Firm Size or Firm Age? The Effect on Wages Using Matched Employer-Employee Data

Fredrik Heyman*

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Abstract

This paper uses a large matched employer-employee data set for Sweden to study the relationship between firm age and individual wages, systematically addressing a variety of possible explanations for observing a firm-age wage effect. The paper also addresses the question whether the firm size wage premium is, in fact, a relationship between firm age and wages. Results show considerable heterogeneity across years, along segments of the firm age distribution and across industries. A positive and significant firm age-wage premium, robust to a number of control variables, is found in 1995. This effect is not found for 1987 and 1991, two periods characterised by different business cycle conditions than 1995. The relationship between firm age and wages is not monotonic; rather it varies along segments of the firm age distribution. It also differs systematically across different sectors of the economy. Finally, taking into account that larger firms are also older firms, the results show that the inclusion of firm age does not alter the positive effect of firm size on wages.

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*Research Institute of Industrial Economics, P.O. Box 55665, SE-102 15 Stockholm, Sweden, fredrik.heyman@industrialeconomics.se. I thank Mahmood Arai, Lena Nekby, Juhana Vartiainen, an anonymous referee and seminar participants at FIEF and the 2004 European Association of Labour Economists conference in Lisbon for helpful comments. I am also grateful to Per Weidenman, MM Partner AB, for providing the data on firm performance and firm age. Financial support from Jan Wallander's and Tom Hedelius' Foundation is gratefully acknowledged.

1 Introduction

"Is it possible that the size-wage premium is really a relationship between employer age and wages?" (Brown and Medoff (1989), pp. 1056-1057).

A number of studies have found wages to be distributed in a manner that cannot be explained by differences in productivity or by observable and unobservable human capital characteristics. Instead, wages seem to be systematically related to a variety of firm and industry characteristics. One much studied example is the size-wage premium.[1] Studies on a number of different countries and time-periods have reported that employees in large firms systematically earn more than those in small firms (for an exposition of the firm size-wage literature, see Oi and Idson (1999)). For instance, Brown *et al.* (1990) report that for the US, hourly wages in firms with more than 500 employees were 35 percent above wages in firms with less than 25 employees. Despite several attempts to explain the size-wage premium, the proposed explanations only explain a minor part of the premium.

Related to firm size is firm age. In most cases, larger firms are also older firms. A natural question is then how wages are related to firm longevity. Older firms have, on average, characteristics that differ systematically from younger firms. Observable differences between firms of different ages may then lead to a systematic relationship between employer age and wages.

There are several reasons for expecting a positive association between firm age and wages. By definition, new firms have employees with low levels of firm tenure. In contrast, employees in older firms have, on average, longer tenure. This implies that a positive firm age-wage correlation is due to older firms having employees with longer tenure and possibly longer experience. Another channel between firm age and wages goes through prof-

[1] Other non-competitive characteristics that have been found to be related to wages are industry (see e.g. Dickens and Katz (1987) and Kreuger and Summers (1988)) and unionization (see e.g. Freeman and Medoff (1984)).

itability. Passive learning models suggest that it takes time for new firms to become profitable (see Jovanovic (1982)), which implies a positive relationship between firm age and profits. If, as have been found in several studies, wages are related to profits through a rent-sharing mechanism, a positive firm age premium may, in fact, be due to systematic differences in profitability (see e.g. Hildreth and Oswald (1997) for evidence on rent-sharing). Further candidates for a causal effect of employer age on wages include capital-skill complementarities, systematic sorting of skilled workers into older firms, and differences in firm survival rates, employer stability and working conditions between young and old firms.

Evidence on the effect of firm age on wages is mainly based on data for the US manufacturing sector. Early studies generally found wages to be positively correlated with employer age (see Brown and Medoff (2003) for a summary of these studies). For instance Troske (1998), estimating plant-level regressions of log average wages on plant age, finds wages to be approximately 20 percent higher in plants that are older than 15 years than for plants that are less than five year old. However, these studies do not control for firm differences in employee characteristics. Sorting of workers with different human capital has explained some of the pay differentials associated with other firm characteristics, for instance firm size. Troske (1999) finds that when controlling for worker characteristics and estimating individual wage regressions, the plant age effect disappears. This result is also found in Kölling *et al.* (2002), using matched employer-employee data for Germany.

The most comprehensive study to date on the relationship between firm age and wages is Brown and Medoff (2003). Using survey data for the US on about 1,000 individuals (telephone interviews), they find that observable worker characteristics fully explain the firm age-wage premium. Controlling for a set of employee characteristics, Brown and Medoff report that the relationship between age and wages is negative over much of the firm age distribution. Their tentative conclusion, given the limited sample, is that

the relationship between firm age and wages is U-shaped.

The purpose of this paper is to study the effect of firm age on wages, using a large employer-employee data set for the entire private sector in Sweden. Using detailed information on individual and firm characteristics, this paper will systematically address a variety of possible explanations for a firm age-wage effect. Given the high correlation between firm age and firm size, this paper will also address the question asked by Brown and Medoff (1989); is it firm age or firm size that is of importance? More specifically, how is the estimated coefficient for firm size affected by the inclusion of firm age in individual wage regressions? The data consist of very detailed information on approximately 170,000 employees. These data are then matched with balance sheet data for the employing firms through the Swedish system of corporate registration numbers. The information on firm age originates from register-based direct information on the exact date of firm formation and ranges from one to 101 years in business. In addition to controls for worker characteristics, the matched data make it possible to control for firm profitability and capital intensity. Objective measures for firm profits and capital intensity have not previously been used in studies on the firm age-wage relationship.[2]

Given that the data cover the entire private sector, a careful study on differences between the manufacturing and the non-manufacturing sectors regarding the firm age-wage relationship will be presented. Furthermore, the analysis is carried out for three time periods characterized by very different business cycle conditions. Since previous studies are based on a single year, this paper addresses the question of whether the effect of firm age on wages differs across years. In sum, using disaggregated data, this study can analyze the effects of employer age and size on wages for individuals with comparable productivity characteristics and for firms with comparable observable characteristics.

[2] Oi and Idson (1996) and Brown and Medoff (2003) stress the importance of controlling for profits when estimating the impact of firm age on wages.

The results show considerable heterogeneity across years, along segments of the firm age distribution and across industries. For 1995, a positive relationship is found between firm age and individual wages. This relationship is robust to the inclusion of a variety of variables that might explain the firm age-wage premium.

In 1991 a positive relationship, robust to the inclusion of individual human capital characteristics, turns insignificant when firm characteristics such as profits and firm size are added. Hence, for this year, differences in firm characteristics can fully explain the firm age-wage premium.

The results for 1987 are mixed. Separate inclusions of a variety of individual and firm characteristics lead to an insignificant effect of firm longevity on wages. However, the inclusion of all the relevant control variables in the same wage equation gives rise to a negative and significant firm age effect.

Further results include (i) a strong heterogeneity concerning the effect of firm age on wages at different parts of the firm age distribution. Behind the results summarized above are marked differences in the firm age elasticity at different segments along the age distribution. These differences also seem to differ across years, and (ii) clear differences between the manufacturing and non-manufacturing sectors. A positive firm age-wage premium is only present in manufacturing, whereas the negative relationship found for 1987 is only present in the non-manufacturing sector.

Concerning the relationship between firm age and firm size, the results indicate that the inclusion of firm age does not affect the impact of firm size on wages. Also after controlling for the fact that, on average, larger firms are also older firms, firm size continues to be an economically important determinant of wages. The firm size-wage premium is robust to the inclusion of a variety of variables that may explain this premium.

The remainder of the paper is organized as follows. Theoretical links between employer age and individual wages are presented in Section 2. Section 3 describes the data and the empirical set-up. The results are presented in

Section 4. Finally, the paper is concluded in Section 5.

2 Explanations for a Firm Age-Wage Relationship

There exist several explanations for why firm age is related to individual wages. These can be divided into those stressing the importance of different firm characteristics and those based on differences in individual human capital accumulation. Many of the explanations for a systematic relationship between firm age and wages are identical to the explanations for a positive firm size-wage correlation (see e.g. Brown and Medoff (1989) and Troske (1999)). In fact, the strong correlation between how long a firm has been in business and firm size makes it difficult to distinguish between a firm size and a firm age effect. By definition, very large firms have, on average, been in business for quite a long time. Hence, a positive firm size and wage relationship might, in fact, be a positive firm age-wage relationship.

A natural explanation for a systematic correlation between firm age and wages is that individuals in young and large firms have different observable characteristics. One such difference is tenure within the firm. By definition, young firms cannot have employees with long tenure. Since tenure generally turns out to be positive and significant in individual wage equations, the difference in average individual tenure between firms of different ages may provide one explanation for observing higher wages in older firms. In addition, individuals in older firms are also likely to have longer labor market experience. This human-capital explanation implies that the firm age-wage correlation is the result of not controlling for employees' tenure and experience.

It may also be the case that older firms employ more skilled workers. If capital intensity is higher in old firms and there exist capital-skill complemen-

tarities, these firms will employ more high-skilled workers (see Hamermesh (1980)). Furthermore, if old capital-intensive firms use technologies relying on standardization and teamwork, then old firms will demand a more high-skilled homogenous work-force (see Oi (1983)).[3] This, in turn, implies a systematic sorting of high-skilled workers into older (and on average) larger firms.[4] The capital intensity-skill explanation means that it is important to control for the capital-labor ratio and the skill-mix of the firms.

Another reason for observing higher wages in more mature firms is related to profitability. If it takes time for firms to make profits, systematic differences will be observed in profitability and, hence, in the ability to pay between young and old firms. One model that explains such differences in profitability across firms of different ages is Jovanovic (1982). Jovanovic emphasizes the selection effects associated with passive learning about initial conditions. New entrants are equipped with different efficiency parameters which are unknown to the entrepreneur at the date of entry. Over time, the entrepreneur updates its true efficiency and the plant's relative efficiency gradually becomes known. Firms that accumulate favorable information about their relative efficiency expand, while plants with poor performance eventually decide to leave the market. New plants go through a shake-out period eventually revealing their long-term profitability. Unprofitable firms exit and are selected out of the population of mature firms. Profitable firms survive to maturity and eventually settle down to relatively stable employment levels. Hence, the Jovanovic model has empirical implications for the relationship between firm age, profitability and wages.

A number of studies have found wages to be positively correlated with profits through a rent-sharing process (see e.g. Hildreth and Oswald (1997)).

[3]Evidence of sorting of workers by ability across firms with different technological intensity is found in a recent paper by Luque and Miranda (2000) using matched employer-employee data for the US manufacturing sector. They find that the most technological intensive plants hire the most skilled workers.

[4]Older firms may also have more skilled managers that employ more skilled workers with higher wages (Oi (1983)).

If older firms are more profitable and employees extract part of the rents created, then a positive effect of firm age on wages can be due to differences in profitability.

A positive relationship between firm age and profits on the one hand and wages on the other can also depart from the notion of fair wages. According to the Akerlof and Yellen (1990) model, employees withdraw effort, hence becoming less productive, if their wage is lower than the "fair" wage. This means that older, more profitable firms have incentives to share profits with their employees. As stressed by Brown and Medoff (2003), the claim of inability to pay higher wages is more credible for young firms with unknown expectations of long-run profitability than for more mature firms. In sum, the discussion on firm age and profitability implies that controlling for firm profits is crucial.[5]

Differences in failure rates and thus employment stability between young and old firms can also affect the firm age-wage relationship. Several studies have found a negative relationship between plant age and plant failure (see e.g. Dunne *et al.* (1988, 1989) and Davis and Haltiwanger (1991)). The fact that the risk of layoff due to plant closing is significantly higher in new firms may influence wages in several ways. On the one hand, a higher risk for young firms to fail can be seen as a negative job characteristic, well known to both employers and employees. A compensating wage differential argument would then call for younger firms to compensate employees for the higher risk of layoff by offering a wage premium, thereby implying a negative relationship between firm age and wages. A similar argument can be based on the desire of risk-averse employees to insure against the risk of becoming unemployed (see Malcomson (1996) for a summary of the literature on individual employment contracts).

[5]The necessity of including information on profits is stressed in Oi and Idson's (1999) contribution to the latest *Handbook of Labor Economics* in which they discuss the relationship between wages and firm age in an appendix.

On the other hand, old firms with secure employment prospects may be more willing to invest in firm-specific on-the-job training and offer more opportunities for advancements within the firm. This, in turn, can influence the mix of workers the firm employs, leading to higher demand for high-skilled, high-ability workers and thus, also leading to higher average wages in older firms as compared to younger firms (see Brown and Medoff (2003) for explicit theories). Further, the more insecure and unstable jobs at young firms may attract a certain group of workers who themselves are unstable and more prone to quit jobs. This implies that firms do not need to pay a wage premium for these workers to compensate for a higher layoff risk. Furthermore, individuals willing to accept unstable jobs may themselves be less skilled. Taken together, this means that wages, in equilibrium, are lower in new than in old firms (see Evans and Leighton (1989)).

Finally, working conditions may systematically differ between firms of different age. For instance, older firms may systematically be found in certain industries offering certain working conditions. The sign of the correlation between working condition and firm age is, however, not clear.

3 Data and Empirical Specification

The data on individuals originate from the Swedish Level of Living Surveys (LNU) in 1991, a representative survey of non-agricultural workers aged 18-64. Each individual has a unique organization-number, mapping each worker to his or her employer. These firms then form the basis of the Swedish Establishment Survey (APU).[6] By matching the organization number for the firms in APU with employment data from Statistics Sweden, information on *all* individuals working in these firms some time during 1987, 1991 or 1995 is available. These individuals, working in private APU-establishments in

[6]For a detailed description of the Swedish Establishment Survey (APU), see le Grand *et al.* (1996).

1987, 1991 and 1995, constitute the worker data set.[7] Each year contains approximately 170,000 employees in the private sector.[8] To ensure that the sample is representative, it is compared to another randomly drawn sample of individuals. A comparison of sample means from the two samples indicates no significant differences.

For these individuals, rich information is obtained by matching data from several Swedish data sources. Data on wages and job characteristics are provided by Statistics Sweden (*SCB*) and from data collected by the Swedish Trade Union Confederation (*LO*) and the Swedish Employers' Confederation (*SAF*). Information on employment, including total labor market experience and seniority, originates from the Swedish Employment Register. Data on individual characteristics such as age and gender are from the Population Census from *SCB* (*Registret över totalbefolkningen*). Detailed information on education, including grades from high school, is from the Swedish Education Register (*Utbildningsregistret*). See the Appendix for a detailed description of the data. Table A.1 shows descriptive statistics. As can be seen from the table, the mean real log wage is fairly stable over the years, ranging from 9.49 in 1987 to 9.52 in 1995. The deep recession in Sweden in the early 1990:s, which hit the manufacturing sector very hard, affected the relative wages between manufacturing and non-manufacturing industries. In 1987, the mean wage was slightly higher in manufacturing than in non-manufacturing. In 1995, after the recession, the opposite was true. Table A.1 also shows an increase in the educational attainment among employees across the years. The share of employees with only compulsory school or less has decreased, while the share of employees with at least post secondary education has increased.

[7] Since information on employees in establishments is conditioned on having one of these individuals in the LNU sample, the data do not always cover all employees in firms with several establishments. For the vast majority of firms, however, information on all employees is available.

[8] 52 percent of the individuals are present for one year in the matched data, 31 percent for two years and 17 for all three years.

The unique organization number for each employing firm is utilized to match the individuals with the firms where they work. Balance-sheet information for these firms is available for the period 1987-1996. Before matching individuals and firms, those firms in the balance-sheet data that are observed for less than two years or with less than two employees are removed.

Annual profits after capital depreciation per employee are used as a measure of firm performance. This direct measure of firm performance has not previously been used to investigate the relationship between firm age and wages. As a measure of capital intensity, value of equipment per employee is used. Finally, from the balance sheet data, register-based direct information on firm age, ranging from 1 to 101 years, is available. Register-based data on firm age have not been available in previous studies.

Compared to other data sets used in the literature on the impact of firm age and firm size on wages, the information available in this study is very detailed.[9] No other study combines detailed register-based information on individuals and firms with comprehensive balance-sheet data on firms.[10]

I use the following specification to study the relationship between employee age and individual wages:

$$\ln w_{it} = \alpha + \beta_0 \ln AGE_{J(i,t),t} + \mathbf{X}_{it}^{'}\beta_1 + \mathbf{F}_{J(i,t),t}^{'}\beta_2 + \mathbf{S}_{J(i,t),t}^{'}\beta_3 + \varepsilon_{it}, \qquad (1)$$

[9] See Abowd and Kramarz (1999) for a survey of linked data from 17 different countries.

[10] Brown and Medoff (2003) use answers from around 1,000 respondents to the US Survey of Consumers in 1991. Information on firm age originates from a supplementary question regarding the employing firm of the respondents. The question asked was: How long has this (company/organization) been in (business/operation)? For half of the sample, around 500 individuals, they also use firm age information from Dun and Bradstreet. The data in Troske (1999) originate from the Worker Establishment Characteristics Database, consisting of approximately 200,000 manufacturing workers who responded to the 1990 Decennial Census. These workers are linked to the establishment surveys in the Longitudinal Research Database, where information of plant age originates. The matched data consist of 130,000 workers. Finally, Kölling *et al.* (2002) use a large German matched worker-establishment data set (the LIAB) for 1996. Since information on plant age is left-censored, they analyze three separate firm-age groups.

where w_{it} is the full-time equivalent monthly wage for worker i at time t; $AGE_{J(i,t),t}$ denotes firm age in firm J that employs worker i in period t $(= 1987, 1991, 1995)$; $\mathbf{X}_{it}$ is a vector of individual characteristics including gender, education, labor market experience, labor market experience squared and tenure; $\mathbf{F}_{J(i,t),t}$ is a vector of firm characteristics such as firm size, profits per employee, capital intensity and industry affiliation and $\mathbf{S}_{J(i,t),t}$ is a vector of firm averages of the skill mix of the work force, accounted for by including the share of the work force in the firm that (i) has attended at least long upper secondary school (ii) has more than five years of labor market experience, (iii) has more than three years of tenure, and (iv) are women, respectively. Finally, ε_{it} is the random error term.

A question to investigate is if the firm age-wage relationship differs between different parts of the firm age distribution. For this purpose, I estimate a spline function model to allow for a more flexible relationship. The spline model has kinks at firm ages 21 and 65 in 1995, corresponding to the first and third quartiles of the firm age distribution.[11] The following spline function will be estimated (see Greene (1997), section 8.2.6):

$$\begin{aligned} \ln w_{it} &= \alpha + \beta_0 \ln AGE_{J(i,t),t} + \sum_{k=1}^{2} \eta_k [D_k(\ln AGE_{J(i,t),t} - \ln AGE^*_{kJ(i,t),t})] + \\ &+ \mathbf{X}'_{it}\beta_1 + \mathbf{F}'_{J(i,t),t}\beta_2 + \mathbf{S}'_{J(i,t),t}\beta_3 + \varepsilon_{it}, \end{aligned} \tag{2}$$

where $AGE^*_{kJ(i,t),t}$ is the age of the firm at the $k\acute{}$th quartile (first and third), and D_k=1 for $AGE_{J(i,t),t} > AGE^*_{kJ(i,t),t}$ and zero otherwise.

This specification reflects the possibility that the elasticity of wages with respect to firm age might differ between different segments of the firm age distribution. Hence, the firm age elasticity will be β_0 up to the first quartile, $\beta_0+\eta_1$ between the first quartile and the third quartile, and finally $\beta_0+\eta_1+\eta_2$

[11] The corresponding kinks in 1987 and 1991 are at {27, 65} and {30, 71}, respectively.

above the third quartile.

To further account for a non-linear relation, I also estimate individual wage equations where firm age enters as a categorical variable. Firm age is split into three intervals corresponding to firms younger than six years, firms in the interval six to ten years and firms older than ten years.

A potential problem in estimating individual wage equations on individual- and firm variables is that observations may be correlated within firms. This issue arises since firm age is the same across all individuals in the same firm. Standard OLS may then produce standard errors that are downward biased. This, in turn, overstates the level of significance of the explanatory variables that do not vary across individuals within the same firm. To account for group effects, all equations are adjusted for within-firm error correlations (see Moulton (1990)).

4 Results

To begin the analysis, column 1 in Table 1 reports results on the effect of firm age on individual wages in 1987, 1991 and 1995, respectively.

– Table 1 about here –

This simple specification corresponds to estimating equation (1) without any control for worker and firm characteristics, i.e. setting $\mathbf{X}=\mathbf{F}=\mathbf{S}=0$. The results show individual wages to be higher in older firms. The estimated coefficients range from 0.017 in 1991 to 0.034 in 1995. These elasticities are similar in magnitude to the size-wage effects obtained for Sweden (see Albaeck *et al.* (1998)).

As stressed in Section 2, one possible explanation for observing a positive firm age-wage effect is systematic differences in tenure among employees in young and old firms. This explanation is taken into consideration in column

2 by adding individuals' tenure at the current employer.[12] If variation in seniority lies behind the positive relationship between firm age and wages, the inclusion of seniority should make the coefficient for firm age insignificant or highly reduced. However, the results indicate that firm age is still positive and significant, with only a slight reduction in the coefficient value. Note that the t-value implies that the firm age coefficient is only significant at the ten-percent level in 1991.

In column 3, a variety of human capital characteristics are added to account for individual differences in education, experience and gender.[13] Adding these human capital characteristics leads to a statistically significant reduction in the coefficient for log firm age in 1995. Both in 1991 and 1995, the elasticities are reduced by around 50 percent when individual differences in human capital are accounted for. Moreover, in 1987, the firm age variable is now insignificant, implying that differences in human capital accumulation between individuals in firms of different age are responsible for the positive and significant effect of firm age presented in column 1. Finally, in column 4 an interaction term between firm age and seniority is added. This term is not statistically significant, however.

Next, I turn to investigating how firm characteristics such as profitability and size affect the firm age-wage relationship. I will also evaluate how the estimated coefficient for size is affected by the inclusion of the firm age variable.

Column 1 in Table 2 present results when profits per employee is added. If profits systematically vary with firm longevity, estimating the effect of firm age on wages without taking the variation in firm profits into account would

[12] No information on seniority is available in 1987, so the analysis is carried out for 1991 and 1995. All estimations presented in the paper have been resestimated for 1991 and 1995, excluding seniority, i.e. only including variables that are common for all years. The results are not affected.

[13] The estimated coefficients for these variables are not included in the tables but are available upon request. The coefficients have the expected signs and are statistically significant.

bias the results. Specifically, a positive firm age-wage effect would instead be due to systematically higher profits in older, more mature firms.

– Table 2 about here –

This variable is positive and highly significant in all years. The inclusion of profits has a large effect on the coefficient for log firm age. The firm age variable is now statistically insignificant in both 1987 and 1991. This implies that, for 1991, variation in profits across firms can fully explain the positive firm age-wage effect reported in Table 1. Inspecting the correlation between firm age and profits, this correlation turns out to be positive and significant (based on both ordinary and rank correlations). So, given a positive relationship between how long a firm has been in business and profits, it seems that the previously reported positive effect of firm age on wages in 1991 is due to not taking into account variation in profits. Note that this is the first study to include an objective measure of firm profits.

The results differ for 1995. Adding firm profitability does not affect the impact of firm age on wages. The coefficient for firm age remains highly significant and the coefficient value is only marginally decreased. It should be noted that wage negotiations in 1995 were carried out under very different economic conditions than in 1991. During the period 1991-94, Sweden experienced a very deep recession with falling GDP and unemployment increasing from 5 percent in 1991 to 15 percent in 1995. This difference in business cycle conditions may affect the results. If conditions are more secure in older, mature firms, the turbulence of a recession may have an asymmetric impact on young and old firms, respectively. Old firms which are, on average, larger and have a higher profitability than young firms may be more willing to pay higher wages. As pointed out by Brown and Medoff (2003), the inability to pay higher wages is much more credible when made by young firms than when made by mature, long surviving firms. This may be especially true in an economic downturn. The issue of a heterogeneous effect of firm age on

wages during different economic cycles has not previously been investigated. Earlier studies are instead based on single year cross-section data only.

The restructuring that took place during the recession can be seen in the data. Comparing 1995 with 1987, it can be seen that there are fewer firms in 1995, but these firm have a higher capital intensity and marginally higher profits per employee than the firms in 1987. This suggests that weaker firms have been forced out of the markets, leaving more productive and profitable firms to continue. Additional models have been estimated to further investigate the impact of business cycle conditions on results.[14] These include (i) estimating models on individuals who work in firms that are present in all years, (ii) estimating models on firms that are in some ways observationally similar in all years and (iii) estimating regressions separated by industry.[15] One problem when dividing the data is that data become less representative and selectivity and selection bias become a problem.

Results when estimating wage equations only on individuals working in firms that are present in all years show no systematic pattern regarding the effect of firm age on wages. Dividing the material into groups of firms with similar characteristics across the years once more shows a tendency for a positive firm age effect in 1995, whereas the effect is negative in the estimations for 1987.[16] Finally, the results when estimating regressions separated by 14 industries are mixed, but there is a weak tendency for the firm age variable to be relatively more positive in 1995 than in 1987. In sum, these additional regressions do not reject the hypothesis that economic conditions have an impact on the mixed results across the years. However, results for other countries, using data on several years, would be interesting.

[14] I thank an anonymous referee for suggestions regarding the impact of economic conditions.

[15] These results can be obtained from the author upon request.

[16] The data were split into three groups, divided by capital intensity and profits per employee, respectively.

I now turn to firm size, accounting for the fact that older firms are also, on average, larger firms. How is the firm age variable affected by the inclusion of firm size? Moreover, does there exist a positive size effect on wages after controlling for how long a firm has been on the market? In other words, is it firm size or firm age that is of importance?

The inclusion of firm size in the wage equation leads to very similar results to those in the model including profits. Hence, taking into account differences in firm size leads to an insignificant coefficient for firm age in 1987 and 1991. For 1995, the firm age variable continues to be positive and significant. Firm size has a positive and significant effect on individual wages for all years. The elasticities range from 0.005 in 1995 to 0.017 in 1991.[17]

Estimating columns 1 and 2, but excluding the firm age variable, does not change the estimated coefficient for log firm size (compare columns 3 and 4). Hence, firm size has its own separate effect that is robust to control for firm age, implying that it is not a result of larger firms also being older firms.To further analyze this issue, all equations in the paper are estimated with firm size as an explanatory variable, with and without control for firm age. [18]

The final column in Table 2 shows results when firm age, firm size and profits are all included. Once again, the firm age variable is positive and significant in 1995, but insignificant in 1991. However, in 1987, the firm age variable turns negative and significant. This result underlines the importance of studying a number of years, characterized by different economic conditions, as well as controlling for a variety of firm characteristics.

Next, the hypothesis that older firms pay higher wages because of systematic differences in worker skills is examined as well as the existence of capital-skill complementarities. The results are presented in Table 3.

– Table 3 about here –

[17]Note that the elasticity in 1991 is more or less identical to the plant size elasticity obtained for Sweden in 1991 in the Albaeck *et al.* (1998) study.

[18]I have also re-estimated all equations, excluding the largest firms, to account for the fact that many employees work in large firms. The results are not affected by this exercise.

First looking at the results for 1995, I find, in line with the capital-skill complementary hypothesis, that individual wages are positively correlated to the capital-labor ratio (K/L). This result is identical to, among others, Troske (1999) and Arai (2003). Inspecting the coefficient for firm age, the results show that the inclusion of K/L does not affect the firm age-wage relationship. Firm age continues to be positive and significant with only a small reduction in magnitude. Hence, the positive firm wage premium in 1995 is not due to capital-skill complementarities.

In column 2, firm differences in work force skill are added. If capital intensity is higher in old firms, then older firms will also employ more high-skilled employees. The results in column 2 indicate that the inclusion of work force skill has no impact on the firm age-wage premium. Although the estimated elasticity is somewhat lower (compare 0.013 with 0.017 in column 3 in Table 1), the difference is not significantly different from zero. This result is robust to including both K/L and work force skill (column 3) as well as profits and firm size (column 5). Quantitatively, the coefficient of 0.009 in the full model (column 5) indicates a one standard deviation increase in log firm age to be associated with an increase in wages by one percent.

Once more, the results for 1987 are mixed. Log firm age is insignificant in columns 1-3, but turns negative and significant in the full model (column 5). Results for 1991, not reported in the paper, show that the coefficient for firm age is never statistically significant when firm characteristics are added.[19]

The impact of adding the capital/labor ratio and control for firms' skill-mix on the coefficient for firm size, with and without taking into account firm age, can be seen in columns 4 and 5. As is clear, firm size has its own effect and the estimated coefficient is basically unchanged. Again, this suggests that the size-wage premium is not due to a relationship between employer age and wages. So, for Sweden, the answer to Brown and Medoffs' question of whether the firm size-wage premium is really a relationship between firm age

[19]These results can be obtained from the author upon request.

and wages, must be "no". The firm size premium is robust to the inclusion of a variety of variables that might explain the firm size effect.

A question to investigate is whether the firm age-wage relationship differs between different parts of the firm age distribution. Brown and Medoff (2003) report a non-monotonic relationship between firm age and wages. They find the wage-age relationship to be U-shaped, with wages falling as age increases, but that the relationship is reversed among older firms. However, given their limited number of observations (around 1,000), the spline equations cannot be estimated very precisely. With this in mind, Table 4 shows results on estimating a spline function model, to see if a U-shaped relationship can be found in Swedish data. The spline model has kinks at firm ages corresponding to the first and third quartiles of the firm age distribution. Results on this specification, holding different individual and firm characteristics constant, are presented in columns 1 and 2.

– Table 4 about here –

Consider first the results for 1995. The results presented in Table 4 show no U-shaped relationship between firm age and wages. Instead for 1995, the age-wage relationship is first increasing, thereafter having a decreasing segment and finally for firms above the upper quartile of the age distribution, the relationship is once more positive.

Studying the individual segments in more detail, it seems that the positive and significant effect of firm age on individual wages in 1995, presented in Tables 1-3, originates from a strong positive and significant effect for the youngest firms (< first quartile). For firms in the middle segment, we even observe a negative and significant firm age-wage relationship. For the oldest firms (> third quartile), the effect is not statistically different from zero.

For 1987, the positive firm age effect obtained with no control for firm- or individual characteristics seems to stem from a positive effect for the youngest and the oldest firms. Behind the insignificant effect when controlling for

worker characteristics is a positive and significant effect for the youngest and oldest firms, combined with a negative and significant effect in the middle segment. However, the positive segment is not strong enough, thus leading to an insignificant effect in total. Finally, the negative and significant effect obtained in the full model specification in Tables 2 and 3 seems to originate from a statistically negative effect for firms between the lower and upper quartiles of the firm age distribution.

In sum, the results obtained for the spline models suggest strong heterogeneity concerning the effect of firm age on wages, both in relation to points in time and differences across different parts of the firm age distribution. Behind the results obtained in Tables 1-3 are clear differences in the elasticity of wages with respect to firm age at different segments of the distribution. These differences are not constant over time, but instead they seem to vary across different time periods, characterized by different business cycle conditions.

To further account for a non-linear relationship between firm age and wages, results from estimating firm age class dummies are presented in columns 3 and 4 in Table 4. The presented estimated firm age-wage differentials are relative to the reference class in the estimations consisting of the youngest firms ($\leq$5 years). The estimated firm age-wage differentials are all statistically significant and indicate higher wages in older firms in 1995, but not in 1987 when controlling for a variety of individual and firm characteristics.

Finally, results on estimating separate equations for the manufacturing and non-manufacturing sectors are presented in Table 5. There are reasons to believe that the firm age effect may systematically differ between these sectors. For instance, the size of the firm, capital intensity and the mix of employees differ systematically between these two sectors. The question is then if these differences can explain some of the differences in results obtained for the different time periods. Furthermore, earlier evidence on the existence of a firm age wage premium is, with the exception of Brown and Medoff

(2003), solely based on evidence on manufacturing data.

Interestingly, very strong results on sector heterogeneity can be seen in Table 5.

– Table 5 about here –

For 1995, the positive and significant impact of firm age on wages, presented in earlier tables, is only present in the manufacturing sector. In the non-manufacturing sector, no statistically significant effect is found. This implies that it is in manufacturing with firms that are, on average, larger and more capital intensive, that a firm age-wage premium is present.

For 1987, the results are very different. From the table, it is clear that the negative effect, previously found in the full model, originates from the non-manufacturing sector. In column 6, the coefficient for log firm age is negative and statistically significant as opposed to the similar specification in manufacturing (see column 3). Hence, sector differences seem to play an important role as an determinant of the relationship between firm age and individual wages.

Concerning the impact of firm age on the firm size wage premium, it is once more clear that firm size is not affected by the inclusion of employer age.

5 Summary and Conclusions

Studies on a number of different countries and time-periods have reported that employees in large firms systematically earn more than those in smaller firms. Related to firm size is firm age. In most cases, larger firms are also older firms. A natural question is then how wages are related to firm longevity. Older firms have, on average, characteristics that differ systematically from younger firms. Observable differences between firms of different

ages may then lead to a systematic relationship between wages and employer age.

This paper studies the effect of firm age on wages, using a large and detailed employer-employee data set for the entire private sector in Sweden. Using detailed information on individual and firm characteristics, this study systematically addresses a variety of possible explanations for a firm age-wage effect as well as addressing the question of whether the size-wage premium is really a relationship between employer age and wages. The analysis is carried out for three time periods, characterized by very different business cycle conditions. Since previous studies are based on a single year, this paper also addresses the question of whether the effect of firm age on wages differs across year.

The results show considerable heterogeneity across years, along parts of the firm age distribution and across sectors of the economy. For 1995, a positive relationship between firm age and individual wages is found. This relationship is robust to the inclusion of a variety of variables that might explain the firm age-wage premium.

In 1991, a positive relationship, robust to the inclusion of individual human capital characteristics, turns insignificant when firm characteristics such as profits and firm size are added. So for 1991, differences in firm characteristics fully explain the firm age-wage premium.

Finally, for 1987 the results are mixed. Separate inclusions of a variety of individual and firm characteristics lead to an insignificant effect of firm longevity on wages. However, the inclusion of all relevant control variables in the same wage equation gives rise to a negative and significant firm age effect.

The results also show strong heterogeneity concerning the effect of firm age on wages at different segments of the firm age distribution. The positive firm age-wage premium in 1995 seems to originate from a very strong effect for young firms, whereas the negative effect in 1987 is due to a negative

relationship for firms in the middle of the firm age distribution. These results show that the firm age-wage relationship is not monotonic, a result in line with Brown and Medoff (2003). However, the exact nature of the relationship is rather complex, and a general U-shaped relationship, found in Brown and Medoff, is not found in the data used here.

Estimating separate equations for manufacturing and non-manufacturing show that the positive firm age effect for 1995 is only found in manufacturing. In the non-manufacturing sector which, on average, consists of smaller and less capital-intensive firms, no effect of firm longevity on wages can be traced. In contrast, the negative firm age-wage relationship found in the full model in 1987 originates from the non-manufacturing sector, whereas the corresponding specification in manufacturing shows an insignificant coefficient for firm age.

Concerning the relationship between firm age and firm size, the results indicate that the inclusion of firm age does not affect the impact of firm size on wages. Moreover, after controlling for the fact that, on average, larger firms are also older firms, firm size continues to be an economically important determinant of wages. The firm size-wage premium is robust to the inclusion of a variety of variables that may explain this premium. The message of these results is that, in the end, it seems to be size and not age that is of importance.

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Tables

Table 1. Effect of firm age on wages. Including measures of individual characteristics. OLS estimates for 1987, 1991 and 1995. Dependent variable is log monthly wage. Robust standard errors corrected for within-firm error correlation in parentheses.

	1	2	3	4
			1987	
Log firm age	.019***		.006	
	(.006)		(.005)	
Individual characteristics	NO		YES	
R^2	0.05		0.50	
N	160,952		160,952	
			1991	
Log firm age	.018***	.016*	.009*	.010*
	(.009)	(.009)	(.005)	(.006)
Seniority		.005***	.001	.001
		(.001)	(.000)	(.002)
Log firm age*Seniority				-.000
				(.001)
Individual characteristics	NO	NO	YES	YES
R^2	0.04	0.06	0.43	0.43
N	172,288	172,288	172,288	172,288
			1995	
Log firm age	.034***	.029***	.017***	.019***
	(.008)	(.008)	(.005)	(.007)
Seniority		.005***	.002***	.003
		(.001)	(.000)	(.002)
Log firm age*Seniority				-.000
				(.000)
Individual characteristics	NO	NO	YES	YES
R^2	0.04	0.05	0.45	0.45
N	176,333	176,333	176,333	176,333

Notes: *** indicate significance at the 1%-level and * at the 10%-level. Individual characteristics correspond to control for gender, education, experience and experience squared. All equations include control for industry affiliation, corresponding to 14 industries. All estimations in the paper have been re-estimated using a more disaggregated industry classification with over 400 4-digit industries. Adding controls for these industry characteristics has no impact on the effect of firm age on wages or the other included explanatory variables.

Table 2. Effect of firm age on wages. Including measures of firm size and firm profitability. OLS estimates for 1987, 1991 and 1995. Dependent variable is log monthly wage. Robust standard errors corrected for within-firm error correlation in parentheses.

	1	2	3	4	5
			1987		
Log firm age	.002	-.007			-.009*
	(.005)	(.005)			(.005)
Profits/Employee	.039***			.021**	.025*
	(.014)			(.010)	(.010)
Log Firm size		.014***	.013***	013***	.014***
		(.003)	(.003)	(.003)	(.003)
Individual characteristics	YES	YES	YES	YES	YES
R^2	0.50	0.51	0.51	0.51	0.51
N	160,952	160,952	160,952	160,952	160,952
			1991		
Log firm age	.005	-.000			-.002
	(.005)	(.004)			(.004)
Profits/Employee	.045**			.027	.028
	(.02)			(.02)	(.02)
Log firm size		.017***	017***	015***	.016***
		(.003)	(.003)	(.003)	(.003)
Individual characteristics	YES	YES	YES	YES	YES
R^2	0.43	0.44	0.44	0.44	0.44
N	172,290	172,288	172,288	172,288	172,288
			1995		
Log firm age	.016***	.015***			.013**
	(.005)	(.006)			(.006)
Profits/Employee	.014***			.019***	.015***
	(.005)			(.005)	(.005)
Log firm size		.005**	007**	.008**	.006**
		(.002)	(.002)	(.002)	(.003)
Individual characteristics	YES	YES	YES	YES	YES
R^2	0.45	0.45	0.45	0.45	0.45
N	176,333	176,333	176,333	176,333	176,333

Notes: *** indicate significance at the 1%-level, ** significance at the 5%-level and * significance at the 10%-level. Individual characteristics correspond to control for gender, education, seniority (not available in 1987), experience and experience squared. All equations include control for industry affiliation, corresponding to 14 industries.

Table 3. Effects of firm age and firm size on wages. Including measures of capital intensity and workforce skill. OLS estimates for 1987 and 1995. Dependent variable is log monthly wage. Robust standard errors corrected for within-firm error correlation in parentheses.

	1	2	3	4	5
		1987			
Log firm age	.006	.005	.005		-.010**
	(.005)	(.005)	(.005)		(.005)
(Capital/Labor ratio)/100	.0007		.0006	.0004	.0004
	(.0005)		(.0006)	(.0005)	(.0005)
Workforce skill	NO	YES	YES	YES	YES
Profits/Employee				.019**	.024**
				(.009)	(.010)
Log Firm size				.012***	.014***
				(.003)	(.003)
Individual characteristics	YES	YES	YES	YES	YES
R^2	0.50	0.51	0.51	0.51	0.51
N	160,952	160,952	160,952	160,952	160,952
		1995			
Log firm age	.017***	.014***	.014***		.009*
	(.005)	(.005)	(.005)		(.005)
(Capital/Labor ratio)/100	.0003***		.0003***	.0002***	.0002***
	(.0001)		(.0009)	(.0001)	(.0001)
Workforce skill	NO	YES	YES	YES	YES
Profits/Employee				.014***	.012**
				(.005)	(.005)
Log Firm size				008**	007**
				(.003)	(.003)
Individual characteristics	YES	YES	YES	YES	YES
R^2	0.45	0.46	0.46	0.46	0.46
N	176,333	176,333	176,333	176,333	176,333

Notes: *** indicate significance at the 1%-level, ** significance at the 5%-level and * significance at the 10%-level. All equations include the same set of individual characteristics and control for industry affiliation as in Tables 1 and 2. Workforce skill corresponds to control for workers' experience, seniority (not available in 1987), education and gender at the firm level. F-tests for the joint insignificance of the workforce skill variables are rejected in all equations where they are included. F-tests for the joint insignificance of the industry dummies are rejected in all equations.

Table 4. Effect of firm age on wages. OLS estimates using spline functions and age class dummies. Dependent variable is log monthly wage. Robust standard errors corrected for within-firm error correlation in parentheses.

	1	2	3	4
	1987			
Log firm age	.021**	.001		
	(.010)	(.005)		
Log firm age (1:st quartile)	-.059**	-.048***		
	(.033)	(.018)		
Log firm age (3:rd quartile)	.194***	.189***		
	(.072)	(.059)		
Firm age (6-10 years)[a]			.025*	-.004
			(.014)	(.013)
Firm age (>10 years)[a]			.033***	-.013
			(.010)	(.009)
Log firm size		.014***		
		(.002)		
Individual characteristics	YES	YES	YES	YES
Firm characteristics	NO	YES	NO	YES
Workforce skill	NO	YES	NO	YES
R^2	0.50	0.52	0.50	0,51
N	160,952	160,952	160,952	160,952
	1995			
Log firm age	.045***	.039***		
	(.012)	(.011)		
Log firm age (1:st quartile)	-.067***	-.070***		
	(.025)	(.024)		
Log firm age (3:rd quartile)	.096	.094		
	(.059)	(.057)		
Firm age (6-10 years)[a]			.048***	.037*
			(.003)	(.019)
Firm age (>10 years)[a]			.073***	.052***
			(.002)	(.019)
Log firm size		.007***		.007**
		(.002)		(.003)
Individual characteristics	YES	YES	YES	YES
Firm characteristics	NO	YES	NO	YES
Workforce skill	NO	YES	NO	YES
R^2	0.45	0.46	0.45	0.46
N	176,333	176,333	176,333	176,333

Notes: a) The reference category is Firm age (<6 years). See also notes to Tables 1-3.

Table 5. Effects of firm age and firm size on wages. Separate estimations for the Manufacturing and Non-manufacturing sectors. OLS estimates for 1987 and 1995. Dependent variable is log monthly wage. Robust standard errors corrected for within-firm error correlation in parentheses.

	1	2	3	4	5	6
	1987					
	Manufacturing			Non-manufacturing		
Log firm age	.008	-.005		.000	-.016***	
	(.007)	(.006)		(.005)	(.006)	
Log firm size		.015***	.015***		.011***	.007***
		(.004)	(.004)		(.003)	(.002)
Individual characteristics	YES	YES	YES	YES	YES	YES
Firm characteristics	NO	YES	YES	NO	YES	YES
Workforce skill	NO	YES	YES	NO	YES	YES
R^2	0.47	0.48	0.48	0.58	0.59	0.59
N	121,636	121,636	121,636	39,316	39,316	39,316
	1995					
	Manufacturing			Non-manufacturing		
Log firm age	.023***	.016**		.007	.003	
	(.007)	(.007)		(.007)	(.007)	
Log firm size		.005	.007		.007**	.008**
		(.004)	(.004)		(.003)	(.003)
Individual characteristics	YES	YES	YES	YES	YES	YES
Firm characteristics	NO	YES	YES	NO	YES	YES
Workforce skill	NO	YES	YES	NO	YES	YES
R^2	0.42	0.43	0.43	0.51	0.53	0,53
N	123,329	123,329	123,329	53,004	53,004	53,004

Notes: *** indicate significance at the 1%-level, ** significance at the 5%-level and * significance at the 10%-level. All equations include the same set of individual characteristics and industry affiliation as in Tables 1-4. Workforce skill corresponds to control for workers' experience, seniority (not available in 1987), education, gender and age at the firm level. F-tests for the joint insignificance of the workforce skill variables are rejected in all equations where they are included. F-tests for the joint insignificance of the industry dummies are rejected in all equations.

Appendix: Data Description

Individual characteristics:
Wages: Monthly pre-tax full-time equivalent wages in 1990 prices (using CPI) based on Swedish Trade Union Confederation (*LO*) and the Swedish Employers' Confederation (*SAF*) wage data and completed with the income registers from Statistics Sweden (*SCB*).
Gender and Age are from SCB's Population Census (*Registret över totalbefolkningen*).
Education level dummies are based on the 2-digit level of the Swedish Education Nomenclature (SUN-codes) from the Swedish Education Register (*Utbildningsregistret*). These are *Elementary School* (less than 9 years), *Compulsory School* (9 years), *Upper Secondary School* (less than 3 years), *Upper Secondary School* (3 years), *Post Secondary School* (less than 3 years), *University Undergraduate Studies* (3 years or more, not including graduate studies) and *University Graduate Studies*.
Experience is number of years on the labor market according to the Employment Register (*Sysselsättningsregistret*) of Statistics Sweden.
Seniority is number of years at the establishment based on tracing the individual back to 1986 in the Employment Register (*Sysselsättningsregistret*). The variable is left censored at 5.5 years. Individuals with more than 6 years of seniority are given the mean seniority in Sweden according to the Level of Living Survey, i.e. 16 years.

Firm characteristics
Firm age refers to number of years in business. Available for the period 1987-95 (MM Partners).
Profits (Swedish kronor) are defined as annual profits after capital depreciation. Available for the period 1987-95 (MM Partners). The profits data for 1991 and 1995 are transformed into four-year averages. The reason for this is twofold. First, measurement errors in variables, such as profits per employee, are reduced when four-year averages are uses. Second, due to high variability in profits, four-year averages yield a better measure of long-run profitability, removing transitory variation in profits. Since balance-sheet information is not available before 1987, the 1987-estimations use profits for 1987.
Firm size refers to number of employees according to the Employment Register (*Sysselsättningsregistret*). Available for 1987, 1991 and 1995.
Capital/labor ratio is defined as value of equipments per employee. Available for the period 1987-95 (MM Partners).

Industry characteristics
Industry dummies are based on the 2-digit SIC (*SNI69* and *SNI92*). Own classification of 14 industries. 6 are classified as manufacturing industries (Metal and Machinery, Chemistry, Wood etc, Textiles, Food and Mining), and 8 as non-manufacturing industries (Electricity, Construction, Trade, Hotel and Restaurants, Transport, Banking, Real Estate and Other Services).

Table A.1. Descriptive statistics.

	1987			1991			1995		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Individual characteristics:									
Log monthly wage:	160 952	9.49	.27	172 288	9.49	.26	176 333	9.52	.30
1:st quart. (firm age distr.)	48 315	9.49	.28	43 517	9.46	.26	44 980	9.48	.30
4:st quart. (firm age distr.)	38 465	9.53	.28	41 816	9.50	.26	42 817	9.57	.30
Manufacturing	130 418	9.50	.26	131 124	9.49	.25	123 329	9.51	.28
Non-manufacturing	41 034	9.47	.33	41 164	9.48	.31	53 004	9.54	.34
Female	160 952	.27	.44	172 288	.26	.44	176 333	.29	.45
Experience	160 952	15.67	9.27	172 288	16.99	9.96	176 333	19.49	10.2
Seniority				172 288	7.92	6.64	176 333	10.32	6.9
Education level:									
Elementary School < 9	160 952	.18	.39	172 288	.16	.36	176 333	.11	.32
Compulsory School $=9$	160 952	.16	.37	172 288	.14	.35	176 333	.13	.33
Upper Secondary School < 3	160 952	.32	.47	172 288	.35	.48	176 333	.34	.47
Upper Secondary School $=3$	160 952	.16	.37	172 288	.16	.37	176 333	.17	.37
Post Secondary School	160 952	.09	.29	172 288	.11	.31	176 333	.14	.35
University undergraduate	160 952	.07	.26	172 288	.08	.28	176 333	.11	.31
University graduate	160 952	.004	.06	172 288	.004	.06	176 333	.006	.08
Firm characteristics:									
Log firm age	160 952	3.63	.73	172 288	3.62	.85	176 333	3.44	.92
Profits/Empl., 100.000 SEK	160 952	.25	.32	172 288	.27	.34	176 333	.33	.63
Log firm size	160 952	7.60	2.04	172 288	7.34	1.80	176 333	7.18	1.66
Capital/labor ratio	160 952	545.5	1 493	172 288	518.7	1 989	176 333	789.3	2 50
Number of firms		7 137			6 937			5 769	
% of firms that are present 1, 2 or 3 years:	1:	73 %	2:	20 %	3:	7 %			
% of individuals that are present 1, 2 or 3 years:	1:	52 %	2:	31 %	3:	17 %			
% of individuals in firms that are present in 1, 2 or 3 years:	1:	10 %	2:	20 %	3:	7 %			