector, the age effects are not significant. This is consistent with other recent work with the Finnish data (Ilmakunnas et al., 2010), which shows that while the age–productivity profile in manufacturing was inverted U-shaped in the period from

Table 1. Estimation results for establishment productivity.

	Dependent variable log (Real sales/employees)				
	Service sector	Trade, hotels, and restaurants	Transportation and communication	Business services	Industrial sector
Average characteristics					
Average age	0.007** (0.003)	0.004 (0.004)	0.015 (0.011)	0.025*** (0.008)	0.005 (0.005)
Average age^2/100	−0.008* (0.005)	−0.004 (0.005)	−0.020 (0.015)	−0.035*** (0.010)	−0.009 (0.007)
Average tenure	0.010*** (0.002)	0.002 (0.002)	0.022*** (0.006)	0.008* (0.005)	0.004 (0.003)
Average tenure^2/100	−0.025*** (0.009)	−0.000 (0.009)	−0.059* (0.031)	−0.003 (0.025)	−0.031** (0.012)
Average education	0.009** (0.004)	0.002 (0.004)	0.028 (0.017)	0.017** (0.007)	0.018** (0.007)
Dispersion of characteristics					
Standard deviation of age	−0.002*** (0.001)	−0.003*** (0.001)	−0.005** (0.002)	0.000 (0.002)	−0.002** (0.001)
Standard deviation of tenure	−0.002* (0.001)	−0.001 (0.001)	−0.004 (0.004)	0.002 (0.003)	0.003 (0.002)
Standard deviation of education	0.003 (0.003)	−0.002 (0.004)	0.009 (0.014)	0.005 (0.008)	−0.003 (0.007)
Controls					
Share of females	−0.004 (0.016)	−0.011 (0.017)	0.195** (0.084)	−0.080*** (0.029)	−0.036 (0.028)
Establishment size 0–19	0.409*** (0.039)	0.490*** (0.090)	0.408*** (0.079)	0.381*** (0.044)	0.274*** (0.026)
Establishment size 20–49	0.228*** (0.038)	0.264*** (0.089)	0.239*** (0.071)	0.235*** (0.042)	0.170*** (0.023)
Establishment size 50–99	0.095*** (0.031)	0.074 (0.073)	0.170*** (0.056)	0.099*** (0.035)	0.083*** (0.018)
R^2 within	0.047	0.041	0.083	0.066	0.074
Number of observations	223,831	138,278	30,715	54,838	117,968
Separate establishments	46,276	27,527	6539	12,714	22,281

Note: Estimation with establishment fixed effects. Standard errors in parentheses, corrected for clustering within establishments. Unreported control variables are indicators for 10 years in all of the models.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

Table 2. Projections of ageing and tenure effects.

	Service sector	Trade, hotels, and restaurants	Transportation and communication	Business services	Industrial sector
Mean of average ages in 2004	37.4	36.7	39.4	37.7	40.1
Productivity effect of 2 year increase in average age, log %	0.1	0.2	−0.1	−0.5	−0.4
Mean of average tenures in 2004	6.2	6.6	6.4	5.3	8.3
Productivity effect of 1 year increase in average tenure, log %	0.7	0.2	1.4	0.8	−0.2
Net effect (%)	0.8	0.4	1.3	0.3	−0.6

late 1980s to early 1990s, more recent data show a rather flat relationship. The point estimate for the age at which productivity peaks is 30.5, whereas the mean of the establishment average ages is clearly higher.

The tenure terms are significant in the whole service sector, but this time also in transportation. In both cases, the estimates imply a peak at around 20 years of tenure, which in practice means that for most establishments tenure has an increasing relationship with productivity in the relevant range of the variables (a typical service sector establishment has average tenure of 6 years). In the industry sector, the tenure effect is imprecisely estimated, but taken at face value would imply a peak at around 6 years of tenure, whereas the mean of the average tenures is 6.8 years. Given that age and tenure may be correlated, we also estimated the models leaving out the tenure terms. The results (not reported in Table 1) showed significant age effects also in transportation and the industry sector. Overall, the estimated peaks of the productivity profiles were a few years later than when tenure was included.

There is a positive but small education effect, close to 1% productivity increase from 1 additional year of average education, which mainly comes from the business services (where the returns are somewhat higher). This is understandable, as business services include more high-skill jobs than the other service fields. In the industrial sector the education effect is quite similar to that in business services.

The SD of age has consistently a negative coefficient (with the exception of business services, where it is zero). The relationship is very similar in services and the industry sector. There is a tenure diversity effect only in the whole service sector and no significant educational diversity effects. These results seem to support the O-ring type of relationship for age diversity.

The coefficients of the control variables show that smaller establishments tend to have higher productivity measured by sales per employee. The effect of the share of females is significant in transportation (positive) and business services (negative). A likely explanation is that the industry classification used still hides rather different activities, for example, from IT services to cleaning in business services, which may have different kinds of typical gender compositions.

The establishment age structure variables, average age and age dispersion, may be endogenous. For example, shocks to productivity (included in the error term) are likely to be correlated with hiring of new, mostly young, employees, and thereby with the age

structure. As a sensitivity analysis of the results we therefore estimated the models using lagged values of the variables as instruments in generalised method of moments (GMM) estimation. Qualitatively the results on the hum shape of the age–productivity relationship were relatively similar to the fixed effects estimates. However, the lagged values did not seem to be particularly good instruments, so these results should be considered only tentative.[10]

All in all, the results show that there may be some concern for employers from the ageing of the work force. If the trend of ageing of the work force continues, more establishments will be in the declining part of the productivity profile. This can partly be compensated with longer tenure. When the average age increases, it is unlikely that average tenure stays constant. Rather, it will also increase, but to a lesser extent (see the distributions in the second section). Older employees are typically less likely to switch jobs, which leads to longer average tenures as the average age increases. As the estimated peaks of the productivity–tenure profiles are in most cases increasing in the relevant range of tenure, the increased experience would be a compensating factor for ageing. In business services, a negative age effect seems to step in earlier, but it can be compensated with a higher educational level. The age effect is more unfavourable in the industry sector, although imprecisely estimated.

To illustrate the combined effects of age and tenure, consider the following thought experiment. We evaluate the contributions of employee average age and average tenure on productivity for an establishment that has the same average age and tenure as the whole sector under consideration in year 2004. Then, we increase the average age by 2 years and average tenure by 1 year and examine the impact on productivity. (These changes are roughly equal to those which happened in the industry sector in 1995–2004.) We use the point estimates from Table 1, irrespective of whether they are statistically significant. Obviously, the confidence intervals of our calculations would in some cases be rather wide.

The means of the establishment average ages and average tenures are shown in Table 2. If the average age increases by 2 years, productivity would drop in transportation, business services, and the industry sector (line 2 of the table). A simultaneous increase in average tenure by 1 year would increase productivity in all of the service sector branches and the net effect is positive (last line of the table). However, in the industrial sector both ageing and increase in tenure contribute negatively to productivity. When we left tenure out of the model and let the age term pick also experience effects, the results were fairly similar, with the exception that a 2-year increase in the average age affected also business services negatively.

Individual earnings

After analysing employer productivity, in the analysis of individual earnings, we concentrate on those employees in the sample data who can be linked to the same establishments that we use in the establishment-level analysis.[11] The FLEED data include information on the annual earnings of the individuals, as well as on months worked. The dependent variable we use is the *logarithm of real monthly earnings*.[12]

We use the following demographic variables to describe the individuals and their workplaces:

Individual-level demographic variables:

- age and its square
- tenure and its square
- education years

Group demographic variables (average characteristics and dispersion of characteristics):

- average age of employees and its square
- average tenure years of employees and its square
- average education years of employees
- SD of employee ages
- SD of tenure
- SD of education years

Relational demographic variables:

- age dissimilarity index
- education dissimilarity index
- tenure dissimilarity index

We estimate the following model, where the individual, group, and relational demographic variables are included:

$$\begin{aligned}\ln(\text{Real monthly earnings})_{ijt} &= \alpha_{ij} \\ &+ \zeta_1 \text{age}_{it} + \zeta_2 \text{age}_{it}^2 + \xi_1 \text{tenure}_{ijt} + \xi_2 \text{tenure}_{ijt}^2 + \rho \text{education}_{it} \\ &+ \beta_1 \text{average age}_{jt} + \beta_2 \text{average age}_{jt}^2 + \gamma_1 \text{average tenure}_{jt} + \gamma_2 \text{average tenure}_{jt}^2 \\ &+ \phi \text{average education}_{jt} + \lambda_1 \text{SD of age}_{jt} + \lambda_2 \text{SD of tenure}_{jt} + \lambda_3 \text{SD of education}_{jt} \\ &+ \mu_1 \text{age dissimilarity}_{it} + \mu_2 \text{tenure dissimilarity}_{it} + \mu_3 \text{education dissimilarity}_{it} \\ &+ \delta' X_{jt} + \epsilon_{ijt}, \end{aligned} \tag{2}$$

where i indexes the individual, j the establishment, and t time. X includes other variables, including the share of females and establishment size.

The individual-level variables age, tenure, and education are typical for wage equations. It is expected that the age and tenure effects are concave ($\zeta_1 > 0$, $\zeta_2 < 0$,; $\xi_1 > 0$, $\xi_2 < 0$). Age and tenure reflect accumulation of general and firm-specific experience, respectively. The coefficient ρ gives the (private) returns to education. Note that we do not include gender, as we are using a fixed effects estimation method that does not allow time-invariant variables. The returns to education are identified through persons obtaining a higher level of education while working, so the years of education is not a fully time-invariant variable.

The use of the so-called relational demographic variables and group demographic variables is based on the large literature on diversity (e.g. Jackson et al., 2003; Riordan, 2000; Williams & O'Reilly, 1998). Relational demography is defined as the extent to which a particular member is different from other members within the same work unit. Group diversity refers to the degree to which a work unit is heterogeneous with respect to demographic attributes.

The group-level demographic variables are the same as those used in the establishment-level analysis. In the case of individual wages, they reflect the spill-over effects that individuals may gain from the establishment level. If these variables influence productivity at the establishment level and if wage setting is based on productivity, one should see a similar effect on individual wages. We therefore expect concave average age and tenure effects ($\beta_1 > 0$, $\beta_2 < 0$; $\gamma_1 > 0$, $\gamma_2 < 0$). The coefficient ϕ of the average educational variable now reflects the fact that individuals may get beneficial

spill-over effects from the educational level of the others, here measured by the general educational level. The interpretation of the establishment-level diversity variables is again similar to that in the establishment-level analysis. If there are productivity gains from a certain kind of diversity at the workplace level, they should be reflected in individual wages, too. There may be skill complementarity ($\lambda_k > 0$, $k = 1,2,3$) or an O-ring effect ($\lambda_k < 0$, $k = 1,2,3$).

The relational demographic variables are dissimilarity measures. These dissimilarity indices measure a person's difference from all the other employees in the same establishment. These have been popular in diversity research in psychology and human resource management (see for example, Harrison & Klein, 2007). The dissimilarity index based on Euclidean distance is defined as square root of the average squared deviation of a person's characteristic (age, education, or tenure) from the corresponding characteristic of the other employees. This can be shown to be square root of the sum of establishment-level variance and squared deviation from establishment-level mean. If A_i denotes age of individual i and there are n employees, the index can be written as

$$\text{Age dissimilarity}_i = \sqrt{\frac{1}{n}\sum_{k=1}^{n}(A_i - A_k)^2} = \sqrt{(A_i - \bar{A})^2 + \text{Var}(A)}, \tag{3}$$

where the bar denotes average. For tenure and education the dissimilarity index is calculated in an analogous way.

Relational demography suggests that individuals compare their demographic characteristics with others at the workplace. Being different from others tends to have a negative impact on work attitudes: the less similar an individual is to his/her peers, the less organizational commitment to work unit there is (for example, Riordan, 2000). This argument would suggest negative dissimilarity effects ($\mu_k < 0$, $k = 1,2,3$), if the organizational commitment is reflected in individual's performance (including, besides productivity, less intentions to quit, better communication, etc.) and therefore also wage. However, the empirical literature has obtained conflicting results on the relationship between age dissimilarity and work outcomes and similarly the results on the effects of tenure and educational dissimilarity are mixed (see Riordan, 2000).

The unobservable characteristics may be correlated with the explanatory variables, thereby biasing the results. We therefore estimate fixed effects models. Using person-fixed effects, we would remove unobservable individual characteristics that may correlate with education, for example. However, within-individual analysis may still leave in the error term unobservable workplace characteristics that correlate with the person's position at the workplace or the establishment-level variables. We therefore estimate the model using match fixed effects (see for example, Andrews, Schank, & Upward, 2006). The matches are defined as separate individual-establishment combinations with match unobservables α_{ij}. Within-match analysis is suited for removing time-invariant unobservables that correlate with the persons' relative positions. In addition, since we have used establishment-level variables to explain the individual-level outcomes and it is possible that observations belonging to the same establishment are correlated, usual standard errors may be biased. We therefore correct the standard errors for clustering within establishments.

Table 3 presents the estimation results. The individual age and tenure effects are concave in all of the industries. The estimates indicate a peak at an age slightly below 60 for the service sector (57 for the whole service sector and 59, 53, and 57 for trade, transportation, and business services, respectively). In the industrial sector the peak is at 62,

Table 3. Individual-level wage models.

	Dependent variable log(Real monthly earnings)				
	Service sector	Trade, hotels, and restaurants	Transportation and communication	Business services	Industry sector
Individual characteristics					
Age	0.084*** (0.002)	0.076*** (0.002)	0.078*** (0.006)	0.110*** (0.004)	0.063*** (0.002)
Age^2/100	−0.074*** (0.002)	−0.064*** (0.002)	−0.074*** (0.005)	−0.097*** (0.004)	−0.051*** (0.002)
Tenure	0.017*** (0.001)	0.017*** (0.001)	0.013*** (0.001)	0.020*** (0.001)	0.017*** (0.001)
Tenure^2/100	−0.012*** (0.002)	−0.010*** (0.003)	0.001 (0.004)	−0.022*** (0.004)	−0.012*** (0.002)
Education	0.096*** (0.002)	0.100*** (0.002)	0.096*** (0.006)	0.086*** (0.003)	0.095*** (0.003)
Group-level demographic variables					
Average characteristics					
Average age	0.016*** (0.004)	0.002 (0.003)	0.026** (0.011)	0.032*** (0.006)	0.021*** (0.005)
Average age^2/100	−0.021*** (0.005)	−0.002 (0.004)	−0.034** (0.014)	−0.041*** (0.007)	−0.029*** (0.006)
Average tenure	−0.005 (0.004)	0.001 (0.002)	−0.011 (0.010)	−0.012*** (0.003)	−0.005*** (0.002)
Average tenure^2/100	0.020 (0.014)	−0.009 (0.007)	0.062 (0.042)	0.029** (0.013)	0.008 (0.006)
Average education	−0.005** (0.002)	−0.007*** (0.003)	0.005 (0.008)	−0.006* (0.004)	0.000 (0.004)
Dispersion of characteristics					
Standard deviation of age	−0.002*** (0.001)	0.000 (0.001)	−0.003 (0.002)	−0.006*** (0.001)	−0.002** (0.001)
Standard deviation of tenure	0.002 (0.002)	0.001 (0.001)	0.003 (0.005)	0.007*** (0.002)	0.001 (0.001)
Standard deviation of education	−0.001 (0.003)	−0.001 (0.004)	−0.019 (0.011)	0.011* (0.006)	−0.008* (0.005)
Relational demographic variables					
Age dissimilarity	0.001* (0.001)	−0.000 (0.001)	0.003** (0.001)	0.002 (0.001)	0.002*** (0.001)
Tenure dissimilarity	−0.002*** (0.001)	−0.004*** (0.001)	0.000 (0.002)	−0.006*** (0.001)	−0.003*** (0.001)
Education dissimilarity	−0.002 (0.003)	−0.003 (0.003)	0.002 (0.008)	−0.004 (0.005)	0.001 (0.003)
Controls					
Share of females	−0.004 (0.011)	−0.019 (0.012)	0.046 (0.046)	−0.004 (0.018)	0.008 (0.017)
Establishment size 0–19	−0.052*** (0.006)	−0.037*** (0.009)	−0.001 (0.015)	−0.077*** (0.011)	−0.049*** (0.006)
Establishment size 20–49	−0.023*** (0.006)	−0.012 (0.008)	0.007 (0.011)	−0.040*** (0.010)	−0.018*** (0.005)
Establishment size 50–99	−0.011*** (0.004)	−0.008 (0.006)	0.003 (0.008)	−0.021*** (0.007)	−0.007* (0.004)
R^2 within	0.084	0.084	0.068	0.098	0.107
Number of observations	1,293,105	650,345	263,001	379,759	1,382,522
Separate matches	464,686	226,294	85,541	155,380	353,079
Separate individuals	303,619	163,915	61,120	115,823	260,286

Note: Estimation with match fixed effects. Standard errors in parentheses, corrected for clustering within establishments.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

indicating that for practically all employees the predicted earnings are rising until retirement age. There is an additional effect on individual earnings from the establishment average age. Also this is concave, with peak at 38 years of average age in the whole service sector and in transportation and 39 in business services; in trade the average age terms are not significant. The establishment-level results indicated a peak in productivity at a relatively similar average age. Therefore, it seems that the establishment-level productivity development is at least to some extent transmitted to wages. However, this still leaves a large share of earnings affected by the individual's own age. There can hence be some discrepancy between the developments of productivity and earnings by age. In the industry sector, the shape of the relationship between earnings and average age is quite similar to that of the services, with a peak at 36 years, whereas at the establishment level the age effect was imprecisely estimated.

The tenure estimates imply a peak at such high individual tenures that earnings are actually increasing throughout tenure in the range of tenure observed, but the establishment average tenure effects are mostly non-significant or negative. The returns to individual's own education are fairly consistently 9–10% in all of the industries. It seems that individuals get a higher return on their education than what is the return at the firm level. The spill-over effect from establishment average educational level to individual earnings is a small negative figure or insignificant.

The establishment-level diversity measures are in most cases insignificant. There is some evidence of negative age diversity effect both in the service and industrial sectors, but in services this is driven by business services. There is also a negative educational diversity effect in the industrial sector. The only statistically significant positive diversity effects are the tenure and educational diversity effects in business services. All in all, these results give weak support for the O-ring argument. If the ageing process leads to very varying age structures, this might have adverse effects. The results may again be driven by high productivity in low-diversity 'only young' workplaces. However, especially in business services there seem to be compensating factors.

Among the control variables, we can see that larger establishments pay more. There is no female share effect, but as in workplaces with a high share of females the share stays relatively stable over time, there is little variation in this variable within job matches. Without the fixed effects, pay would be lower in female-dominated workplaces.

Age dissimilarity has a positive, but small coefficient in the service sector as a whole and in transportation. This is similar to what is found in the industrial sector. Tenure dissimilarity, on the other hand, has mostly negative coefficients. Finally, educational dissimilarity has mostly negative, but insignificant coefficients. These results imply that a person's work outcome, here measured by earnings, is positively related to working in an environment with employees of different age than him/herself. Note, however, that the group-level result (SD of ages) is different from the relational result (age dissimilarity). One possible explanation is that in 'old-dominated' workplaces the earnings of the young tend to be pulled up, leading to a positive dissimilarity effect. Similarly, in 'young-dominated' workplaces the possible productivity losses of ageing workers can be compensated by working with the young.

Conclusions

We have empirically examined whether work force ageing has productivity effects on the service sector and whether these effects differ from what is happening in the industrial sector. We have used the FLEED data set to study these issues. There is evidence that

ageing of the work force has initially a positive effect on establishment productivity, but after a peak the ageing effect is negative. This peak is reached when the average age of 43 is reached, but there is some variation across different service sector fields. A large majority of the service sector establishments seem still to be in the rising part of the age–productivity profile, but with work force ageing the situation may change. In the industrial sector, the ageing effect seems to be more severe, although the age effect is imprecisely estimated. There is no establishment-level evidence of benefits from age dispersion. In contrast there seems to be a small negative effect. This may result from extreme age distributions in small establishments included in our data.

At the individual level, it seems that the establishment-level age effects are at least partly transmitted to individual earnings. Since there are also strong individual age and tenure effects, the firms may face the problem of discrepancy of pay and productivity with work force ageing. For individuals, there is some evidence that group-level (establishment-level) age dispersion has weak negative consequences, whereas the relational effect, i.e. being different from others in terms of age, is beneficial.

The conclusion from the results is that there is some worry about a double burden from ageing of the work force and expansion of the low-productivity service sector. However, to the extent that the expansion of the service sector is related to outsourcing of activities from the industrial sector, the worries are less severe. First of all, our results show that the ageing effect can be compensated with both education and tenure (firm-specific experience) in business services, although the age–productivity profile peaks earlier than in other services. Secondly, following Oulton's (2001) argument, expansion of the intermediate input producing services need not lead to lower aggregate productivity growth. Even in labour-intensive, low-skill services, the length of tenure can compensate for the loss of productivity with ageing. Still, the challenges of raising productivity are highest in these fields. The situation is quite different in the industry sector, where productivity is high, but the ageing effects are potentially more severe.

Notes

1. In this section, we define 'industry' to include manufacturing, mining, energy, construction, 'public' to include public and personal services and accordingly 'services' to include the rest of the branches, i.e. trade, hotels and restaurants, transportation and communications, financial intermediation, and business services. Agriculture, forestry, and fishing are excluded. The data for these graphs originate from the EU-KLEMS data base (www.euklems.net). We include the countries for which information on the composition of labour input by age was available for the period starting in the 1970s.
2. Sasaki (2007) has, however, showed that the growth slowdown may still arise in a model where services are used both for final consumption and intermediate goods.
3. The figures are based on FLEED data; see the third section for a description of this data set.
4. A similar shift could be seen in the distributions of establishment SDs of ages.
5. An interesting issue would be the role of ICT in the productivity of services. Unfortunately, our data set has limited information on ICT.
6. The nominal values are deflated by output deflators taken from the EU-KLEMS data base. We use price indices for eight different branches in the service sector and 16 different branches in the industry sector.
7. The information on degrees has been transformed to years by using information on how long it typically takes to take different degrees in question.
8. According to the component that caused the destruction of a space shuttle.
9. Note, however, that the standard errors of the ages at which productivity peaks are wide enough so that the overall averages are not significantly different from the peaks.

10. We added the lagged dependent variable in the model and used the system-GMM method where the fixed effects are removed by differencing the model and lagged levels of the variables are used as instruments; in addition, the level form model is included in the system and instrumented with lagged differences (e.g. Roodman, 2009). The method allows the work force characteristics to be treated as endogenous. The results were somewhat disappointing as the Sargan test of over-identifying restrictions failed.
11. Many of the studies of productivity and wage profiles by age compare the relationship of establishment average age and establishment productivity with the relationship of average age and average wage. Dostie (2006) is an example of studies that use individual earnings instead of average wage.
12. The nominal values have been deflated with the consumer price index. Since there is no information on individual hours worked, there is likely to be some measurement error in the wage variable. An additional measurement error is caused by the fact that the sum of annual earnings and months worked may originate from several employment relationships, whereas the link to establishments is based only on the employment relationship at the end of the year.

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