# Sorting, Risk and Frictions
## Wages in New Establishments *

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**Abstract**

Classic economic theory predicts that wages reflect marginal productivity of workers. Contrary to this notion, I show that wages for comparable workers in newly founded establishments are 14 percent higher than wages in older establishments. I estimate the age - wage relationship using a unique linked employer-employee panel dataset that follows workers and establishments over time. The effect of establishment age on wage remains strongly negative after controlling for a wealth of detailed establishment and worker characteristics. Fixed effects techniques show that wage levels within establishments are declining as establishments age. Contrary to the theory that the wage difference is driven by longer contracts and therefore higher deferred compensation in older establishments, there is no evidence that wage growth in young firms is significantly slower. Three potential explanations for the age - wage relationship are explored theoretically and empirically: 1) More productive workers go to younger establishments. 2) Young establishments pay a compensating differential for higher displacement risk. 3) The elasticity of the hiring rate with respect to wages is positive so that young firms pay more in order to grow faster. Looking at workers that switch between firms, I provide strong evidence that all three mechanisms are important in practice.

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# Contents

# 1 Introduction

Researchers in labor economics have long been puzzled by the large unexplained component in standard wage regressions. The $R^2$ in such regressions is typically only about 0.3 when individual level explanatory variables, such as has experience, schooling, seniority and other demographics, are included. Seemingly similar workers get paid very different wages. Particularly interesting is the fact that the unexplained component varies systematically with characteristics of the employer, such as firm size and industry[1]. It is well documented now that large firms and certain industries (for example technology intensive industries and mining) pay higher wages and a large theoretical and empirical literature has attempted to find the mechanism behind this form of wage dispersion. The age of the firm or plant is one attribute of employers that has received very little attention from the perspective of wage dispersion. This is somewhat surprising, given that there is a considerable body of research on determinants of new establishment creation and their role in gross job flows[2].

The reason these questions have so far led to little research is the scarcity of datasets that contain information on the age of the establishment, as well as detailed wage information. Yet there are many important issues connected to this: First, we would like to have a good understanding how employees' wages and careers are determined by characteristics of the establishment. Many policies are targeted at changing the wage structure, by encouraging faster wage growth, reduction in inequality or higher employment levels. Since these policies often work through regulations and policies directly affecting employers, it is important to understand how employer characteristics are related to these goals. Second, the type of employment contracts establishments offer is important for determining what kind of workers the business can attract, how productive they are and thus how the business will perform in the medium run. From the existing literature we know there is a lot of heterogeneity in terms of productivity, profits, and wages paid by establishments, even within relatively narrow categories of establishments. Part of this might be viewed as "technological differences", where establishments have to find out what the best wage contracts are to offer to workers. Research on performance pay (e.g. Lazear 2000) shows that how establishments pay wages may have a large influence on the productivity of workers. Thus the type of wage profiles offered by establishments may influence how fast establishments grow and whether or not they go out of business. Third analyzind wage differentials between firms of different age is a particularly interesting setting to test for different theories that may explain such differentials. In contrast to other forms of wage differential between employers,

[1]For some empirical papers showing this, see Krueger and Summers (1988), Katz and Summers (1989) , Davis and Haltiwanger (1991), Doms, Dunne, and Troske (1997), Abowd, Kramarz, and Margolis (1999), and Oi and Idson (1999)

[2]See for example Davis, Haltiwanger and Schuh (1996), Davis and Haltiwanger (1999)

establishment age varies a lot within establishments over time, so that one can control for firm fixed effects to control for many unobserved employer characteristics. Conditional on firm fixed effects one can then explore directly what causes wage differentials within establishments over time, which is a much cleaner setting to distinguish between competing theories.

The first main contribution of this paper is to show that there is a strong negative relationship between establishment age and wages, which is robust to the inclusion of detailed worker and plant characteristics as controls and remains very similar in a model with establishment fixed effects. For this I use a unique matched employer-employee dataset from Germany, that allows to follow both firms and workers over many years. This setting will be used to explore three main theories of wage dispersion. First I present evidence that there is some sorting of more productive workers into younger firms, but that this can only account for a small part of the negative wage age relationship. Then I explore two main explanations: on the one hand young firms may pay higher wages to compensate for the higher risk of displacement (due to plant closure and mass layoffs). On the other hand young firms may pay higher wages because they have to grow faster and thus are forced to pay higher wages to attract more workers, for example by poaching them from other firms. In order to convince workers from other firms or workers who live further away to move to them they have to pay a wage bonus. From a theoretical discussion of these two explanations I derive various empirical predictions that I then test with my data.

The next section (2) discusses closely related literature. Section 3 compares competing hypothesis that can account for a negative wage-age relationship, namely unobserved heterogeneity, compensating differentials and search frictions, and lays out the empirical implications. This section also presents a simple model that shows how such a relationship arises naturally in many models of search frictions. Section 4 briefly describes the data and section 5 explains the estimation strategy and discusses various econometric issues. Section 6 presents the empirical results of this paper. Section 7 concludes.

## 2 Background

Other work that investigates the relationship between employer age and wages include Kölling, Schnabel and Wagner (2002); Brown and Medoff (2003); Brixy, Kohaut, Schnabel (2007); and Heyman (2007). For the United States Brown and Medoff (2003) represent the only study, to the best of my knowledge, to analyze the relationship between employer age and wages[3]. They use a dataset based on a monthly consumer

[3]Doms, Dunne, and Troske (1997) show some regressions, where plant age in included as a control in cross section regressions. The coefficient on plant age is negative and similar in magnitude to the effect I document in this paper but due to the small sample size

telephone survey which in 3 months asked about the age of the employer. This gives them a sample size of 1400 worker observations with a cross section structure. Controlling for relatively standard worker characteristics they show a slightly negative correlation between employer age and wages. Furthermore they interact tenure and establishment age in a wage regression and show that for older establishments wage profiles tend to be steeper than for younger establishments. While these results are interesting, they are relatively fragile (e.g. sometimes depend on whether age is entered in levels or in logs). The small sample allows for little precision in the results and the lack of panel data makes it hard to gauge, how important omitted variable bias might be. With their data it is also hard to explore different theories about why wage levels and slopes might be related to establishment age. Since they don't observe establishments over time it is impossible to tell whether establishment age is just masking other fundamental differences in establishment characteristics. It might be that as establishments age, they are selected in such a way that establishments that pay too much go out of business, while those with more competitive wages stay. This explains a negative age/wage correlation just as well as establishments actually changing their wage structure as they grow older. Similarly this research does not explore the differences in wage/tenure slopes in any detail.

For Germany Kölling, Schnabel and Wagner (2002) and Brixy, Kohaut and Schnabel (2007) analyze the employer age - wage relationship using the same data that I am using. The former paper uses an earlier version of this data (the first 5 waves as opposed to 12 waves in this paper) and does not use panel data estimators such as fixed effects. It shows a slightly positive employer age - wage relationship which becomes insignificant when including more detailed controls. The second paper focuses on very young establishments and shows that in the cross section these young establishments appear to pay less than older establishments.

# 3 Theory

## 3.1 Unobserved worker and firm heterogeneity

One possible explanation for a negative wage - firm age relationship is that different types of workers are working in young firms than in old firms. To some degree this is controlled for by the inclusion of firm fixed effects, since workers are probably more different across than within firms. Firm fixed effects control for a all time invariant unobservables on the firm side, that might be responsible for different selection patterns

not significant

of workers into firms. However, firm fixed effects are of course not controlling for time varying characteristics of the firm. There is not much evidence supporting the notion that worker composition changes within firms as firms get older. Haltiwanger, Lane, and Spletzer (2007) analyze changes of worker composition within young firms as they grow older and show that this is very stable. Doms, Dunne, and Troske (1997) are interested in the relationship between worker composition and the technological state of production technology within firms. While in their cross section analysis, firms with very modern technology have a significantly more educated work force, this is not the case in their longitudinal analysis: firms that adopt more modern production technologies have higher quality workers even before the upgrade. However, there might still be reasons to believe that workers differ in young and old firms along unobserved dimensions. To deal with such sorting, one can either try to control for such time varying characteristics with the available variables, or control for sorting by following workers over time as they switch between jobs.

A seminal paper in the analysis of matched employer-employee data is Abowd, Kramarz and Margolis (1999) which decomposes firm size and industry wage differentials in worker and firm fixed effects. If worker quality determines log wages as an additive component that is constant over a worker's career and employer's wage policies stay constant over time than sorting issues will be captured by the inclusion of individual fixed effects and firm wage policies by the inclusion of firm fixed effects in a wage regression. In a related paper Abowd, Creecy and Kramarz (2002) show, that in the state of Washington about 50 percent of inter-industry wage differentials are accounted for by firm fixed effects, while the remainder can be attributed to the worker fixed effects. I will follow this paper by controlling for worker and firm fixed effects in some regressions. However, the focus is different: rather than showing the role of different wage policies of employers that are captured in the firm fixed effects, I show that there are substantial wage differentials within the same employer over time, which is captured by firm age controls. The question then is, whether these wage differentials are an artifact of sorting of workers or whether they really mean that equivalent workers get paid differently. In the latter case the challenge is to identify what might be the causes for such wage differentials. I focus on two main hypothesis: higher wages in young firms compensate for increased displacement risk and higher wages are caused by search frictions.

### 3.2 Compensating differentials for displacement risk

One distinctive dimension in which young and older establishments differ, is the risk of going out of business. This risk is directly connected with the risk for workers in these firms of getting displaced. There is a large literature on displacement that shows that workers are scarred for a long period of time from displacement. One of the most prominent papers in this literature, Jacobson, Lalonde and Sullivan (1993), find an initial drop in earnings of 50 percent of the predisplacement wage and 6 years after displacement wages are still 25 percent lower. Krebs (2007) provides a recent discussion of the literature on lifetime earnings losses and arrives at the conclusion that long term earnings losses are about 25 percent for high tenure workers and about 10 percent for low tenure workers. Given that these earnings persist for many years, displacement presents indeed a very significant risk.

A few papers estimate whether workers in industries or regions of higher unemployment get compensated for the increased unemployment risk. A very early paper is Abowd and Ashenfelter (1980) who estimate that in certain industries compensating differentials for unemployment risk are up to 14 percent high. Diamond and Simon (1990) argue that in regions with very high industry concentrations employment is more volatile and unemployment risk is higher. They also come to the conclusion that there are significant compensating differentials for unemployment risk. More recently Moretti (2000) uses a dataset on agricultural workers and compares seasonal workers with a high unemployment risk to permanent workers with a much lower risk. Seasonal workers receive about 15 percent higher wages than permanent workers after controlling for selection and unobserved heterogeneity in unemployment risk. It is therefore a plausible hypothesis that young firms pay higher wages to compensate workers for the increased risk of getting displaced.

### 3.3 Search frictions

Search frictions are another possible explanation for higher wages in younger establishments. In this section I show in a simple model how a negative establishment age - wage relationship arises naturally in typical search models of the labor market. I discuss how this model fits into existing general equilibrium search models and derive a number of testable implications from this view of the labor market.

A distinctive feature of a young firm is that it has to hire a number of new workers. It is likely that the job creation rate at a young firm is higher than at an older firm. The literature that explains wage dispersion in a search framework is based on the notion that the number (or the speed) of new hires of firm depends on the wage paid by the firm[4]. In the influential paper by Burdett and Mortensen (1998), workers search for jobs both while they are unemployed and while on the job. Workers who are employed have higher reservation wages than unemployed workers. Firms that offer higher wages will therefore hire workers at

[4] This literature is well summarized in the books by Pissarides (2000), Mortensen (2003) and Manning (2003). A recent survey of the theory is Rogerson and Shimer (2005), while Eckstein and van den Berg (2007) review the empirical literature.

a faster rate because they can draw more workers from the pool of employed workers. In Acemoglu and Shimer (1999) hiring rates also increase with wage offers but the mechanism is different. In their model there is no on the job search of workers. Instead unemployed workers can sample one or more job offers at increasing costs. They prove the existence of an equilibrium in which some workers sample two jobs while the rest samples one job. The workers who sample two jobs will have a higher reservation wage than the workers who sample one job (in equilibrium this exactly compensates them for the additional search cost). When firms are allowed to pick different levels of capital (technology), they show that an equilibrium emerges in which firms with more capital pay higher wages. Neither of these papers analyze how wages would change as a newly established firm grows older. Burdett and Mortensen only analyze a steady state equilibrium in which firms are infinitely lived, while workers leave the workforce at a constant rate. Acemoglu and Shimer analyze their model in a dynamic framework, but firms only hire one worker with a fixed wage so that no firm age - wage profile is possible[5]. The following model analyzes the wage setting behavior of a firm over its lifecycle in a world that is very similar to the settings in Burdett and Mortensen, and Acemoglu and Shimer[6].

Consider a continous time, infinite horizon search economy. Workers are either unemployed or employed. Firms employ up to two workers and they maximize the present discounted value of profits. Firms die at a constant rate $\delta$ and discount future profits at a discount factor $\beta$. The overall discount factor is $r = \beta + \delta$. Each worker $i$ is paid a wage $w_i$ which can differ between workers but is fixed once a worker is hired[7]. Capital $k$ has to be hired up front and the rental cost of capital is $-\gamma k$. The marginal product of the first worker is $b_1$, the marginal product of the second worker is $b_2$, which may depend on the level of capital. The instantaneous flow of profits to a firm depends on the number of workers it has and is given as:

**2 workers:** $\pi_2 = b_1 + b_2 - w_1 - w_2 - \gamma k$

**1 worker:** $\pi_1 = b_1 - w_1 - \gamma k$

**0 workers:** $\pi_0 = -\gamma k$

[5] Although Acemoglu and Shimer do not mention this explicitly, their model actually implies that in the cross section wage and firm age are negatively correlated. This is due to the fact that firms that pay higher wages will find workers faster so they will on average be younger (once they actually have a worker and a wage is observed) than firms that pay lower wages.

[6] I refrain from developing a full general equilibrium model, but it should be fairly straightforward to embedd the analysis here both in the Burdett and Mortensen model and the Acemoglu and Shimer model by assuming that firms (rather than workers) die at a fixed rate.

[7] This is not restrictive in this model. One can also allow for flexible wage contracts e.g. with increasing tenure profiles. In this case $w_i$ simply stands for the annuitized value of the stream of expected future values. The analysis stays the same

The hiring mechanism is such, that firms post a wage and applicants arrive to sample the wage offer. Whether applicants accept the wage offer depends on the wage. The rate of hiring is thus a Poisson process where the rate of hiring depends on the wage offer: $\lambda(w_i)$. Assume $\lambda'(w_i) \geq 0$. Once a worker is hired he never quits. A firm with 2 workers has no choice variables, a firm with 1 worker has only $w_2$ as a choice variable and a firm with 0 workers has $w_1$ and $w_2$ as choice variable. If a firm does not hire a worker at a given wage, nothing changes for the maximization problem of the firm, so that the optimal set of wages $w_i$ will stay constant over time. The problem can be solved using backward induction. Once the firm has hired a second worker the value of the firm $V_2$ will be given by the constant flow of profits $\pi_2$:

$$V_2 = \int_0^\infty e^{-rt} (\pi_2) \, \mathrm{d}t$$

Integrating gives the asset equation:

$$rV_2 = \pi_2 \tag{1}$$

The flow of expected profits when a firm has one worker is $\pi_1$ plus the value of the option value of the chance of hiring a second worker. The asset equation for the value of a firm with one worker is therefore:

$$rV_1 = \pi_1 + \lambda(w_2)(V_2 - V_1)$$

After rearranging terms and plugging in equation 1 one gets:

$$\begin{aligned} rV_1 &= \frac{\pi_1 r + \lambda(w_2)\pi_2}{r + \lambda(w_2)} \\ &= \pi_1 + \frac{\lambda(w_2)}{r + \lambda(w_2)}(\pi_2 - \pi_1) \end{aligned}$$

Similarly for the value of the firm when it has 0 workers:

$$\begin{aligned} rV_0 &= \pi_0 + \lambda(w_1)(V_1 - V_0) \\ &= \frac{\pi_0 r + \lambda(w_1) rV_1}{r + \lambda(w_1)} \\ &= \pi_0 + \frac{\lambda(w_1)}{r + \lambda(w_1)}(rV_1 - \pi_0) \\ &= \pi_0 + \frac{\lambda(w_1)}{r + \lambda(w_1)}(\pi_1 - \pi_0) + \frac{\lambda(w_1)}{r + \lambda(w_1)} \frac{\lambda(w_2)}{r + \lambda(w_2)}(\pi_2 - \pi_1) \end{aligned}$$

The firm chooses $w_1$ and $w_2$ to maximize this expression. Because $\pi_2 - \pi_1 = b_2 - w_2$ and $\pi_1 - \pi_0 =$

$b_1 - w_1$.the term $\Delta(w_2) \equiv \frac{\lambda(w_2)}{r+\lambda(w_2)}(\pi_2 - \pi_1) = \frac{\lambda(w_2)}{r+\lambda(w_2)}(b_2 - w_2)$ does not depend on $w_1$. One can then prove the following proposition (see Appendix for proof):

**Proposition 1.** *Assume the applicant arrival rate is not too convex:*

$$\lambda''(\omega) < \frac{2\lambda'(\omega)(r + \lambda(\omega))}{r(b - \omega)}$$

*and marginal productivity is not increasing too fast with additional workers:*

$$b_1 + \Delta(w_2^*) > b_2$$

*Then the wage paid to the second worker is lower than the wage paid to the first worker and therefore the level of wages is declining with firm age.*

Since it seems intuitively plausible that the applicant arrival rate is concave and marginal productivity is generally assumed to be decreasing with additional workers, Proposition 1 shows that under quite general conditions wages decline with establishment age. It is striking that the negative establishment age - wage relationship does not depend on decreasing marginal productivity of labor: even if the marginal product of the first and the second workers is the same, (weak) concavity of the arrival rate is sufficient for a negative wage-age relationship. The intuitive reason for this is that there are two counteracting incentives when deciding on a wage offer: a higher wage means that once a worker is hired the benefit from this worker will be lower but also that the stream of profits is moved forward in time and thus becomes more valuable. For the second worker the benefit of hiring is simply his marginal product minus his wage. For the first worker the benefit is the marginal product minus his wage plus the option value of hiring the second worker later on. In a sense what the firm gains is that the job posting opens up for the second worker once the first worker is hired. If the firm could post both wage offers at the same time this effect would not exist, but this would also mean that the firm can costlessly increase the arrival rate of applicants. On the other hand the analysis holds as long as having additional job postings (or rather more intense search for applicants) is not costless. In this case, as long as the arrival rate is a concave function of wages and job posting investments, the higher incentives to the firm of hiring a worker in the first period will partly lead to more intense job posting and higher wages. In practice it seems likely that the marginal product of workers on the firm level is decreasing as the firm grows larger and that it is not costless for firms to increase the arrival rate of applicants. The relative magnitude of these two effects is an empirical question and likely depends on the particular labor market.

The above model assumes that all workers are hired from unemployment as in Acemoglu and Shimer (1999). If workers are also poached from other employers as in the Burdett and Mortensen model, then the hazard that a worker leaves the firm later on, lowers the expected benefit of hiring the worker. Since the hazard of leaving depends on the wage a worker is paid, this creates an additional incentive for a firm to pay higher wages. In the case of linear marginal productivity ($b = b_1 = b_2$) this incentive is the same for the hiring decision of the first and the second worker (because the cost of losing a worker does not depend on whether the firm employs another worker). Therefore the previous analysis holds. If marginal productivity is decreasing, then the costs of losing a worker are lower once the second worker is hired for either of them, because the cost of losing one of the workers will be $b_2$. At the point of hiring, the potential cost of losing the first worker is therefore higher than for the second worker because he might leave the firm while his marginal product is $b_1$ or $b_2$. This creates an additional reason for the firm to pay more to the first worker. Thus the analysis also carries over to the Burdett and Mortensen model.

The direct empirical prediction of the model is clear: wages should fall with increasing establishment age. However there are more specific implications the depending on whether the upward sloping applicant arrival rate emerges because of on the job search of workers or because of unemployed workers sampling several jobs at the same time. General predictions from the model are

**Prediction G1:** Young firms pay higher wages.

**Prediction G2:** Young firms should grow faster.

**Prediction G3:** Fast growing firms pay higher wages. Controlling for the growth rate young firms should pay the same wages as older firms.

**Prediction G4:** Firms that pay higher wages should have shorter vacancy durations.

**Prediction G5:** Conditional on capital intensity larger firms should pay lower wages.

If the wage elasticity of the hiring rate is driven by the Burdett and Mortensen (1998) mechanism additional predictions are:

**Prediction BM1:** New hires at young firms (and fast growing firms) are more likely to be hired directly out of employment.

**Prediction BM2:** When the labor market is tighter the wage differential in young firms becomes steeper.

If on the other hand the wage elasticity of the hiring rate comes from the mechanism in Acemoglu and Shimer (1999), the predictions are:

**Prediction AS1:** Workers at young firms are more likely to be workers that have lower search costs and therefore sample more jobs: singles, no children, living closeby...

**Prediction AS2:** The negative age wage profile should be steeper for firms with higher initial investments.

In practice it seems realistic that both aspects are relevant: employers hire workers from unemployment and from other employers and that the hiring rate from both pools is somewhat elastic with respect to wages. In next section the goal is therefore not to contrast the Burdett and Mortensen model with the Acemoglu and Shimer model, but rather to view them as complementary and see to what extend the search mechanism is a better exlanation of the negative age wage profile than the compensating differentials explanation. I will therefore first test to what extend these predictions are matched in the data, to see whether the search framework has the potential to explain the relationship. Second, I will test whether controlling for job creation rate or for displacement risk on the firm level has more potential to explain the negative wage establishment age profile. This is a direct test between these two theories[8].

## 4 Data

The data for this paper is the LIAB matched employer-employee dataset generated by the Federal Employment Agency of Germany (BA). The core of this data is an establishment level panel dataset based on extensive interviews with the managers. This panel data is then linked with individual level administrative data from the German social security system. This data has many advantages over datasets based on social security records in the US. Due to the establishment surveys, very detailed information is available on the employer side. Furthermore, firms are followed for many years (currently data is available from 1993 to 2004) with yearly updates on the firm side. The information on workers is fairly detailed compared to other social security datasets (wages, education, nationality, age, gender, occupation, children). For all establishments in the survey, information on all workers on June 30th of that year is available.

Establishment age is derived from survey questions regarding the year when the establishment was created. There are some questions to check whether this was truly a new establishment (rather than just a change in ownership). The question design changed from year to year (in some years the question wasn't

[8] Another paper that explores the relationship between the plant level job creation rate and wages is Belzil (2000). He shows for Danish firms that job creation rates on the firm level are indeed positively related to wages controlling for the business cycle.

asked at all) and in some years this was censored at the year 1990. I keep only firms for which I know the exact age or that were created before 1960 (so that the censoring doesn't matter given my empirical specification in the methods section). In the end I am left with 9351 establishments and a total of 43 136 establishment year observations (i.e. on average there are about 4.6 valid observations per establishment). These are matched to slightly more than 6.5 million worker year observations. For a subset of these firms workers are not just matched in the survey years, but rather for those firms the employment (and unemployment) history of workers before and after they are employed at the survey firm is available, irrespective of whether these workers were employed at other firms of the sample or not. The data is described in more detail in the data appendix, which also contains a number of summary tables.

Attrition in the LIAB is relatively high and no information is available on reasons for attrition. Thus it is not possible to estimate displacement rates or the risk of going out of business with this data. For this purpose I use another German dataset which covers the universe of German employers. The establishment history panel dataset (BHP) is created from German unemployment insurance data by collapsing all unemployment insurance records since 1975 on the year - employer ID level, thus generating essentially a panel of employers with one observation per employer and year since 1975. For each employer year a number of variables aggregated from the individual employee level are available: size, demographic composition, education levels, wages, and more. A problem arises, because establishment IDs are not entirely consistent through time and there are circumstance where establishments change their ID-number (for example in situations of mergers or ownership changes). In order to obtain valid measures for establishment age and establishment deaths, I merged the BHP data with information on the exact inflows and outflows of workers to these establishment IDs in each year. In particular, I have information whether the in- and outflows were concentrated from or to an individual establishment ID. For example, if a new establishment ID shows up and most of the workers at this ID are reported to have worked together under a different establishment ID this is unlikely to be a truly new establishment, but rather a case of ownership change or outsourcing. I thus identify an establishment as newly created only if less than 10 percent of the workers have been working together (at the same employer ID) in the previous year. Similar problems arise when establishment IDs disappear. I define an establishment death as a case where the employer ID disappears and less than 30 percent of workers are reemployed at a single employer ID in the next year. Other cases where employer IDs disappear are counted as censored. Mass layoffs are identified as drops in 30 or 60 percent of employment with not more than 20 percent of those outflows being concentrated to the same employer.

# 5 Methods

## 5.1 The wage regression function

The main econometric estimates in this paper are built on wage regressions that include employer characteristics and establishment age. Since establishment age varies over time I can use establishment fixed effects techniques to analyze this relationship.

The basic wage regression function is given as:

$$log\ w_{it} = X_{it}\beta + Z_{j_{(i,t)},t}\alpha + \gamma_{j_{(i,t)}} + \theta_t + \Lambda(a_{j_{(i,t)},t}) + \epsilon_{it} \tag{2}$$

where $w_{it}$ is the wage of a worker $i$ in year $t$ who works in establishment $j = j_{(i,t)}$. $X_{it}$ is a vector of individual control variables such as sex, education, or age; $Z_{j_{(i,t)},t}$ is a vector of establishment level controls such as size; $\gamma_{j_{(i,t)}}$ is a vector of establishment fixed effects; $a_{j_{(i,t)},t}$ is the age of establishment $j$ at time $t$ and $\Lambda(a_{j_{(i,t)},t})$ is a flexible function modeling the wage profile in the a establishment. There is a well know identification problem for the estimation of $\Lambda(a_{jt})$: In a model that allows for full flexibility in (establishment) cohort and year effects, the linear component of the age effect is not identified. Since an important goal is to estimate establishment fixed effects models, cohort effects are automatically part of this. Furthermore, it appears important to control for the business cycle and other time trends by including year effects. I therefore make the identifying assumption, that the age effect eventually plateaus after reaching age 30. This is both intuitively reasonable and fits the data very well. In particular the models below that include neither fixed effects nor cohort effects but still year effects, show a very similar profile that becomes flat after about 15 to 20 years of age. I use two specifications for $\Lambda(a_{jt})$: First I use a set of dummies for different establishment ages (dummies for 2 year intervals from 0 to 19, one dummy for 20 to 29, the omitted category being older than 30 years). This is very flexible and the coefficients can be nicely graphed to show the wage-age profile, but the large amount of dummies makes it difficult to read a regression table or to include interactions. The second specification for $\Lambda$ therefore breaks the age variable up into flexible splines ($\mathbf{1}$ is the indicator function):

$$\Lambda(a_{jt}) = \lambda_1 a_{jt}\mathbf{1}_{a_{jt}<30} + \lambda_2(a_{jt} - 10)\mathbf{1}_{10\leq a_{jt}<30} + \lambda_3(a_{jt} - 20)\mathbf{1}_{20\leq a_{jt}<30} + \lambda_4\mathbf{1}_{a_{jt}\geq 30}$$

The first spline is the age of the establishment at values 0 to 29 and takes the value 0 for older establishments. The second [third] spline is the age of the establishment minus 10 [20] at values 10 [20] to 29 and 0 everywhere else. In addition a dummy for age greater or equal to 30 is included. Note that both the dummy and the spline specification have the characteristic that the marginal effect of age is 0 at age greater or equal to 30. The spline is slightly different from the way splines are usually used because of the flat part after 29. Note that the marginal effect of age on wage in the spline specification is thus $\lambda_1$ for establishments up to age 9, $\lambda_1 + \lambda_2$ for age 10 to 19 and so on.

Firm age varies on the establishment year level, but is constant across workers within establishment year cells. It is well known that estimating equation 2 directly using OLS may dramatically overstate the precision of the estimates in the presence of group error terms. Various methods to deal with have been suggested. This paper follows the suggestion by Donald and Lang (2007) and employs a two stage method[9]. In the first stage log wages are regressed on all individual level variables and a complete set of establishment * year dummies. In the second stage the estimated coefficients on these dummies are regressed on establishment age, other establishment level variables and year and establishment fixed effects. In these regressions standard errors are clustered on the establishment level to control for serial correlation over time.

## 5.2 Extensions

After using this methodology to establish the main establishment age - wage profile, I show various extensions to the basic empirical model. First, I will analyze whether the results for the mean wage level is driven by different returns to tenure in younger and older firms. One way to do this is by restricting the sample to workers with zero years of tenure, in order to look at wages of people just starting a job. Another way is to interact establishment age with tenure to see whether the interaction term is negative and whether older firms have steeper or flatter wage growth with seniority. Finally, I also estimate the model by including dummies for each tenure firm age combination in the standard wage regression. It is easy to graph the coefficients on these dummies in such a way that one can simultaneously observe how for different levels of tenure wages are related to firm age. One problem is that the identification issues here get trickier. To simplify this, I estimate the model without year effects. Since for this, wage variation within establishment year cells is necessary (across tenure groups) I run the regression directly with the individual level data.[10] While the graph is very illustrative, it is hard to actualy compare whether differences in slopes are significant, so I also present regressions with log wage growth over two and five years after job entry on the left

[9]Since the number of clusters is large one could also use the Stata clustering command as suggested by Duflo, Bertrand, Mullainathan (2004). The advantage of the two stage method is that it allows to cluster standard errors on the establishment level in the second stage to control for correlation over time of the error terms

[10]One could also use a two stage method where in the first stage wage is regressed on establishment * year * tenure dummies and in the second stage these dummies are regressed on age * tenure interactions. Since this exercise is mainly for illustrative purposes I follow the one step method.

hand side, using the previous two stage method.

In order to check whether unobserved heterogeneity of workers is important, I use the fact that I observe workers over several years, even when they switch between firms. Observing a worker while he stays at a firm is not very informative: as will be shown in the empirical section the declining wage-establishment age relationship is not driven by workers experiencing declining wages, but rather by the fact that new workers starting at a firm later receive smaller wages. Thus it is most informative to look at the switchers and starting job wages. I do this in two ways: There are about 45000 workers in the sample that move between firms and are observed prior and after the move. For those, I keep only the observations directly before and directly after switching. I then estimate equation 2 on this resticted sample but controlling for worker fixed effects rather than firm fixed effects.[11] Since the sample for this is fairly small I also use a second method. As mentioned in the data section for a subset of workers long employment histories are observable even when they worked at out of sample firms. I use all the workers for which I have at least one observation before working at a firm in the sample.[12] I run wage regressions for the period prior to entering firms in the sample. The residual of this regression can be interpreted as a proxy for unobserved productivity (similar to the worker fixed effects component). I then include this residual in a regression of the entry wage on firm age to see wether it explains part of the relationship.

To see whether compensting for displacement risk is empirically relevant it is necessary to derive a measure for displacement risk for each firm at different ages. For this I use the BHP data, which provides information such as age and employment flows for all establishments in Germany since 1975. I divide the data in cells defined by firm age, industry, region, year, size, and educational composition. Since the dataset contains the universe of establishments it is very large and very detailed cells can be defined. For each cell I then compute the empirical hazard of going out of business and for experiencing a 30 percent or 60 percent mass layoff. These empirical hazard rates will then be merged onto the LIAB data and provide very precise and completely non-parametrical measures for the displacement risk. The simplest test is then to include the displacement risk (the plant closing, the 30 percent mass layoff and the 60 percent mass layoff) in the wage equation 2. If workers expect to be employed for several years and contracting issues are important, what might be relevant rather than the immidiate displacement risk is the displacement risk over the next

[11] Note that one might want to control for worker and firm fixed effects simultaneously, however there are two problems. On the one hand there might not be enough observations for this (this involves another 4000 dummies for firms) and the power for estimating the age coefficients might be too low. On the other hand this is computationally a bit tricky since the standard fixed effect transformation can only be used for the worker fixed effects. The firm dummies would be included manually and this causes both memory and computing difficulties which are difficult to overcome with only remote access to the data right now. Abowd et. al. (2002) provide some Fortran algorithms that I will hopefully be able to use eventually.

[12] For jobs at firms that are not in the survey I don't know their age, therefore the first method is not feasible for these workers.

couple of years, so that a natural extension of this test will be to include future values for the displacement risk in the wage regression. This will also be interacted with average industry turnover rates, since in industries with high turnover, expected employment duration is shorter and thus future employment risk should be less important.

To test the search frictions theory, I include various measures for employment growth in the wage regression. If every firm faces the same labor supply curve, the relevant statistic to capture the upward sloping supply effect would be the absolute value of total employment growth. However, it is also possible that young (and relatively unknown) firms have a steeper supply curve since less workers sample their job offers. In this case the effect might be better captured by a relative measure of employment growth, such as the percentage change, or a measure such as the change in employment between two periods divided by the mean employment in these two periods. A careful specification search seems important here, since so little is known on individual firms labor supply curves. To avoid data-mining, it is best to do the specification search on a sample of older firms and then use the resulting specification to control for search frictions in the model with young firms.

To compare the search frictions and the displacement risk theories directly against each other, I will first-difference the wage equation 2 and restrict the sample to young firms. This will give the wage change with age on the left hand side. In such a model one can then control for displacement risk and employment growth simultaneously and test which of the two has more explanatory power.

# 6 Results

## 6.1 The wage - establishment age relationship

Table 1 presents the first stage of estimating equation 2. Apart from the reported controls, the regression also includes a full set of establishment * year interactions as fixed effects. All coefficients are very precisely estimated thanks to the large sample size. The magnitude and sign of the coefficients are in line with previous research for Germany: returns to tenure and experience are moderate (about 1 and 1.7 percent per year), women earn about 14 percent less than men, non-Germans about 3 percent less. Returns to education are large, but because of the importance of different schooling tracts and degrees not directly comparable with the US. The constant is the mean of the fixed effects.

The main results on the establishment age - wage relationship is shown in table 2. The first four columns don't include establishment fixed effects. Column (1) shows the estimates without including establishment

Table 1: First Stage of Log Wage on Individual Level Variables

| | |
|---|---|
| Female | -0.140** |
| | (0.00112) |
| Foreign | -0.0341** |
| | (0.00106) |
| Tenure with employer | 0.0102** |
| | (0.000273) |
| Tenure squared | -0.000176** |
| | (0.00000958) |
| Experience | 0.0177** |
| | (0.000235) |
| Experience squared | -0.000371** |
| | (0.00000707) |
| Education: middle school, | -0.0421** |
| no vocational training | (0.00380) |
| Education: middle school, | 0.0903** |
| vocational training | (0.00373) |
| Education: high school, | 0.117** |
| no vocational training | (0.00607) |
| Education: high school, | 0.222** |
| vocational training | (0.00428) |
| College (FH) | 0.363** |
| | (0.00450) |
| College (Uni) | 0.410** |
| | (0.00485) |
| Constant | 4.198** |
| | (0.00397) |
| Establishment-Year Fixed Effects | Yes |
| R-squared | 0.291 |
| Number Estab/Year Cells | 43136 |
| Number Workers | 6543561 |

* P-value $\leq$ 0.05, ** P-value $\leq$ 0.01.
Standard errors clustered on the establishment year level.
Dependent variable is log of daily pay in real terms.
Estimates of establishment year effects are used in second stage.

age. Interestingly the wage firm size relationship is quite different from the US literature: wage and firm size is only positively related among the small firms with less than 30 workers. After that the splines cancel each other out and the relationship becomes essentially flat. Since among the small firms the effect is nearly one percentage point per worker (implying a 30 percent difference between very small firms and large firms) the magnitude of the employer size differential is similar to US size differentials, although at different parts of the size distribution. The second column includes establishment age as a right hand side variable. The estimates reveal a U-shaped wage profile: declining wages during the first 10 years of an establishment's life, flat wages for the next 10 years and increasing wages between age 20 to 30. The decline is about 0.7 percent per year during the first 10 years. Column (3) adds establishment size back to the model. The effect of this on the age profile is that the U-shape disappears and that the early wage decline becomes even steeper. During the first 10 years wages decline by approximately 12 percent, after that the relationship becomes essentially flat. Column (4) adds the number of hours worked per week, overtime work[13] and the availability and magnitude of on the job training programs as control variables. This variable is only available as a survey question on the establishment level for some years, I keep observations with missing values and include a dummy for missing in the regression. Running the regression and dropping observations with missing values yields very similar results but larger standard errors. The dummy for firms older than 30 years provides an estimate of the wage difference between very young and very old firms. In the OLS specification it appears that old firms pay roughly 5 percent lower wages than very young firms.

Columns (5) to (7) repeat the specifications of the previous three columns but include establishment fixed effects. For young firms the negative effect of firm age becomes larger: mean wages decrease by about 0.9 percent per year up to age 20. After that it becomes flatter. The coefficient on age larger than 30 indicates that old firms pay around 30 percent higher wages then younger firms. One should however keep in mind that most firms are only observed for a few years and never for more than 12, so that the entire wage-age profile is really based on the identification of different segments of the profile and putting them together. One should therefore be cautious in interpreting this 20 percent difference too literally. The identification of the marginal effects at young firm ages is much clearer.

One possibility to explain the relationship might have to do with rent sharing. Perhaps younger establishments are more profitable so that if there is rent sharing, the labor force receives a larger part of their income as a share in the profits. Or it might be the case that younger establishments are more covered by collective bargaining or face stronger unions which increases the bargaining power of the workers and

[13] The establishment panel collects information about overtime in different ways in different years. In the regressions very flexible specifications for this were used

thus their wages. Both these explanations do not seem very likely though, as one would intuitively think that the effect would go in the other direction, that older establishments are more profitable and also more likely to be confronted with strong Unions. Ideed, including coverage by collective bargaining, a proxy for profitability (such as the subjective rating of profitability or development of revenues over time), revenues and the export share as controls in the regressions has no effect on the results (not reported here).

Since the estimates of the spline functions are not easy to read, the specifications from column 5 and 6 were also estimated using age dummies. Figure 1 plots the estimated coefficients on the age dummies together with standard error bands (twice the standard error on the coefficients) from regressions including establishment fixed effects. The figure shows that the wage / establishment age relationship can be relatively precisely estimated even in this completely non-parametric specification. The shape of the graph gives a justification for picking the kink points of the splines at 10, 20 and 30. Also the flattening at high ages serves as a good justification for the identifying assumption of a flat profile after age 30.

The evidence is strong, that establishment age is negatively related with wages. Even the very flexible specification that controls carefully for establishment differences by using establishment fixed effects and uses conservative standard errors, shows a statistically and economically significant negative impact of establishment age on wages for roughly the first twelve to twenty years during an establishments lifecyle.

Table 2: Second Stage - Effect of Firm Age on Log of Real Wage

| | (1)<br>OLS | (2)<br>OLS | (3)<br>OLS | (4)<br>OLS | (5)<br>Firm FE | (6)<br>Firm FE | (7)<br>Firm FE |
|---|---|---|---|---|---|---|---|
| Age if Age less than 30 | | -0.00535** | -0.00751** | -0.00673** | -0.00914** | -0.00919** | -0.00917** |
| | | (0.00145) | (0.00137) | (0.00133) | (0.00141) | (0.00141) | (0.00142) |
| Age Spline: (Age - 10)***1**(Age$\geq$10 and | | 0.00381 | 0.00472 | 0.00450 | -0.000747 | -0.000583 | -0.000689 |
| Age less than 30) | | (0.00312) | (0.00285) | (0.00276) | (0.00219) | (0.00220) | (0.00220) |
| Age Spline: (Age - 20)***1**(Age$\geq$20 and | | 0.0119* | 0.00740 | 0.00613 | 0.00754* | 0.00739* | 0.00739* |
| Age less than 30) | | (0.00495) | (0.00448) | (0.00436) | (0.00361) | (0.00354) | (0.00355) |
| Dummy: Age $\geq$ 30 | | 0.0505** | -0.0551** | -0.0469** | -0.210** | -0.209** | -0.211** |
| | | (0.0121) | (0.0114) | (0.0110) | (0.0374) | (0.0374) | (0.0375) |
| Establishment Size: Tot Number | 0.0104** | | 0.0106** | 0.00867** | | 0.000800 | 0.000781 |
| Workers | (0.000421) | | (0.000423) | (0.000409) | | (0.000901) | (0.000904) |
| Est Size Spline: | -0.0104** | | -0.0105** | -0.00874** | | -0.000809 | -0.000793 |
| (Size - 30)***1**(Size$\geq$30) | (0.000488) | | (0.000488) | (0.000470) | | (0.000942) | (0.000945) |
| Est Size Spline: | 0.000552** | | 0.000533** | 0.000520** | | -0.0000331 | -0.0000353 |
| (Size - 150)***1**(Size$\geq$150) | (0.000168) | | (0.000168) | (0.000158) | | (0.000146) | (0.000146) |
| Est Size Spline: | -0.000584** | | -0.000569** | -0.000444** | | 0.0000394 | 0.0000444 |
| (Size - 300)***1**(Size$\geq$300) | (0.0000753) | | (0.0000752) | (0.0000706) | | (0.0000733) | (0.0000736) |
| West Germany | 0.236** | 0.253** | 0.237** | 0.236** | — | — | — |
| | (0.00752) | (0.00919) | (0.00873) | (0.00848) | | | |
| Hours per week for fulltime workers | | | | -0.00266 | | | -0.00266 |
| | | | | (0.00144) | | | (0.00144) |
| Did workers work overtime this | | | | 0.0907** | | | -0.00114 |
| year? | | | | (0.00611) | | | (0.00283) |
| Establishment Fixed Effects | No | No | No | No | Yes | Yes | Yes |
| Controlling for on the job training | No | No | No | Yes | No | No | Yes |
| R-squared | 0.324 | 0.213 | 0.326 | 0.355 | 0.024 | 0.025 | 0.025 |
| Number Establishments | 9351 | 9351 | 9351 | 9351 | 9351 | 9351 | 9351 |
| Observations (Establishment-Year Cells) | 43136 | 43136 | 43136 | 43136 | 43136 | 43136 | 43136 |

Coefficients from regressions on establishment-year level. Dependent variable is log of daily pay.
Regressions control for year dummies. In column (5) and (6) establishments with missing hours and overtime were included together with a dummy for whether the information was missing. The coefficients on the missing dummies are not reported. The data if from the LIAB 1993 to 2004, provided by the IAB in Nuremberg
Standard errors clustered on firm level

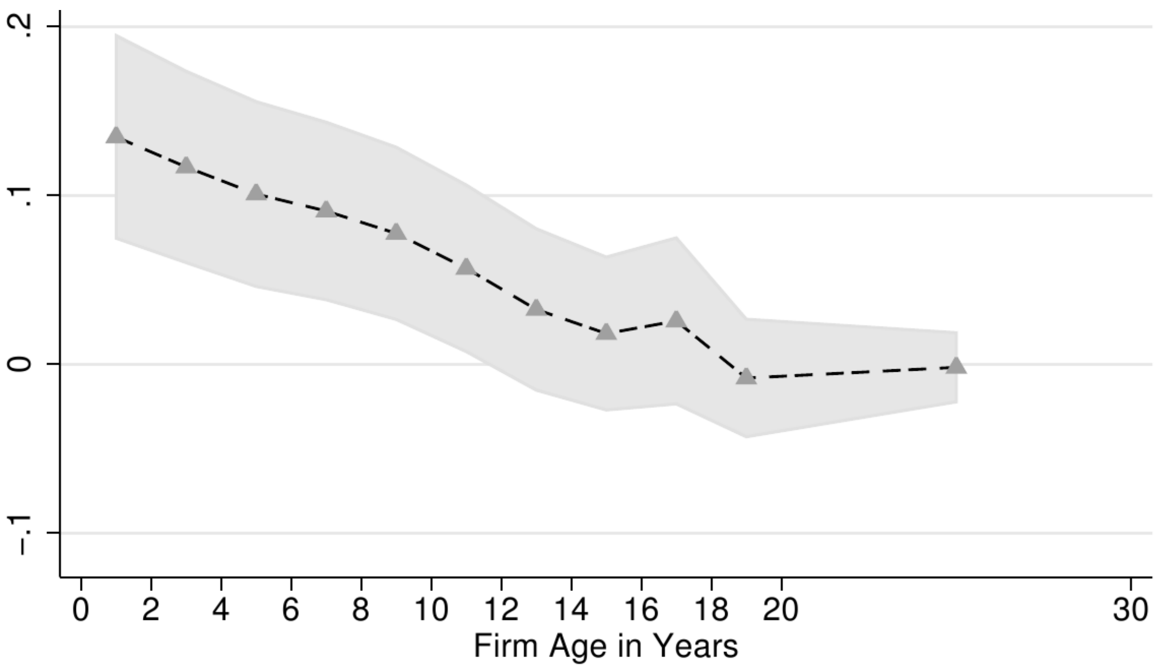


Figure 1: Plot of nonparametric establishment age - wage relationship
Controlling for firm fixed effects.
Y-axis: log wage differentials relative to age >30 years.

### 6.2 Returns to tenure and establishment age

The previous analysis focused on average wages in an establishment, lumping together all cohorts of workers. An interesting question is whether the returns to tenure change during the lifecycle of a firm. Perhaps young firms find it harder to offer contracts where a lot of compensation is backloaded. Lazear [??] argues that wages may grow with seniority as an incentive device. However if young firms have shorter expected job durations e.g. because they face a risk of going out of business, workers are reluctant to accept such a backloaded compensation scheme and thus young establishments initially pay higher wages. One way to look at this is to see whether returns to tenure change over the lifecycle of a firm. Table 3 shows regressions of log wage on a flexible establishment age specification (splines) and an interaction of establishment age with tenure. The same controls from the previous regressions are used but not reported here. I include a log(Firm Age) specification to make it easier to compare results with the OLS results in Brown and Medoff (2003). In their paper the coefficient on ln(Firm Age) is -0.0399 and on ln(Firm Age) * Tenure 0.0023, while in table 3 the coefficients in the OLS specification (column 3) are 0.0071 and -0.0033. In contrast to their results, the interaction term is strongly negative, indicating that returns to tenure decrease in older firms. The positive coefficient on ln(Firm Age) shows that the log specification does not fit the data very well

Table 3: Effect of Establishment Age on Wage - Interactions with Tenure

| | (1) OLS | (2) OLS | (3) OLS | (4) Firm FE | (5) Firm FE |
|---|---|---|---|---|---|
| Firm age in years | -0.00627** | -0.00760** | | -0.0119** | |
| | (0.000442) | (0.000446) | | (0.000523) | |
| Age Spline: (Age - 10)*(Age≥10) | 0.00666** | 0.00744** | | 0.00178* | |
| | (0.000662) | (0.000662) | | (0.000875) | |
| Age Spline: (Age - 20)*(Age≥20) | 0.000369 | 0.00306** | | 0.0142** | |
| | (0.000364) | (0.000385) | | (0.000653) | |
| Birth Year before 1960 | 0.00238 | 0.00266 | | – | |
| | (0.00167) | (0.00167) | | | |
| (Firm Age / 10) * Tenure | | -0.00221** | | -0.00218** | |
| | | (0.000105) | | (0.0000756) | |
| ln(Firm Age) | | | 0.00709** | | -0.0523** |
| | | | (0.00124) | | (0.00241) |
| ln(Firm Age) * Tenure | | | -0.00325** | | -0.00728** |
| | | | (0.000228) | | (0.000197) |
| R-squared | 0.546 | 0.547 | 0.545 | | |
| Number Firms | | | | | |
| Observations | 213209 | 213209 | 213183 | 244778 | 244751 |

Coefficients from regressions on establishment-cohort-year level. Dependent variable is log of daily pay.
Regressions control for year, tenure, experience, education, establishment size, fraction female, fraction foreigners, west germany
The data if from the LIAB 1993 to 2004, provided by the IAB in Nuremberg
Standard errors clustered on firm level

compared to the flexible definition with splines.

One has to be cautious about these results though: the specification lumps together the returns to tenure for all cohorts. However, the composition of cohorts changes as establishments grow older and older establishments naturally have more workers with higher tenure. If high tenure workers have lower wage growth, then the decline in returns to tenure among older firms partly explains the decline in returns to tenure. To look closer at this I analyze the wage trajectories of worker cohorts that enter establishments at differnet ages of the establishment. I estimate Equation 2 again, replacing $\Lambda(a_j t)$ by a set of dummies for each cohort-establishment age-establishment cell. So there is one dummy for workers who enter establishments in the year when the establishment is born, another dummy for this cohort in the next year, the year after and so on; similarly for the next cohort. The set of coefficients on these dummies for each cohort shows the wage trajectories. The regressions are run on the cohort-establishment age-year cell level and include the same controls as before together with establishment fixed effects. Figure 2 shows the estimated log wage differentials for different tenure, establishment age combinations. The bottom line for example shows how starting wages (tenure equal to zero) develop as firms grow older. The line above that shows wages for workers with one year of tenure at different firm ages. One can see the steep profile for starting wages, indicating that the age wage differentials really start when workers just enter at firms of different age. The top line (workers with 9 years of tenure) shows that there is still a clear negative firm age wage

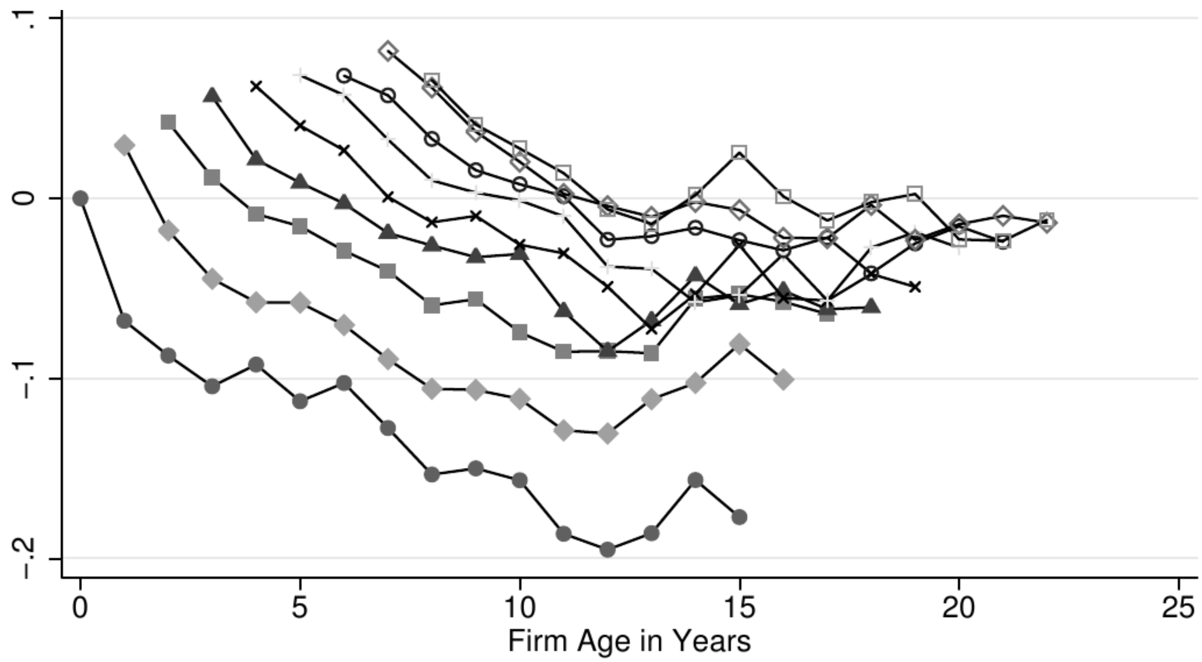


Figure 2: Wage-Firm Age Profiles for different Tenure Groups
Bottom line tenure = 0, line above tenure = 1, . . . . Controlling for firm fixed effects.
Y-axis: log wage differentials relative to age >30 years.

relationship after 9 years of working at the firms. Thus the negative relationship between wages and establishment age can not be easily explained by different wage profiles. On the other hand in the graph it does look as though at higher firm ages wages increase slightly faster and that there is some catch up of the later cohorts at higher tenure.

In figure 2 it is difficult to see whether differences in returns to tenure are significant. Therefore I also show direct regression results in table 4. This table provides a closer look on how the wage trajectories for different cohorts change. In order to avoid the problem that the tenure composition changes as establishments grow older, Colum 1 shows regressions where only workers who just started working in the establishment are included. Entry wages fall even faster than average wages. Column 2 has wage growth during the first two years on the left hand side; column 3 wage growth during the first five years. Column 2 and 3 show that there are no significant differences in wage growth among older and younger firms.

### 6.3 Unobserved worker heterogeneity

Links between establishment age and wages may arise because of unobserved differences in workers productivity. Perhaps workers select differently in young and old establishments in ways that are not picked

Table 4: Effect of establishment age on entry wages, and wage growth

| | (1)<br>Entry Wage | (2)<br>Wage growth 2 Year | (3)<br>Wage growth 5 Year |
|---|---|---|---|
| Age if Age less than 30 | -0.0109** | 0.00127 | 0.00133 |
| | (0.00275) | (0.00407) | (0.0193) |
| Age Spline: (Age - 10)*$\mathbf{1}$(Age≥10 and | 0.00309 | -0.00611 | -0.0269 |
| Age less than 30) | (0.00432) | (0.00604) | (0.0247) |
| Age Spline: (Age - 20)*$\mathbf{1}$(Age≥20 and | 0.00785 | 0.00786 | 0.0111 |
| Age less than 30) | (0.00630) | (0.00739) | (0.0303) |
| Dummy: Age ≥ 30 | -0.169* | -0.0595 | -0.460 |
| | (0.0678) | (0.0867) | (0.460) |
| Establishment Size: Tot Number | 0.00219 | -0.00391 | -0.00146 |
| Workers | (0.00149) | (0.00286) | (0.00908) |
| Est Size Spline: (Size - | -0.00203 | 0.00332 | 0.00624 |
| 30)*(Size≥30) | (0.00155) | (0.00293) | (0.0147) |
| Est Size Spline: (Size - | -0.000144 | 0.000604 | -0.00442 |
| 100)*(Size≥100) | (0.000350) | (0.000776) | (0.00868) |
| Est Size Spline: (Size - | -0.0000197 | -0.0000268 | -0.000335 |
| 300)*(Size≥300) | (0.000168) | (0.000438) | (0.000599) |
| R-squared | 0.008 | 0.023 | 0.060 |
| Number Establishments | 7168 | 1689 | 352 |
| Number Estab/Year Cells | 24512 | 6920 | 1704 |

Coefficients from second stage of two stage regression. See text for explanation.
The first stage controls for gender, education, nationality, and experience.
The second stage also controls for year dummies, on the job training, hours and overtime.
Wage is measured in log of daily real wage. Wage growth is differences between
log wage after 2 (5) years and log entry wage.
Standard errors are clustered on the establishment level.

up by variables like education and experience. A first way to look at this is how workers select into old an young establishments along observable dimensions. This can be done by simple regressions of establishment age on worker characteristics (with and without establishment fixed effects).

Table 5 explores the importance of individual heterogeneity. The first two columns use only the subsample of establishments for which I can observe workers before and after they worked for the establishment. Column 1 shows that one get's actually similar results for this smaller sample using the same specification as before. From an economic perspective what might be relevant rather than the wage at a particular point in time, is the expected total wage over the entire employment spell. This is a function of starting wage, wage growth and duration of the job. It is likely that workers leave jobs selectively and that establishments fire workers selectively. Perhaps, young establishments keep only the workers that have the highest wage growth (productivity growth) and fire those with lower wage growth, which would explain the steeper tenure profiles in younger establishments. If this selection process becomes less important for older establishments this might also explain the level effect. In the longitudinal version of the data I can calculate for a worker who just entered a establishment the total wage he will earn during the next 1, 2, 3, years (at the establishment but also after eventual job changes). Using this measure in a wage regression on establishment

Table 5: Controlling for Individual Unobserved Heterogeneity

| | (1) Firm FE | (2) Firm FE | (3) Individual FE |
|---|---|---|---|
| Age if Age less than 30 | -0.00897** | -0.00663** | -0.00574** |
| | (0.00265) | (0.00254) | (0.000955) |
| Age Spline: (Age - 10)*$\mathbf{1}$(Age≥10 and Age less than 30) | -0.00227 | -0.00619 | 0.00435 |
| | (0.00373) | (0.00357) | (0.00230) |
| Age Spline: (Age - 20)*$\mathbf{1}$(Age≥20 and Age less than 30) | 0.00543 | 0.00929 | 0.00829* |
| | (0.00637) | (0.00635) | (0.00375) |
| Dummy: Age ≥ 30 | -0.286** | -0.258** | -0.0331** |
| | (0.0833) | (0.0816) | (0.00457) |
| Residual from Preentry Wage Regression | | 0.177** | |
| | | (0.00831) | |
| R-squared | 0.251 | 0.292 | 0.111 |
| Number Firms | 2005 | 1732 | |
| Observations | 107079 | 98202 | 98451 |

Regressions on individual level (not 2 stage method).
Column (1) and (2): dependent variable log entry wage.
Standard errors are clustered on establishment level.
Column (2) controls for residual from wage regression in job before entry.
Column (3) uses only switchers between firms and only the periods directly before and after the switch. Standard errors are clustered on individual level

age in a sense automatically accounts for some of the risks that might be involved with starting at a young establishment, though it still doesnt account for the disutility of losing a job apart from the wage loss. It is also possible to look at whether workers with faster / slower wage growth than the average in a cohort are more or less likely to leave by estimating hazard models, where the effect of wage growth is estimated on the hazard of leaving the job.

### 6.4 Search Frictions

In order to test the hypothesis that the negative wage age profile is caused by search frictions, I include controls for employment growth on the plant level in the main wage regression. Since the immidiate effect should be on new hires, I run these regressions only on entry wages, i.e. on the wages of worker who entered the firm in the same year for which the employment change is calculated. Table 6 shows these regressions. The first column does not control for employment growth and shows the previous results for the entry wage again, this is to serve as a reference point for the next two columns. Column (2) controls for net change in absolute employment: $N_t - N_{t-1}$, where $N_t$ is employment in the period where wages are measured for all workers who entered between $t$ and $t-1$. In column (3) the employment change index used by Davis, Haltiwanger, and Schuh (1996) is included. This is defined as: $\frac{N_t - N_{t-1}}{N_t + N_{t-1}}$. This index has the advantage over the more common "percentage change" index: $\frac{N_t - N_{t-1}}{N_t}$, that it is defined even if $N_t = 0$ and is symmetric for growth and decline. It varies between -1 and 1. Where -1 is a drop to 0

Table 6: Testing the search frictions hypothesis

| | (1) Firm FE | (2) Firm FE | (3) Firm FE |
|---|---|---|---|
| Age if Age less than 30 | -0.0106** | -0.0100** | -0.00979** |
| | (0.00276) | (0.00268) | (0.00267) |
| Age Spline: (Age - 10)***1**(Age≥10 and Age less than 30) | 0.00279 | 0.00164 | 0.00140 |
| | (0.00433) | (0.00421) | (0.00421) |
| Age Spline: (Age - 20)***1**(Age≥20 and Age less than 30) | 0.00802 | 0.00892 | 0.00892 |
| | (0.00627) | (0.00622) | (0.00622) |
| Dummy: Age ≥ 30 | -0.163* | -0.162* | -0.160* |
| | (0.0677) | (0.0671) | (0.0670) |
| Net change in absolute employment | | 0.0000441 | |
| | | (0.0000738) | |
| Net emp change / mean employment | | | 0.0602* |
| | | | (0.0302) |
| R-squared | 0.008 | 0.008 | 0.009 |
| Number Establishments | 7183 | 6708 | 6708 |
| Number Estab/Year Cells | 24507 | 23788 | 23788 |

Coefficients from second stage of two stage regression. See text for explanation.
The first stage controls for gender, education, nationality, and experience.
The second stage also controls for year dummies, on the job training, hours and overtime.
Wage is measured in log of daily real wage.
Standard errors are clustered on the establishment level.

(a 100 percent change), and 1 is an increase from 0 (an arbitrarily large increase). Both specifications are clearly ad hoc and this should be considered as very preliminary. Column (2) shows that controlling for employment growth in the level does not have a significant effect, although it goes in the right direction and the establishment age effect becomes marginally smaller. The index has slightly more predictive power (significant at the 5 percent level), but also has only a very small effect on the age-wage relationship. These preliminary results don't bode too well for the search frictions framework, but this might easily be driven by the specific functional forms chosen here.

Next steps will be to use more flexible specifications for employment growth, perhaps interacted with other variables such as size. Furthermore it will be interesting to use other information in the datasets such as information on how hard managers find it to fill open posititions, the number of vacancies, the fraction of workers hired from other firms etc. There is still plenty of hope that the search frictions theory may explain more. An interesting feature to look at will be to use some proxies for moving / transaction costs on the workers side, such as whether they are married, have children or move from far away, to get some sense of whether firms may have to spend extra money to increase their pool of applicants. This could be considered indirect evidence for the search frictions framework.

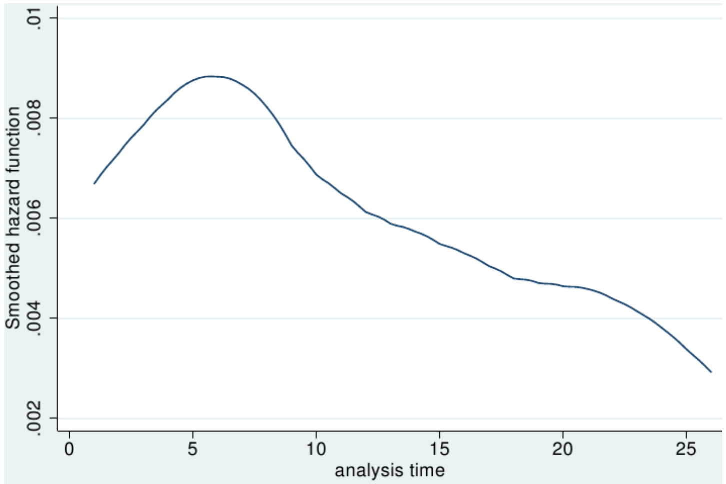


Figure 3: Firm Age - Hazard Rate of Firm Closure, Estimate at Initial Size 20

### 6.5 Compensating Differentials

There are no results on how displacement risk affects wages or the wage age relationship yet. A very preliminary indication of the importance of this channel is given by figure 3, which graphs the estimated hazard function from a cox proportional hazard model. Control variables included industry, mean education, occupation composition, region, year, and initial size. The graphed hazard function is evaluated at the mean of the controls and for a firm with initial size 20. This is was estimated on only a subset of firms and should be considered **very preliminary**. Eventually I don't intend using a hazard model but instead do this entirely non-parametrically as described in the methods section.

## 7 Conclusion

The first main contribution is to document a strong negative reltionship between firm age and wages. It is the first paper that estimates this relationship using firm fixed effects, thus showing that wages of comparable workers *within the same firm* are lower when a firm gets older. The magnitude of this wage differential is large: a worker who starts a job at a very young firm earns 14 percent higher wages than if the same worker would start at the same firm around 15 years later (taking into account the time effect of course). The negative relationship between employer age and wages holds controlling for very detailed worker and time varying firm characteristics, such as profitability, revenues, hours, overtime, on the job training, and more. Unobserved worker productivity accounts for roughly 30 percent of the effect. The structure of the data allows me to not only look at mean wages but also differences in wage growth over various horizons in these firms. While in principle it might be the case that the lower entry wages at older establishments are due to larger wage growth later on during the employment relationship, in practice this is not an important factor.

The paper then moves on to evaluate two plausible candidates to explain this negative relationship: compensating differentials and search frictions. Young firms have higher turnover rates and a significantly higher risk of going out of business. This seems to imply an increased risk for workers of getting displaced at younger firms. Since we know that displacement is very costly to workers it is plausible that higher wages in young firms constitute a form of compensating differentials for displacement risk.

The empirical tests for the compensating differentials theory and the search frictions theory are currently work in progress. Once completed they should give a good indication of the relative importance of the theories in this context of wage dispersion. Being able to distinguish between the theories empirically will be one of the important contributions of this paper.

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# APPENDIX

## A Data appendix

The LIAB is a dataset generated by the Federal Employment Agency of Germany (BA). The core of the LIAB is an establishment level panel dataset based on extensive interviews with the managers. This panel data is then linked with individual level administrative data from the German social security system.

The surveys are extensive and include questions on workforce composition and development, revenues, development of profits (whether got better or worse), investments, innovations, public subsidies, training programs, apprenticeship training, methods of employee recruitment, new positions, vacancies, overall wages, average time worked, overtime worked, trade relations, etc. Apart from these regular questions that are asked in every year, there is a special questionnaire each year with shifting focus.

Due to cofidentiality reasons the dataset can only be accessed through special work stations at the Reasearch Data Center of the German Federal Employment Agency at the Institute for Employment Research (IAB) in Nuremberg. However after using the dataset onsite, one can access the data remotely by submitting code which is run on the local server and the log files are returned. Usage of the dataset if free to academic researchers.

The sample design is a random sample stratified by establishment size, so that sampling probability is approximately proportional to number of employees. In 1996, establishments in East Germany were added for the first time. Furthermore in every year establishments were added to the sample to make up for attrition, to account for newly founded establishments and to make the data more informative. This causes the aggregate time series to be quite inconsistent (e.g. establishment age is declining with time). The initial response rates to the surveys were about 70 percent, roughly constant across establishment size. Establishments that were re-interviewed had a response rate of 80 percent or more.

On the establishment side, there are between about 4,000 and 15,000 observations per year. The large variations are caused by sample attrition and expansion of the sample in later years. Table A-1 gives the number of establishment observations in each year of the sample (1993-2004).

The link to worker level data is done in two different ways, which results in two versions of the LIAB. In the first version, called the cross section LIAB, for every establishment year observation (one interview) the information for all workers at this establishment on June 30th of that year is provided. So, for example, if establishment X has 100 employees in year 1993, then in 1993 there are 100 records for this establishment, one for each worker. These worker level records have information on education, age, sex, nationality, wage, occupation, tenure, and experience. In year 1994 I would have all workers at that establishment again and since the personal identifier remains the same across years, I can see who stayed at the establishment and who didnt. This allows me to follow workers while they are in establishments in the sample, but I dont know anything about their previous or past work history (apart from tenure and experience). The name cross section LIAB thus stems from the fact that there is no explicit attempt to follow workers for a long period, but there can still be repeated observations for workers and there is a panel structure for the establishments. In this version there are about 27 million worker observations.

The second version is called the longitudinal LIAB which allows to follow workers for a long period of time before they enter the establishment sample and after they leave it. Due to performance / size considerations, only a subset of about 9600 establishments is used for the longitudinal LIAB. Here the worker dataset has the entire work history from 1993 to 2002 of each worker who worked in any of the Employer panel establishments for at least one day between 1997 and 2002. Thus for the 10,000 establishments, there are about 3.3 million workers (2.4 m West, 1.1 m East), with close to 45 million observations/spells (a worker can have more than 1 observation per year if jobs are switched or a worker becomes unemployed). Information on workers is the same as described above.

The establishment survey asks a variety of questions relating to when the establishment was created and under what circumstances (e.g. whether it was truly a new establishment creation or rather a change of ownership). During the 12 period of the current LIAB, the question format changed a number of times. In the early waves the respondents were asked whether the establishment was created before or after 1960 and only in the latter case the exact year of foundation was inquired. In the latter waves (after 1997), it was asked whether foundation happened before or after 1990 and only for the establishments after 1990 the exact year of birth was recorded. Furthermore there is a high non-response rate for this question, so that only for a subset of establishments I observe exact establishment age, for another subset I observe establishment age censored at 1960 or 1990 and for the remaining establishments I don't observe it at all. In my analysis I use only the establishment for which I know the exact age plus those that have age censored in 1960. I throw out all establishments that indicated that the given birth year was not really the creation of the establishment. I also only keep establishments that are independent companies or branches of larger companies, this excludes company headquarters and midlevel management units. Furthermore I only keep private businesses, throwing out public services and NGOs.

Table A-2 shows some summary statistics for the cross section of establishments in the year 2000 by age categories. Note that a convenient feature of the chosen age category is that the top category (age 30 and older) contains those establishments that have censored age (born before 1960) throughout the entire sample period (1993 to 2004).

Table A-2 shows clearly that the sample is very unbalanced in several respects. For example the large increase in the number of establishments from the youngest age category up to category 8 to 9 years old is clearly a reflection of the sample design and in part of the fact that in 1991 to 1994 a lot of new establishments were created in Eastern Germany. Thus one has to be very careful in interpreting the cross section relationship in this table. The category of very old establishments appears clearly different: establishments are much larger (570 workers vs. the average of 240), have a large export share of their revenue, bigger investments and much higher wages. Regarding wages there appears to be a U-shaped relationship between establishment age and wages.

Table A-3 shows characteristics of of establishment broken down by size. Here the relationship between the variables and size is very monotonic: bigger establishments are older, have higher export shares and larger investment volumes.

Table A-1: Number of establishments per year

| Year | Frequency |
|---|---:|
| 1993 | 4,109 |
| 1994 | 3,935 |
| 1995 | 3,828 |
| 1996 | 7,862 |
| 1997 | 8,087 |
| 1998 | 8,507 |
| 1999 | 9,055 |
| 2000 | 12,940 |
| 2001 | 14,354 |
| 2002 | 14,018 |
| 2003 | 14,258 |
| 2004 | 13,732 |

Table A-2: Characteristics of establishments in 2000 by establishment age

| Establishment age in years | Number of establishments | Number of workers | Export share in percent | Investments in Euro | Dayly wage in Euro |
|---|---|---|---|---|---|
| 0 to 1 | 106 | 182 | 12.60 | 12 000 000 | 74.98 |
| 2 to 3 | 383 | 134 | 5.90 | 1 331 894 | 75.01 |
| 4 to 5 | 659 | 88 | 6.42 | 819 153 | 74.99 |
| 6 to 7 | 824 | 68 | 6.03 | 536 880 | 72.45 |
| 8 to 9 | 1170 | 92 | 4.44 | 564 418 | 72.65 |
| 10 to 11 | 755 | 86 | 3.61 | 597 608 | 72.32 |
| 12 to 13 | 73 | 85 | 14.26 | 3 012 089 | 69.25 |
| 14 to 15 | 80 | 103 | 13.48 | 961 157 | 67.31 |
| 16 to 17 | 65 | 56 | 7.46 | 365 744 | 68.86 |
| 18 to 19 | 68 | 55 | 4.24 | 382 736 | 69.62 |
| 20 to 29 | 324 | 141 | 9.23 | 993 969 | 76.88 |
| 30 and older | 1983 | 573 | 19.00 | 6 503 343 | 86.66 |
| Total | 6490 | 240 | 9.33 | 2 645 679 | 79.97 |

Table A-3: Characteristics of establishments in 2000 by establishment size

| Establishment size category | Average # of employees | Estab. age in years | Export share in percent | Investments in Euro | Count |
|---|---|---|---|---|---|
| 0 to 9 employees | 3.6 | 11.47 | 2.51 | 33 047 | 1854 |
| 10 to 49 employees | 21.5 | 16.29 | 5.24 | 226 662 | 1993 |
| 50 to 99 employees | 64.2 | 18.29 | 9.31 | 571 490 | 657 |
| 100 to 249 employees | 153.6 | 22.45 | 15.32 | 1 080 928 | 748 |
| 250 to 499 employees | 328.5 | 25.20 | 22.56 | 2 690 758 | 501 |
| 500 and more employees | 1617.8 | 31.46 | 35.18 | 20 300 000 | 737 |
| Total | 240.9 | 18.24 | 9.33 | 2 645 679 | 6490 |

Table A-4: Death rates by establishment age in BHP Data

| Estab. age in years | Count | # Employees | Fraction death |
|---|---|---|---|
| 0 | 302 504 | 4.2 | .053 |
| 1 | 177 801 | 9.2 | .016 |
| 2 | 154 494 | 10.4 | .017 |
| 3 | 133 604 | 11.3 | .014 |
| 4 | 117 548 | 12.0 | .012 |
| 5 | 104 339 | 12.3 | .010 |
| 6 | 93 705 | 12.1 | .010 |
| 7 | 84 166 | 12.3 | .010 |
| 8 | 75 637 | 12.5 | .009 |
| 9 | 68 235 | 12.9 | .009 |
| 10 | 61 226 | 13.3 | .009 |
| 11 | 55 105 | 13.2 | .009 |
| 12 | 49 294 | 13.6 | .008 |
| 13 | 43 926 | 14.0 | .009 |
| 14 | 39 137 | 14.3 | .009 |
| 15 | 34 693 | 14.6 | .009 |
| 16 | 30 624 | 14.8 | .010 |
| 17 | 26 920 | 15.0 | .011 |
| 18 | 23 521 | 15.4 | .009 |
| 19 | 20 454 | 16.0 | .010 |
| 20 | 17 562 | 16.0 | .010 |
| 21 | 14 846 | 16.1 | .010 |
| 22 | 12 195 | 16.4 | .013 |
| 23 | 9 541 | 17.0 | .013 |
| 24 | 6 910 | 18.2 | .014 |
| 25 | 4 478 | 20.0 | .020 |
| 26 | 2 183 | 22.9 | .028 |
| Total | 132117.6 | 10.32195 | .0228217 |

# B Proofs

**Proposition 1:**

*Proof.* The firm chooses $w_2^*$ such that it maximizes $\Delta(w_2)$.

$$w_2^* = \arg\max_\omega \frac{\lambda(\omega)}{r+\lambda(\omega)}(b_2 - \omega) \tag{3}$$

At the optimum $\Delta$ takes the value $\Delta(w_2^*)$. In picking the optimal wage for the first worker $w_1^*$ the firm takes $\Delta(w_2^*)$ as given. Therefore:

$$w_1^* = \arg\max_\omega \frac{\lambda(\omega)}{r+\lambda(\omega)}(b_1 + \Delta(w_2^*) - \omega) \tag{4}$$

Equation 3 and 4 show that the maximization problem for $w_1$ and $w_2$ is actually very similar. Both the $w_1$ and $w_2$ are given as the solution to a maximization problem of the form $\max_\omega \frac{\lambda(\omega)}{r+\lambda(\omega)}(b-\omega)$, where $b$ is either $b_1 + \Delta(w_2^*)$ or $b_2$. The first order condition of this problem is:

$$G \equiv \lambda'(\omega)r(b-w) - \lambda(\omega)(r+\lambda(\omega)) = 0$$

Using the implicit function theorem one gets:

$$\frac{\partial w}{\partial b} = -\frac{\frac{\partial G}{\partial b}}{\frac{\partial G}{\partial w}} = \frac{-\lambda'(\omega)r}{\lambda''(\omega)r(b-\omega) - 2\lambda'(\omega)(r+\lambda(\omega))} \tag{5}$$

The numerator and the second term of the denominator are always negative and at the optimum: $\omega < b$. Therefore $\frac{\partial w}{\partial b}$ is positive if

$$\lambda''(\omega) < \frac{2\lambda'(\omega)(r+\lambda(\omega))}{r(b-\omega)} \tag{6}$$

holds. In other words $\omega$ is declining in $b$ if $\lambda(\omega)$ is not too convex. Weak concavity of $\lambda(\omega)$ is sufficient. Since the first and the second wage emerge from this maximization problem but with different $b$, proposition 1 follows. □