# Who Gets Good Jobs? The Hiring Decisions and Compensation Structures of Large Firms

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## Abstract

Most research in labor economics concerning firm size has focused on the size-wage puzzle, but little attention has been paid to the differences in hiring practices and wage structures between large and small firms. In this paper, I use data from the Benefits Supplement to the Current Population Survey (CPS) to demonstrate that large firms hire younger workers than small firms do, especially for white-collar occupations. This finding is implied by the firm-specific human capital theory since large firms invest more in workers than small firms do and because those investments are fixed costs. I then present a simple model of firm cost minimization within an employee search framework, which is consistent with large firms' propensity to hire younger workers, and has additional testable implications regarding large firms' compensation structures. First, since young workers are more valuable to large firms than to small firms, large firms offer higher starting wages to attract them. This implies flatter starting wage–age profiles among the new hires in large firms. Second, since large firms invest more in workers, they continue to pay higher wages to retain the trained employees. This implies steeper wage-tenure profiles in large firms. Both predictions are borne out by the CPS data. Most strikingly, for the newly hired white-collar workers, not only are the starting wage-age profiles flatter in large firms, but also the size-wage premium disappears for workers hired at age 35 or older. Finally, limited evidence from the BLS Survey of Employer Provided Training 1995 and the CPS suggests that industries that train more also appear to hire younger workers.

Keywords: Firm Size, Hiring, Training, Fixed Costs and Wage Structures.

JEL Codes: J3

# 1 Introduction

It has been well-established that jobs in large firms are characterized by higher wages, better benefits, and more stability than those in small firms (see for example Lester (1967), Mellow (1982), Pearce (1990), and Brown and Medoff (1989))[1]. This suggests that jobs in large firms are "good jobs." For example, the wages paid by firms with 1000 or more employees are about 35% higher than those paid by firms with under 25 employees. There is a relatively large literature aiming to explain the wage-size puzzle, but little consensus seems to have been reached (see Brown and Medoff (1989) and Oi and Idson (1999) for reviews).

The firm-specific human capital investment theory provides one possible explanation for the size-wage premium. Premised on the assumption that firm-specific human capital investment (or training) is more effective in increasing labor productivity in large firms,[2] the higher wages offered by large firms, which are part of the gains shared by firms from the training-induced productivity increase, are viewed as a means to reduce turnover rates. Despite its theoretical appeal, it is very hard to test this theory since information on investment and productivity is typically unavailable.

This paper is not intended to directly test this theory as an explanation for the size-wage puzzle. The aim of this paper is to advance the firm-specific human capital investment theory to explain some important differences in hiring practices and wage structures between large and small firms. These differences have received little attention in the existing literature,[3] yet may be crucial to our understanding of the behaviors of different sized firms and help shed light on the size-wage puzzle.

Given the assumption that large firms invest more in workers, one question that arises is what kind of workers are valuable to large firms. The firm-specific human capital theory suggests that large firms prefer to hire younger workers.[4] The reason is simple: firm-specific human capital

[1] Better fringe benefits in larger employers have been documented previously by Antos (1981), Freeman (1981), and Atrostic (1983).

[2] This may be because large firms have different capital structures or production organizations. Alternatively, large firms have more of an incentive to invest in human capital because their higher survival rates would also enhance the returns to the investments.

[3] One notable exception is Weiss and Landau (1984). They studied firms' recruitment and selection strategies that minimize the per unit cost of labor and how these vary across firms of different sizes. They assumed that the quality of the best worker a firm can hope to attract is determined by its wage offer and that as the number of units to be employed increases, the size of the available pool does not increase in the same proportion, so the number of applicants per vacancy falls. As a result, at any given minimum qualification level, larger employers will have to pay higher wages to attract enough workers to maintain production. This mechanism would generate a positive relationship between employer size and wages, provided the distribution of worker quality in the firm's area satisfies certain conditions.

[4] Ability or innate productivity of workers could be important characteristics along with youth, but they are seldom observable. The theory by Weiss and Landau (1984) cannot explain why large firms hire younger workers unless we

investments are fixed costs regardless of the employment duration, and younger workers have potentially longer working horizons.[5] Therefore, large firms should prefer to hire younger workers to reduce the hiring frequency and better recoup their investments.

I demonstrate empirically that large firms do hire younger workers than small firms, especially for white collar occupations, for which training investments are large. The data I use are from the Benefits Supplements to the Current Population Survey (CPS) conducted in four years between 1979 and 1993.

I then advance a simple illustrative model, incorporating firms' fixed costs of investment and employee search theory, which not only can account for large firms' propensity to hire young workers, but also has implications for large firms' compensation structures. To establish a durable work force, large firms may design compensation packages to attract young workers by paying them higher starting wages (relative to older workers) than small firms and, after hiring, continuing to pay high wages to retain those trained workers. Empirically this generates two testable predictions regarding wage structures. First, since young workers are more valuable to large firms than small firms, we would expect that, for the *newly hired* workers, the wage-age profiles for large firms in a cross-sectional regression will be flatter. This is partly supported by the data for white collar workers. Large firms (with 100 or more employees) do exhibit a flatter starting wage - age-at-hire profile than smaller firms (with employees 25-99). More interestingly, I find that, while newly hired white collar workers under age 35 enjoy higher starting wages in large firms than their counterparts in small firms, the older new hires have starting wages no greater or even lower than their counterparts in small firms. This suggests that large firms do act strategically in their recruiting practices to differentiate between young and old workers.[6]

Second, if large firms invest more in firm-specific human capital, presumably mostly at the beginning of employment, then losing those trained employees later would incur a bigger loss. Thus large firms could design compensation plans to tilt the wage-tenure profile to reduce turnover. This implies both longer job durations and steeper tenure profiles in large firms.[7] Both predictions are supported by the data, although the empirical evidence for the latter is less strong.

In sum, the evidence is broadly consistent with the view that large firms invest more in work-

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are willing to make assumptions about the relationship between a worker's quality and age.

[5] Even though those very young workers may be more mobile, say due to job-shopping, those who settle and stay are more likely to work longer periods with the firm than an older worker. Put differently, the expected job duration is still likely to be longer for young workers than for older workers.

[6] Large firms may also value some other unobserved characteristics such as learning ability, but this is hard to test. However, the fact that large firms pay more than small firms to younger workers and less to older workers suggests that there are some characteristics associated with age that are valued differently by large and small firms.

[7] This is also consistent with Lazear (1981). More discussion can be found later in section 7.

ers and the higher investments may explain many differences in hiring practices, wage levels and structures between large and small firms.

Finally, if the relationship between firm size and workers' hiring ages is indeed a more general relationship between human capital investments and workers' age, we would expect to observe similar patterns across industries. I present some limited evidence from the BLS Survey of Employer Provided Training 1995 (SEPT 95) demonstrating that industries that invest more in human capital appear to hire younger workers.

The rest of the paper is organized as follows. Section 2 provides some empirical evidence of training investment variation by firm size. Section 3 demonstrates that large firms do appear to hire younger workers. Section 4 presents a simple theoretical model which is consistent with the findings in Sections 2 and 3 and yields additional empirically testable predictions regarding large firms' compensation structures. Empirical results are presented in Section 5. Section 6 discusses some related models and Section 7 concludes.

## 2 Training Investments and Firm Size

The firm-specific human capital investment theory, as an explanation for different firms' hiring behaviors, critically depends on the assumption that large firms invest more in workers. It is therefore important to examine available empirical evidence in order to evaluate this assumption. In this section, I provide some evidence of variation in the training investments by employer size.[8]

The data source used in this section is from the Bureau of Labor Statistics (BLS) 1995 Survey of Employer-Provided Training (SEPT95). The SEPT95, sponsored by the Employment and Training Administration of the U.S. Department of Labor, measures different aspects of training. It provides information on the amount of formal and informal training provided by employers as well as the amount of selected training expenditures. This survey was conducted during personal visits to more than 1000 private establishments with 50 or more employees from May through October 1995 (the reference date for the sampling frame is the 4th quarter of 1993). There are two parts of the survey: a survey of establishments and a survey of randomly selected employees in the

[8] Evidence from previous training literature generally supports the idea that large firms are more likely to provide training. For example, Bishop (1985) and Barron, Black and Lowenstein (1987) using Employment Opportunity Pilot Project (EOPP) data, Haber (1988) using SIPP data, and Lynch and Black (1995) using Educational Quality of Workforce-National Employer Survey (EQW-NES), all found that the probability of formal and informal training rises with employer size. However, there was usually no information on the actual dollar amount spent by employer size. Hours or weeks of training were often used as proxy to the costs. The results on this are mixed. For example, Bishop (1985) found that both smallest and largest establishments provide the most training. Barron, Black, and Lowenstein (1987) did not find a statistically significant (linear) relationship between employer size and hours and weeks of training.

surveyed establishments. A representative of the establishment provided information on the hours and costs of *formal* training and randomly selected individual employees provided information on their hours of both formal and informal training received and the wage and salary cost of the time that employees spent in both formal and informal training.

Using this data source, I show that there is variation in the amount of training by employer size, both in incidence (the extensive margin) and in costs per employee (the intensive margin). Figure 1 shows the percentage of employees receiving training from their current employer by establishment size. There appear to be moderate variations – the incidence of formal training ranges from 79% for establishments with 50-99 employees to nearly 88% for establishments with 500 or more employees.[9]

In addition to the incidence of training, the intensity of training is another important dimension in measuring the amount of the training costs. Unfortunately, the measurement of such costs is a very difficult issue, especially for informal training. The SEPT95 has some information on the per employee costs of certain training expenditures, although far from a complete and perfect measure. I calculate two kinds of costs: direct and indirect. The direct costs are *selected* expenditures per employee for the year 1994 of the following: wages and salaries of in-house trainers, payment to outside trainers, tuition reimbursement, contribution to outside training funds, and subsidies for training received from outside sources. The indirect costs are the wages and salaries paid to the employees while in training from May to October 1995 (from the employee survey part), representing the loss of production. Figure 2 plots the two kinds of costs by employer size, and there is sizable systematic variation. Large establishments with 500 or more employees spend almost three times the amount of small establishments with 50-99 employees ($466 versus $159 for the direct costs and $308 versus $110 for indirect costs).

It should be emphasized that those cost figures are only selected training expenditures, and they cannot be taken as the true overall costs. In addition, the costs reported here are per employee expenditures, which may understate the true training expenditures for each new hire. This is because training often takes place at the beginning of an employment relationship, and new hires often comprise a low fraction of the workforce. Furthermore, this discrepancy may disguise a bigger difference in costs of training new workers by firm size, since new hires comprise a lower fraction of workforce in large firms than in small firms. (For example, in the CPS data, new hires with tenure less than or equal to one year comprise about 17% of the overall workforce in firms with 1000 or more employees, and about 35% in firms with under 25 employees.)

In sum, the limited evidence above suggests that large firms do invest more in training their workers than small firms do. In the next section I investigate whether the higher investments in large firms imply that large firms hire younger workers.

[9] There is little variation in the incidence of informal training by establishment: 97%, 95%, and 96% for size 50-99, 100-499, and 500 and above, respectively.

# 3 Do Large Firms Hire Younger Workers?

## 3.1 Data: CPS Benefits Supplement: May 1979, 1983, 1988, and April 1993

The main data source in this paper is the Benefits Supplements to the CPS from May 1979, 1983, 1988, and April 1993. In addition to the usual information on individual demographics and labor market experience, these data also have information on tenure and employer size on the job held at the survey date.[10] With tenure and age information, I can compute a worker's age when he or she was hired by the current employer. Since I want to study firms' hiring behavior, self-employed individuals are excluded and the sample is limited to private sector wage and salary workers aged 20-65.[11] Agriculture, forestry, fishing, and private household services are also excluded due to their different natures. Hourly earnings are computed as weekly earnings divided by the hours worked in the previous week. Outlier observations with hourly earnings under $1 or above $250 are dropped from the sample. All earnings are deflated by the CPI to 1982-84 constant dollars.

There are two measures of employer size: the number of employees at the establishment and, if the firm has multiple establishments, the number of employees at all establishments. Both firm size and establishment size are categorical variables. Without imposing assumptions on the distribution of size within each category and linearity across categories, I report all the results by each category instead of converting the discrete variables into a continuous one. Note that the 3 more recent years have finer categories than the 1979 data. For consistency and comparability, I adopt the cruder category measures available in 1979: number of employees under 25, 25-99, 100-499, 500-999, and 1000 and above. Since there are only a small number of observations in the 500-999 category, I combine it with the 100-499 and end up with four final size categories.

## 3.2 Age-at-Hire and Firm Size

The firm-specific human capital investment theory, as a potential explanation for the "size-difference" in hiring and compensation, is premised on the assumption that there is variation in investments in workers across firms of different sizes. We know that jobs differ by tasks and the skills required to achieve those tasks. Jobs involving only simple repetitive tasks may not require any substantial amount of training investment regardless of firm size, such that we may not observe much size variation in investments for those occupations. In contrast, high-skilled jobs may require a substantial amount of training investment (especially, formal training) to prepare workers for the job. If large

[10] The May 1979 CPS data were used extensively in previous literature to study the size-wage effect in the U.S. labor market (see, for example, Mellow (1982), Brown and Medoff (1989), and Pearce (1990)).

[11] Workers under 20 years old were excluded from the sample since some of them might still be in school and the jobs they held might be temporary and differ in nature from what I am studying. However, I did re-do the analysis for the bigger sample (including 15-19 years-old), and results did not change much.

firms need to invest more in employees in order to organize production efficiently, then we would expect to see greater variations in investments in those jobs by size. Haber et al (1988) find that the gap in training investments between large and small employers is larger at the higher skill levels (see Oi and Idson (1999)). Training data from the previous section suggest that the incidence of formal training for white collar occupations is higher than for blue collar. Using BLS SEPT 95 data, Figure 3 plots the percent of employees who have received formal training by occupation while with their current employer. We see that white collar workers are more likely to receive formal training than blue collar workers: the incidence of training is 87.1% for managerial and administrative, 95.3% for professional and technical, 89.3% for sales, clerical and administrative support, compared to 70.7% for service and 80% for production, construction, operating, maintenance, and material handling. If training of white collar workers is mostly likely to be formal training and that of blue collar workers is mostly informal, we would expect to see the training costs and age-at-hire pattern to be more pronounced for the white collar workers, since there is greater cost variation in formal training by firm size than in informal training. As a result, in the following empirical analysis, I present results by two major occupational groups: white collar (managerial, professional and technicians, sales, and clerical) and blue collar (craft, operative, laborer, transport equipment movers and other services), as a very crude control for those job characteristics.

### 3.2.1 Means

The firm-specific human capital investment theory implies both younger age-at-hire and longer tenure in firms with substantial investments. Table 1 reports workers' mean age-at-hire, tenure with the firm, and education by firm size for the four year sample periods. In each year panel, results for white collar and blue collar workers are reported separately. For white collar workers, the mean age-at-hire declines monotonically as firm size increases. The differences in average age-at-hire between the smallest size and the biggest size group are 4.64 years in 1979, 3.6 years in 1983, 3.0 years in 1988 and 3.85 years in 1993, all of which are statistically significantly different from zero. The consistent pattern across years suggests that large firms do appear to hire younger workers in white collar occupations.[12] For blue collar workers, this pattern does not hold uniformly. The largest firms still appear to hire younger workers than all the other size groups, but the smallest firms with number of employees under 25 also hire younger workers than the medium sized firms.

As alluded to earlier, the lack of a uniform pattern for the blue collar jobs may result from job characteristics such as tasks and skills. First, in general, blue collar jobs may mainly involve tasks which require little training (especially, formal training) regardless of firm size. For example, we would not expect to see large firms necessarily invest more than small firms on training janitors,

[12] This does not contradict the fact that the incumbent workers in large firms are on average more experienced (or older). It is just that the new hires are on average younger.

therefore there is no reason to expect large firms to hire younger workers in this occupation. Second, jobs differ by the skills required to perform these tasks. One indicator for the skill requirement of jobs is education. As can be seen from Table 1, white collar workers are on average better educated than blue collar workers.[13] Since training investment is generally found to be positively correlated with worker's education level, investments may be more of a concern for workers in white collar occupations. Finally, there might be some other non-economic but important factors associated with blue collar workers that are age-related but have little to do with firm-specific training, for example, young workers usually have more physical strength to perform some tasks. For these reasons, the subsequent analysis will be focused on white collar workers, although the results for blue collar workers will also be discussed briefly in comparison, whenever applicable.

For both occupation groups and across all four years, a worker's tenure increases with firm size. The differences in average tenure between the largest and smallest firm range from 2.9 to 4.1 years for white collar workers and 4.7 to 6.1 years for blue collar workers. The longer tenure in large firms is also consistent with the idea that large firms have more firm-specific investments, and that when there is "rent-sharing" between workers and firms, the separation rate is lower.

There are some potential problems with the stock sample including workers with various tenure levels. One concern is due to the fact that hire age is computed as the difference between a worker's age and tenure. At any given point in time, long tenured jobs are over-sampled, and we know tenures are systematically longer in large firms (see, for example, table 1).[14] So even if small firms hire as many young workers at a point in time as large firms, these jobs are more likely to have terminated and therefore are less likely to be included in the sample. But this can be overcome by comparing workers in large and small firms with the same tenure.

Another concern is that firm size may be changing over time. A small firm 5 or 10 years ago may have become a medium or even large one. But we only have information on the current firm size. If a firm that hired younger workers was small at the time of hiring, but has grown to a large one now, we would mistakenly attribute the younger age-at-hire to the large firm. However, we can avoid the problem by examining only the *newly hired* workers who have tenure *less than one year* with the current employer, since it is unlikely that firms grow substantially within one year. Using the new hires sample can also help us avoid the first problem. Therefore in the following analysis, the results are reported for new hires and all workers separately.

Mean differences in age-at-hire across firm-size categories using new hires and all workers (but controlling for tenure for the latter) are reported in columns 1 and 2 of Table 2 in the form of

[13] A white collar worker, on average, has at least some college education (mean education greater than 13 years) while a blue collar worker, on average, has not finished high school (mean education is less than 12 years).

[14] Longer tenure in large firms may also be due to the fact that large firms are less likely to fail and have been in business longer than small firms on average.

regression coefficients. A new hire is, on average, 2.3 years younger in the largest firms than in the smallest firms. This difference is smaller comparing to the number of 3.2 years using all workers with the same tenure, but it is still statistically significantly different from zero at the conventional levels.

#### 3.2.2 Distributions

The mean itself might not be completely informative about the entire distribution of age-at-hire. For example, we would like to know whether the difference mainly comes from youth, prime aged workers or older workers. Figure 4a plots the kernel density estimates of the distributions of age-at-hire for the newly hired and all white collar workers.[15] The first thing to notice is that, for both samples, large firms appear to concentrate their hires in workers in their 20s and small firms have a more spread out distribution. To make the comparison easier, the upper panel of Figure 4b plots the difference in the kernel density between the largest and smallest firm for the newly hired white collar workers. There we see clearly that new hires in large firms are concentrated in the 20s. The lower panel of Figure 4b plots the difference in the empirical cumulative distribution function (CDF) between the largest and smallest firm for the same sample. This difference is everywhere positive, indicating that large firms hire younger workers.

Columns 3 to 10 in Table 2 show this pattern in another way, by reporting the results of linear probability regressions with dependent variables being whether a worker was hired in his or her 20s, 30s, 40s or 50s or older, respectively. In the new hires sample, the largest firms have 8.4 percentage points more workers hired in their 20s than the smallest firm, 2.9 and 5.2 percentage points fewer workers hired in their 40s and 50s or older, respectively (the mean value is 51.5%, 12.5% and 8.7% for workers hired in their 20s, 40s and 50s or older, respectively). All differences are statistically significantly different from zero at the conventional levels.

#### 3.2.3 Multivariate Analysis

Since workers hired at different ages may differ in other demographic characteristics, it is important to see whether this age-at-hire difference holds even for otherwise similar workers. Using the new hires sample (tenure less than one year), Table 3 reports the results of regressions of age-at-hire on firm size indicators controlling for workers's demographics and job characteristics (mainly industry and occupation). Raw differences of mean age-at-hire across firm size are in column 1. On average, the largest firms (firms with 1000 or more employees) hire workers 2.3 years younger than the smallest firms (firms with under 25 employees). Young workers are better educated and large

[15] The Epanechnikov kernel is used. The bandwidth is calculated according to the rule-of-thumb formula in Silverman (1986). The qualitative results were robust to smaller bandwidths.

firms on average have a better educated workforce, however, controlling for the years of schooling in column 2 barely changes the age differences. Similarly, newly hired female workers or workers in union covered jobs are relatively younger, but within each group, the age difference still remains (columns 3 and 4). Workers in full time jobs are of similar age to those on part-time jobs (column 5). Finally, the hire age difference is reduced to about 1.9 years after major industry and occupation are included in columns 6 and 7. The results above suggest that the pattern of large firms hiring younger workers is a robust empirical regularity.

# 4 An Illustrative Model

In this section, I present a simple theoretical model incorporating firm fixed investment costs and employee search. This model can account for large firms' propensity to hire younger workers and has additional testable implications for their compensation structures. This model is only intended to illustrate the ideas and guide my empirical analysis.

This model is of the firm's cost minimization problem within an employee search framework. Throughout, the amount of investments (hiring or training) per employee $c$ is taken as a given parameter for the firm. No attempt is made to endogenize the firm's investment choice.[16] Abstracting from any general equilibrium effects, I only study the firm's optimal decisions in terms of relative demands of young and old workers and the accompanying wage structures and how those decisions vary with different values of the parameter $c$.

## 4.1 The Setting

Assume workers live for 2 periods and the firm lives infinitely. Each period there are two groups of workers: young and old. The size of each cohort is normalized to one. For simplicity, assume all workers are equally productive and are perfect substitutes for each other.[17] But each new hire represents a fixed cost $c$ for the firm, which can be either hiring cost or training investment or both. Each period, workers get one draw from outside, denoted by $w_a$, which has an underlying distribution characterized by p.d.f. $f(w_a)$. We can think of the wage offer coming from an equilibrium spot labor market. The firm offers wages $\{w_y, w_o, w_{yo}\}$ to young, newly hired old ("new" old), and retained old workers, respectively. Assume workers are "myopic" such that they decide whether to

[16] Evidence of training presented in section 2 suggests that there is positive correlation between firm size and $c$, although I do not claim any causal relationship between them.

[17] These assumptions do not affect the main comparative statics results in this section, since I only consider the changes in *relative* labor demands and wages offers between young and old workers as the cost $c$ varies.

accept the firm's wage offer by comparing it only to their current draws from the spot market.[18] The firm can attract and hire the "new" old workers and the young workers if and only if it offers $w_o \geq w_a$ and $w_y \geq w_a$, respectively. Similarly, the firm can retain the workers from the previous period if and only if it offers $w_{yo} \geq w_a$.

Assume that each period, the firm expects to employ the same number of workers (i.e. expected output is given), but it can choose the *relative* number of three kinds of workers: young, "new" old, and retained old, denoted by $L_y$, $L_o$, and $L_{yo}$, respectively, such that $L_y + L_o + L_{yo} = \overline{L}$ for some fixed number $\overline{L}$. Further note that the number of a particular type of worker the firm can attract and hire is a function of its wage offer for that type, since workers compare the firm's wage offer to their one other draw and accept it only if it is higher. Specifically, the expected labor demands for the three types of workers are:

$$\begin{aligned} L_y(w_y) &= \Pr\{w_y \geq w_a\} = F(w_y) \\ L_o(w_o) &= \Pr(w_o \geq w_a) = F(w_o) \\ L_{yo}(w_{yo}) &= \Pr(w_{yo} \geq w_a) \cdot L_{y,-1} = F(w_{yo}) L_{y,-1} \end{aligned}$$

where $L_{y,-1}$ is the number of young workers hired in the previous period.

Then the firm's objective is to minimize the present discounted value of costs by choosing $\{w_{y,t}, w_{o,t}, w_{yo,t}\}$ :

$$\min_{\{w_{y,t}, w_{o,t}, w_{yo,t}\}} \sum_{t=1} \beta^t \left\{ (w_{o,t} + c) \cdot L_o(w_{o,t}) + (w_{y,t} + c) \cdot L_y(w_{y,t}) + w_{yo,t} \cdot F(w_{yo,t}) L_{y,t-1} \right\}$$

$$\text{s.t.} \quad L_y(w_{y,t}) + L_o(w_{o,t}) + F(w_{yo,t}) L_{y,t-1} = \overline{L} \qquad \text{for all } t.$$

Alternatively, since there is a one-to-one correspondence between the wage offer and labor supply, we can invert the labor supply function as $w_o = F^{-1}(L_o)$ and $w_y = F^{-1}(L_y)$. Define $g(\cdot) \equiv F^{-1}(\cdot)$. Then the firm's objective can be written as

$$\min_{\{L_{y,t}, L_{o,t}, w_{yo,t}\}} \sum_{t=1} \beta^t \left\{ (g(L_{o,t}) + c) \cdot L_{o,t} + (g(L_{y,t}) + c) \cdot L_{y,t} + w_{yo,t} \cdot \left( \overline{L} - L_{y,t} - L_{o,t} \right) \right\}$$

$$\text{s.t.} \quad L_{y,t} + L_{o,t} + F(w_{yo,t}) L_{y,t-1} = \overline{L} \qquad \text{for all } t.$$

[18] This assumption makes sense if young workers heavily discount future. The case in which workers maximize life-time income and firms offer life-time contracts is more complicated and much harder to obtain theoretical predictions under general distribution assumptions.

## 4.2 The Firm's Optimal Decision and Comparative Statics

The first order conditions with respect to $L_{y,t}, L_{o,t}$ and $w_{yo,t}$, combined with the constraint are, as follows, in a steady state: [19]

$$g'(L_o)L_o + g(L_o) + c - w_{yo} = \lambda \tag{1}$$

$$g'(L_y)L_y + g(L_y) + c - w_{yo} = \lambda(1 + \beta F(w_{yo})) \tag{2}$$

$$\overline{L} - L_y - L_o = \lambda F'(w_{yo})L_y \tag{3}$$

$$L_y + L_o + F(w_{yo})L_y = \overline{L} \tag{4}$$

Denote $MC(L) = g'(L)L + g(L) + c - w_{yo}$, it is then straightforward to show from equations (1) and (2) that

$$MC(L_y) - MC(L_o) = \beta\lambda F(w_{yo}).$$

Thus young workers have an option value $\beta\lambda F(w_{yo})$ for the firm since they can potentially stay in the second period and save the firm the cost of new hires, where $F(w_{yo})$ is the probability a worker stays and $\lambda = \frac{F(w_{yo})}{F'(w_{yo})}$ (obtained from equations (3) and (4)) is the marginal value of the optimally retained worker.

It is interesting to study the comparative statics – how the change in the values of parameter $c$ (fixed investment cost) affects the firm's optimal choice of wage offers and relative labor demands. Throughout, I assume the probability density function $f$ is log concave and, in addition, the corresponding CDF $F$ satisfies the condition that $\frac{F''F}{[F']^2}$ is a decreasing function in its argument everywhere on the support.[20] For distributions that satisfy the assumptions above, it is straightforward to show, by standard comparative exercises, that

$$\frac{\partial w_{yo}}{\partial c} > 0, \frac{\partial w_o}{\partial c} < 0 \text{ and } \frac{\partial L_o}{\partial c} < 0.$$

The sign of $\frac{\partial w_y}{\partial c}$ (or $\frac{\partial L_y}{\partial c}$) is indeterminate under the current assumptions, but we can bound it from below by $\frac{\partial w_o}{\partial c}$ (or $\frac{\partial L_o}{\partial c}$), which offers some testable implications since we can examine the *slope* of the starting wage - age profile as $c$ varies as well as the relative demands of workers of different ages.[21] The following proposition highlights the two key testable implications of the model.

[19] Since the model parameters $c$ and $\overline{L}$ are constant in each period, the firm's optimal wage offers are the same in each period.

[20] These are the sufficient conditions for the results in this section. Many common distributions are included in this class, such as the normal, uniform, logistic, exponential, and extreme value distributions. For more details on log concave random variables, see Heckman and Honoré (1990).

[21] Note that $\frac{\partial w_o}{\partial c} < 0$ and $\frac{\partial w_{yo}}{\partial c} > 0$ appear to be some implications by themselves, but this model is oversimplified and does not allow for productivity differences for firms with different $c$'s. Therefore we should not expect to have a sensible test based on those expressions from the real data. However, examining the relative slopes of starting wage-age profiles across firms with different $c$'s provides an alternative.

**Proposition 1** *Assume the density $f(\cdot)$ is log-concave and the corresponding CDF satisfies $\frac{F''(\cdot)F(\cdot)}{[F'(\cdot)]^2}$ being a decreasing function in its argument. Then the following comparative statics results hold:*

$$\frac{\partial [L_y - L_o]}{\partial c} > 0 \tag{5}$$

$$\frac{\partial [w_y - w_o]}{\partial c} > 0 \tag{6}$$

*Proof: see appendix.*

Intuitively, comparing two firms with different investment fixed costs $c$, the "new" old workers are the least attractive to the firm with large $c$. So the large $c$ firm will demand fewer $L_o$ and pay lower $w_o$ than the small $c$ firm. To maintain production each period (by assumption), the large $c$ firm will either hire more young workers by paying them higher wages ($L_y \uparrow \Leftrightarrow w_y \uparrow$) or retain more old workers by paying higher wages ($F(w_{yo}) \uparrow \Leftrightarrow w_{yo} \uparrow$) or *both*. We have already shown that the firm will definitely increase $w_{yo}$ in face of a bigger $c$, because losing trained employees incurs too high of a cost. Without imposing a specific distribution assumption, we do not know for sure whether $w_y$ will increase or decrease (since $w_{yo}$ already increases), but we do know that if it decreases, it will not exceed the decline of $w_o$ (equation (6)) since young workers are still more valuable than "new" old workers.

Another object of interest is the relative wage-tenure profile for firms with different $c$. Unfortunately, under the current assumptions, the mathematical expression for $\frac{\partial [w_{yo} - w_y]}{\partial c}$ is very complicated, and its value depends on specific distribution function. However, intuitively, if $w_y$ increases, it is unlikely to increase more than $w_{yo}$, since as the fixed cost becomes very large, losing trained employees incurs too high a cost, thus the firm will retain more workers by paying them higher wages. For example, when the underlying wage offer follows a uniform distribution, we can easily prove that the wage-tenure profile becomes steeper as $c$ increases. That is,

$$\frac{\partial [w_{yo} - w_y]}{\partial c} > 0. \tag{7}$$

## 4.3 Testable Implications

Since large firms have higher fixed costs $c$ (either hiring or training), one immediate implication of this model is that large firms hire younger workers (equation (5)). This is consistent with the findings from section 3. More importantly, this model has additional testable predictions regarding large firms' wage structures: First, among the new hires, the starting wage – age-at-hire profiles are flatter in large firms (equation (6)). Second, the wage-tenure profile is likely to be steeper in large firms (equation (7)).

# 5 More Empirical Results

## 5.1 Wage-Age Profiles among New Hires

There are several ways to test the first implication that, among the new hires, large firms reward age or experience of a worker less than small firms do.[22] First, I use a cross-sectional sample of newly hired (with tenure less than or equal to one year) white collar workers and run the following regression:

$$\ln wage = \sum_k \gamma_k \cdot size_k + \sum_k \delta_k \cdot (\text{size}_k \cdot \text{age}) + \sum_k \lambda_k \cdot \left(\text{size}_k \cdot \text{age}^2\right) + X\beta + \varepsilon$$

where $k$ indexes the firm size groups and $X$ includes the main effect of age, age-squared as well as other usual demographic variables such as education, gender, race, marital status, union, full time status, region, SMSA, major industries, and occupations.[23] Suppose the omitted firm size category is the smallest firms, then we would expect large firms to exhibit flatter wage-age profiles, that is, the slope difference $(\delta_k + 2\lambda_k \text{age})$ is negative. I start with the original 4 size groups: firms with employees under 25, 25-99, 100-999 and 1000 or more. The estimated wage-age profiles are plotted in Figure 5a.[24] The two largest size groups (with at least 100 employees) exhibit *flatter* slopes than the medium sized group (with 25-99 employees), but the smallest firms (with under 25 employees) also have a flat profile. Interestingly, those estimated profiles for the blue collar workers exhibit somewhat different pictures (see Appendix Figure 1)– the largest firms appear to have *steeper* profiles than the medium sized firms, while the smallest firms (under 25) again have a very flat profile. It therefore seems that the main difference in the relative slopes of the starting wage-age profiles between the two occupation groups is between the large and medium sized firms.[25] In the remaining empirical analysis of compensation structures, I therefore focus on firms with 25 or more employees. Since the estimates of the slopes for the two largest firm size groups are similar, in order to make the comparison easier, I group them together (labelled "large") and estimate the

[22] As mentioned earlier, the test is relevant for the relative slopes, instead of levels, of the starting wage-age profiles across firms, since productivity differences across firms were abstracted from the model.

[23] Despite the narrowly defined new hires (tenure equals zero or one year), a tenure variable is included in the regression. As expected, it is not statistically significantly different from zero.

[24] The numerical estimates are reported in Appendix Table 1.

[25] Note that the smallest firm group (with under 25 workers) often have only a few employees and many of them might be family businesses. As a result, they might behave differently, especially in hiring and compensation decisions from what is considered in the framework. In addition, we lack good information on the training incidence and costs for the smallest firms. For example, the BLS SEPT95 data only cover private establishments with 50 or more employees. Educational Quality of Workforce - National Employer Survey (EQW-NES) data used in Lynch and Black (1995) only cover private establishments with 20 or more employees.

following regression

$$\ln wage = \gamma \cdot large + \delta \cdot (large \cdot age) + \lambda \cdot \left(large \cdot age^2\right) + X\beta + \varepsilon$$

where the omitted category is firms with number of employees 25-99. Estimates are reported in column 1 of Table 4. The coefficients on the interactions of large firm and age and age-squared are jointly significantly different from zero (with p-value equal 0.0028).[26] In order to see the slope difference better, I plot the estimated slope difference at each age level $(\delta + 2\lambda \text{age})$ along with standard errors in Figure 5b. There we see that the difference in slopes between these two groups becomes significantly bigger after around age 35.

It is striking to note, from the graph, that newly hired workers aged 50 years or older seem to be paid less in large firms than in small firms, which suggests that large firms dislike hiring new old workers and therefore offer them relatively low wages.[27] Of course, the estimation of the profiles has imposed a quadratic functional form and may therefore give misleading results. To investigate this possibility, I experiment with more flexible specifications. For example, we can compute the wage-size difference (adjusted for usual demographic variables) for 5-year age intervals. If the wage-age profile is flatter in large firms than in small firms, we would expect to see the wage differences between large and small firms decrease as workers' ages increase. Specifically, I estimate

$$\ln wage = \sum_t \phi_t \cdot (age_t \cdot large) + X\beta + \varepsilon \tag{8}$$

where $age_t'$s are indicators for 5-year age intervals and $X$ includes $age_t$ indicators as well as other demographics. We would expect to see $\phi_1 > \phi_2 > ... > \phi_T$. In this case, $age_t$ includes 7 indicator variables for 5-year age intervals from age 20 to 55 and an 8th indicator for age 55 or above. Estimates of $\phi_t$ are reported in column 3 of Table 4. Among the newly hired white collar workers, those hired between age 20 and 35 have higher wages compared to their counterparts in small firms to start with (the premium is approximately 10%). The most striking thing in this table is that this size-wage effect disappears for workers who are over 35 years old and even becomes negative for those aged 50 years or older. This suggests that large firms do act strategically in their hiring practices and differentiate between young and old workers in their compensation structures.[28]

[26] Results of a more restrictive linear specification are reported in column 2 of Table 4. Again, large firms are found to have flatter starting wage-age profiles: the coefficient on the interaction of large firm and age is negative and significant (-0.003 with S.E. 0.001).

[27] I note that large firms often offer better benefits, which are not captured by the simple wage measure.

[28] Note that this pattern does not hold for the blue collar workers (see Appendix Figure 1).This may be because for blue collar occupations, there is not much firm size variation in fixed costs of firm-specific training (especially formal training) and workers' experiences are rewarded more. Again this corresponds well to the finding in Haber et al (1988) that suggested a bigger gap in training investments between large and small employers at a higher skill level (Oi and Idson (1999)).

## 5.2 Wage-Tenure Profiles

Firm-specific human capital investment theory would also suggest that large firms have steeper tenure profiles. I estimate a cross-sectional regression

$$\ln wage = \sum_k \gamma_k \cdot size_k + \sum_k \delta_k \cdot (size_k \cdot tenure) + \sum_k \lambda_k \cdot \left( size_k \cdot tenure^2 \right) + X\beta + \varepsilon \qquad (9)$$

where $X$ includes tenure and other demographics variables. We would expect to see steeper tenure profiles in large firms, that is, the slope difference $(\delta_k + 2\lambda_k tenure)$ is positive. Here the three size indicators are for firms 25-99, 100-999 and 1000 or more, respectively. The omitted category is firms with under 25 employees. Results are reported in Table 5 and estimated profiles are plotted in Figure 6. Using the white collar sample, the coefficients $\delta_k$ and $\lambda_k$, $k = 1, 2, 3$, are jointly significantly different from zero (p-value = 0.000). In Figure 6, we see that the estimated wage-tenure profiles are the steepest for the largest firms and the flattest for the smallest firms.[29] If, to be consistent with my previous analysis of the starting wage-age relationship, we only focus on firms with at least 25 employees, the slopes of the top three profiles do not seem very different, although statistically the joint hypothesis of equality of coefficients on the interaction terms across firm sizes is rejected at the conventional levels (p-value=0.001). Overall, I take the evidence for steeper wage-tenure profile in large firms as mixed, especially if we do not consider firms with under 25 employees.[30]

It is interesting to note that there is little statistically significant difference in tenure profiles but there is difference in starting wage-age profiles across firms. This suggests that jobs in large firms are good to start with, which is, for example, in the same spirit of Abraham and Farber (1987) who find that workers in long jobs earn more throughout.

## 5.3 Training Investments and Industries

I have empirically established a relationship between training investments and workers' hiring ages across firms of different sizes. Specifically, large firms invest more in worker's human capital and hire younger workers. This raises a natural question as to whether this is only a firm size issue or is a

[29] Using a more restrictive linear specification in column (2) of Table 5, the estimated coefficients on the interactions of tenure and size indicators for firms 25-99, firms 100-999 and firms 1000+ are: 0.002 (S.E.=0.001), 0,002 (S.E.=0.001) and 0.004 (S.E.=0.001), respectively. But we cannot reject the null hypothesis that they are not different from each other (p-value=0.124).

[30] Brown and Medoff (1989), using CPS May 1979 data but with a continuous measure of firm size, found a similar pattern: "the estimated coefficients of the interaction terms were sometimes nontrivial, although as often as not they were statistically insignificant." Cross-sectional data often, but not always, reveal steeper tenure profiles for larger employers in U.S. For example, Pearce (1990) found that wage-tenure profiles are steeper in larger establishments for the non-unionized plants, but flatter for unionized ones. Panel data results are more mixed.

more general relationship between investments and hiring ages. For example, if training investments vary by industry, will we observe that high-training industries also hire younger workers?

In the CPS data, there is some variation in age-at-hire across industries (at the one-digit level).[31] Column 1 in Appendix Table 2 reports (tenure-adjusted) industry deviations of mean age-at-hire from the employment weighted overall average. For example, at hiring, white collar workers in the transportation, utility and communication industry (TUC) were about 1.5 years younger than average, while workers in the trade and construction sector were about 0.5 to 0.8 years older than average.[32]

Interestingly, in the SEPT95, the selected training expenditures (direct and indirect costs) per employee are the highest in the TUC sector and are the lowest in the trade and construction sector. To have a clear look at the relationship between the training investments and age-at-hire, Figure 7a plots the industry deviation of selected training investment costs per employee from the overall average against the industry deviation of mean age-at-hire from the overall average. There appears to be a negative relationship between the training costs and age-at-hire, that is, the high training investment industries are also those hiring younger workers. [33]

# 6 Discussion of Other Theories

Although a simple firm-specific human capital investment theory can account for the empirical regularity of large firms' propensity to hire younger workers, there may be other explanations. In this section, I discuss some of these alternative theories. As will become clear, not all of them can also explain the compensation structures established empirically in the previous section.

## 6.1 Delayed Payment Theory

[31]I use all workers instead of newly hired samples to study industry variations since a larger sample is needed to carry out any sensible analysis.

[32]Columns 2 through 5 show a similar pattern, where instead of industry deviation of mean age-at-hire, I report the industry deviation of the fraction of workers hired at different age ranges from the industry mean. Again, the TUC sector possesses a higher fraction (9% more) of white collar workers who were hired in their 20s than the overall average, and a lower fraction of those hired at an older age. In contrast, the retail sector possesses a lower fraction of workers who were hired in their 20s or 30s than the overall average, and a higher fraction of those hired over 50.

[33]Figure 7b plots the same cost variations as y-axis, but the x-axis is the industry deviation of the fraction of workers hired at different age ranges from the overall average. As can be seen from the graph, there is clearly a positive relationship between the investments and the percentage of workers hired young (in their 20s) and a negative one between investments and percentage of workers hired old ( 50 or older).

In fact, any explanation based on some kind of fixed employment costs can generate the prediction that firms prefer to hire young workers. For example, Hutchens (1986) argued that the fixed costs associated with implementation of a delayed payment contract (Lazear 1979, 1981) can also imply a firm's need for a long-term employment relationship and its propensity to hire younger workers. One immediate extension of that theory could be that if large firms are more likely to use delayed payment schedules (say, because of greater monitoring difficulties), then they would also prefer to hire younger workers. Note that without a reliable measure of a worker's productivity, it is very difficult, if not impossible, to distinguish the delayed payment model and the firm-specific human capital investment model, since with some modification, these two models can generate similar predictions, as also recognized in Hutchens (1986).[34]

However, the delayed payment schedule theory alone cannot explain why large firms pay more even at the beginning of an employment relationship. If anything, we would expect to see a lower starting wage in large firms since they need to back-load compensation. In contrast, the firm-specific human capital investment theory coupled with employee search can rationalize the initial high wages as part of the large firm's strategy to attract new employees.[35]

## 6.2 General Training

If large firms are more efficient at providing general training than small firms and younger workers need more training than older workers, then in a general equilibrium model, there will be "sorting" such that younger workers are hired into large firms and older ones are hired into small firms.

[34] A recent paper by Heywood, Ho, and Wei (1999), using a 1996 survey of Hong Kong establishments designed to identify hiring and employment patterns by a worker's age, shows that many Hong Kong firms employ older workers but do not hire older workers. Following the approach by Hutchens, but with a different definition of "older" worker (35 instead of 55 years old), they create an establishment "opportunity index" which is just the ratio of the share of recent hires comprised of older workers to the share of all employees comprised of older workers. Then they regress this index against a list of independent variables, including tenure, pension, broad occupation and industry dummies and establishment size. In general, they find that more skilled jobs, longer tenure, and the presence of a pension are associated with a lower likelihood of hiring older workers. They take these as evidence in support of the firm specific investment and delayed payment theory. Note, however, they do not find this opportunity index to vary by establishment size in their sample.

[35] In addition, even if large firms are indeed more likely to use delayed payment, the extension that they will prefer to hire younger workers does not necessarily hold. To see this, note that Hutchens' argument for firms' desire to have a long term employment relationship was crucially based upon the assumption that there were fixed costs associated with the implementation of the delayed payment schedule because of the possibility of firm cheating. In his model formulation, the fixed costs positively depend on the probability of firm cheating. If we expect smaller probabilities of cheating or reneging by large firms (say due to reputation concerns), then the fixed costs associated with implementing the delayed payment contracts would be lower for large firms, and therefore they would not necessarily be more likely to hire younger workers.

This model is consistent with the hiring age pattern but it cannot explain why large firms actually pay more to the young workers if the training is general. In addition, there is evidence that a larger fraction of the human capital investments made by large firms is firm-specific. For example, Haber et al (1988) found that the ratio of on-site to off-site training is higher in larger firms. Hill (1988) also found larger establishments are more likely to provide training that is useful at that firm (Brown, Hamilton and Medoff (1990, pp. 55)).

## 6.3 Technology and Learning

Recently, there have been reports in the popular press that workers (especially white collar workers) lost jobs as they reached 40 years old and were replaced by younger workers.[36] One reason, as argued, is that young workers are more willing or more able to learn up-to-date technology. If labor productivity in large firms is more sensitive to workers' ability and willingness to learn new skills because of higher technology use, then those firms would prefer to hire young workers. Note this possibility does not in any way contradict the firm investment theory, in fact they are complementary. If large firms are more technology sensitive, then they might need to invest more in workers and therefore hire younger workers. For example, Lynch and Black (1995) found that establishments that have an R&D (Research and Development) center are more likely to provide training. [37]

Ideally, if we had firm-level data on firms' technology use and their hiring age pattern, then we would be able to test this hypothesis directly. In reality, such information is seldom available. However, we can use some proxy for technology intensity, such as R&D expenditures.[38] The COMPUSTAT data set contains financial information on more than 7500 corporations in the U.S. since 1976, including R&D expenditures. One advantage of using this data set is that it covers firms in all sectors, both manufacturing and others, while some other data sources mainly have R&D information for the manufacturing sector. It also has information on firm size (measured by sales, assets or number of employees). Using the data from the annual data files from 1979, 1983, 1988, and 1993, I find that larger firms do spend more on R&D. Even within industry, 100 more employees are associated with 0.6 million dollars more in R&D expenditures. This is consistent with the idea that large firms are more technology intensive and value young workers more than small firms.

It should be pointed out that this data set covers mostly large firms (75% of the firms in the

[36] See Munk (1999).

[37] Note the assumption that young workers have higher learning ability and large firms are more technology sensitive can explain why large firms hire younger workers, but this assumption per se explains little of why large firms also want to retain those workers as they age.

[38] Examples of using R&D as a proxy measure for technology intensity include Autor, Katz and Krueger (1998).

sample have number of employees 100 or more), so there is less firm size variation. However, I can investigate whether there are variations in R&D expenditures across industries.[39] The coefficients on the industry indicator variables are jointly statistically significant in an R&D expenditure regression.[40] Then I examine the relationship between R&D and age-at-hire to see whether industries that spend more on R&D are also those that hire younger workers. Figure 8a just shows that, where the x-axis is the same as in Figure 7a – the industry deviation of mean age-at-hire from the overall average, and the y-axis is the industry deviation of R&D expenditures (in thousand dollars) from the overall average. A similar pattern emerges: industries that spend more on R&D (transportation, utility and communication (TUC) and manufacturing) are also those hiring younger workers.[41] Although this is far from a perfect test due to limitations of the data, it does suggest that firms or industries that emphasize more technology development prefer to hire younger workers.[42] Of course, as pointed out earlier, this does not in any way contradict the firm-specific human capital investment theory since technology intensity and need to train are complementary.

## 7 Conclusion

Motivated by the desire to better understand the firm size-wage premium puzzle, I examine one possible explanation, namely the firm-specific human capital investment theory. Due to data limitations, I can not directly test this theory by controlling for training and productivity in the wage regression. However, I can test other implications of this theory regarding large firms' hiring behaviors and the accompanying compensation structures. If large firms invest more in firm-specific human capital than small firms, and the investments are fixed costs regardless of the employment duration, then large firms would prefer to hire younger workers to minimize costs. This is because younger workers can potentially work longer before they retire and hence allow for a longer period for firms to recoup their investments. A simple model incorporating firm-specific human capital investment and employee search theory is advanced, which can not only account for large firms' propensity to hire younger workers, but also has some testable implications for their compensa-

[39] The Standard Industry Code (SIC) in the COMPUSTAT is matched to the Census Industry Code (CIC) in the CPS.

[40] The p-value for the F-test that coefficients on the industry indicator variables are jointly zero is 0.0000. The same results are obtained when I add firm size variables (either number of employees or market value).

[41] Figure 8b plots a similar graph where the y-axis is the same as in Figure 8a, but the x-axis is the industry deviation of the fraction of workers hired at different age ranges from the industry mean. A similar picture appears: for example, the TUC sector has the highest R&D expenditures, and it has the highest fraction of workers hired in their 20s and the lowest fraction of those hired over age 40.

[42] It is also interesting to note that Oi and Idson (1999) find that the size-wage effects are larger in TUC and manufacturing than in retail and service sectors.

tion structures. Specifically, within the employee search framework, since young workers are more valuable to large firms than to small firms, large firms would offer young workers higher starting wages than small firms to attract them and after hiring, they would continue to pay high wages to retain trained workers. Therefore overall, workers in large firms will be hired younger, be paid more *throughout* the employment relationship, and stay longer.

Using 4 years of data from the Benefits Supplement to the CPS, I find that large firms appear to hire younger workers, especially for white collar occupations, for which training investments are more likely to vary by firm size. I also find that, among the new hires, the starting wage-age profiles are flatter in large firms (with 100 or more employees) than small firms (with 25-99 employees), which suggests that large firms do act strategically in their hiring practices and compensation structures to attract young workers by reward them more relative to small firms. More interestingly, the firm size-wage premium between those two size groups disappears for newly hired white collar workers aged 35 or older. There is also limited evidence suggesting that large firms offer steeper wage-tenure profiles than small firms. Finally, I also present limited evidence that industries that invest more in training appear to hire younger workers.

As a final remark, although I have not presented a direct test of the competing explanations for the firm size-wage premium, this paper helps shed some light on this issue by providing some new evidence of large firms' different hiring behaviors and the accompanying compensation structures. It seems fruitful for future research to devote more attention to learning about large firms' behaviors in aspects other than just wage levels in order to better understand the size-wage premium. Ideally, we can learn more from the employer and employee matched data (e.g. Abowd and Kramarz (1999) and references therein).

# 8 Appendix: Proof of Proposition 1

*Proof:*

*Note that the two inequalities are equivalent in the current setting because of the one-to-one correspondence between* $L$ *and* $w$*:* $L = F(w)$ *where* $F(\cdot)$ *is a CDF (hence increasing function). So it suffices to show the first inequality holds.*

*First note log-concavity of the density* $f$ *implies log-concavity of the distribution* $F$ *(Heckman and Honoré (1990)), which in turns implies* $\lambda = \frac{F}{F'}$ *is an increase function in its argument. Therefore we have* $\frac{\partial[MC_y - MC_o]}{\partial w_{yo}} = \frac{\partial \lambda F(w_{yo})}{\partial w_{yo}} > 0$*, which, combined with* $\frac{\partial w_{yo}}{\partial c} > 0$*, implies* $\frac{\partial[MC_y - MC_o]}{\partial c} = \frac{\partial[MC_y - MC_o]}{\partial w_{yo}} \cdot \frac{\partial w_{yo}}{\partial c} > 0$*. This says, as c increases, the difference in marginal costs of hiring a young and old worker also increases. Under the assumptions above, it is straightforward to show that* $MC(L) \equiv g'(L)L + g(L) + c - w_{yo}$ *is an increasing and convex function in* $L$*.*

*Case 1:*$\frac{\partial L_y}{\partial c} > 0$.

*Since we have already shown* $\frac{\partial L_o}{\partial c} < 0$*, inequality* (5) *immediately follows.*

*Case 2:* $\frac{\partial L_y}{\partial c} < 0$.

*Note* $\frac{\partial [MC_y - MC_o]}{\partial c} = MC'(L_y^*) \cdot \frac{\partial L_y^*}{\partial c} - MC'(L_o^*) \cdot \frac{\partial L_o^*}{\partial c} > 0$ *and* $L_y^* > L_o^*$ *where "*" indicates equilibrium level.*

*Since* $MC'(L)$ *is positive and increasing in* $L$*, we have* $MC'(L_y^*) > MC'(L_o^*) > 0$*, so it immediately follows that* $\frac{\partial L_y^*}{\partial c} > \frac{\partial L_o^*}{\partial c}$*.* *Q.E.D.*

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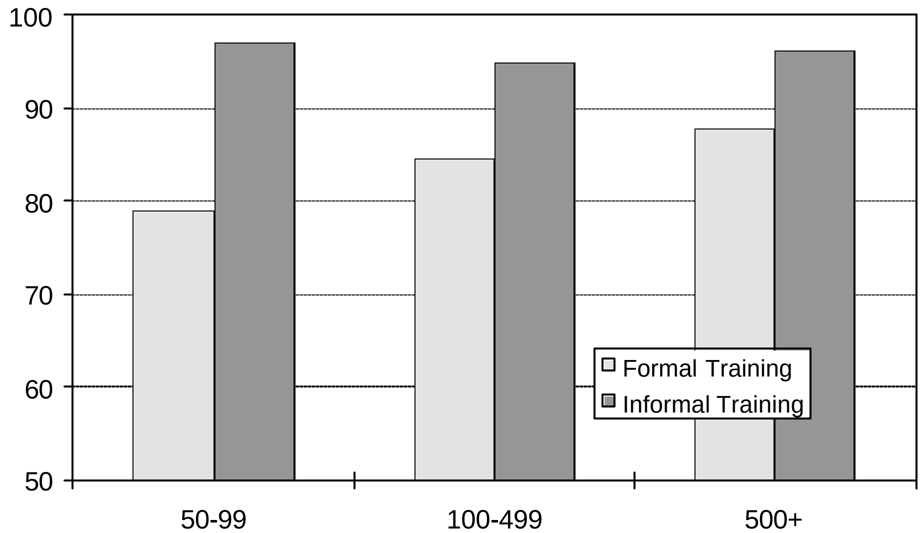
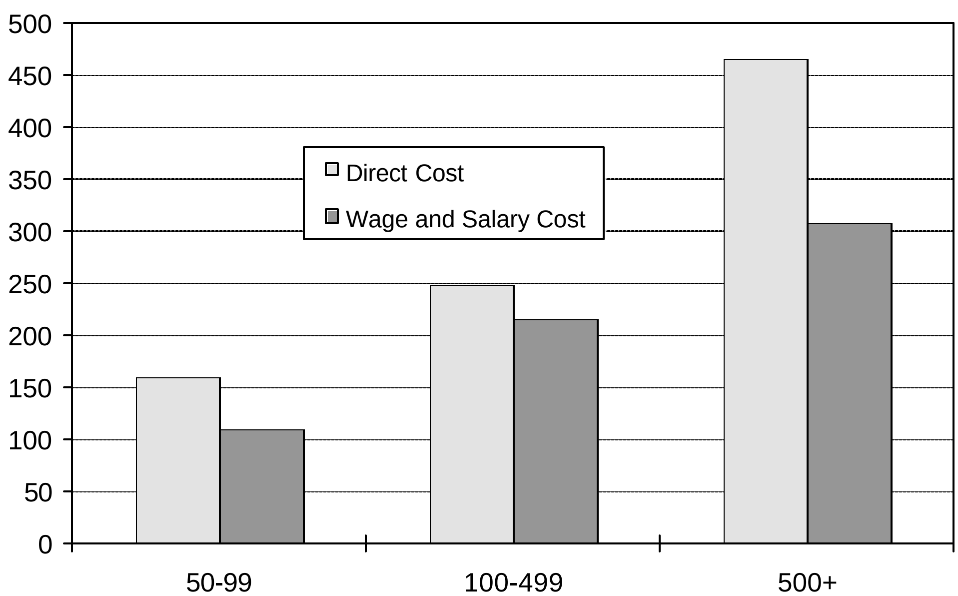


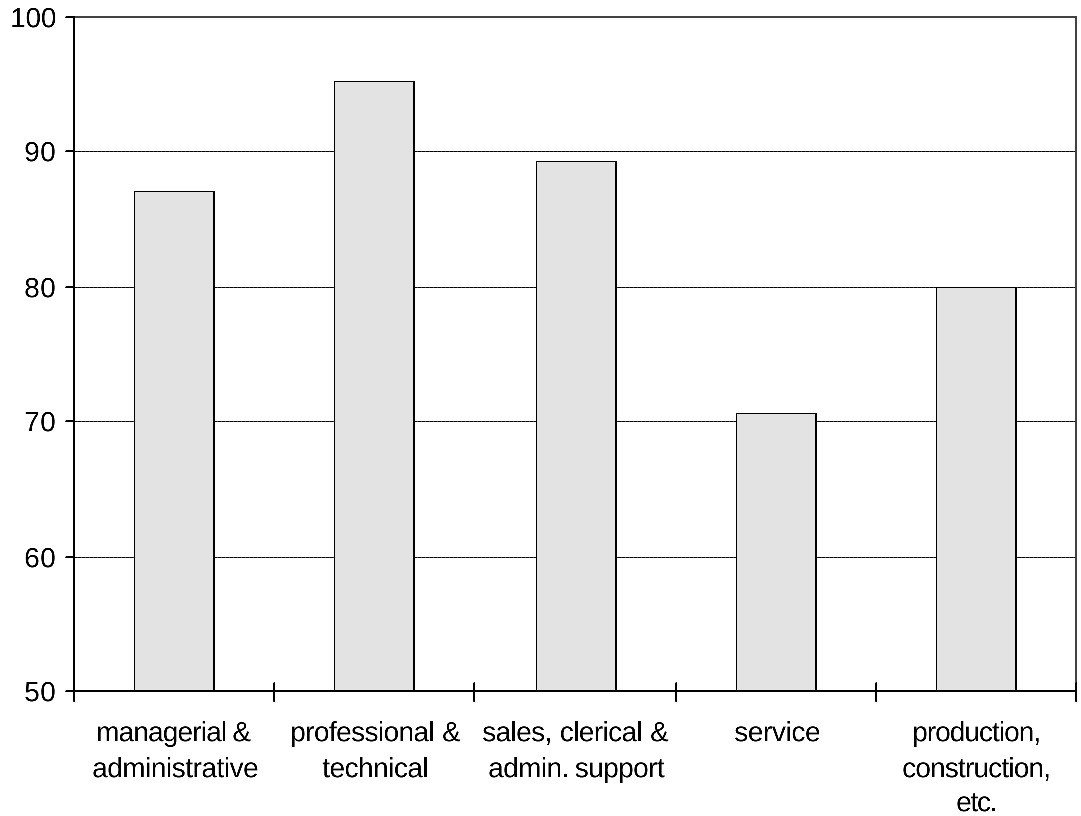

Source: BLS 1995 Survey of Employer Provided Training -- Employee Result.
Note: The universe is employees who work at a private establishment with 50 or more employees.

Figure 1: Percent of Employees Who Have Received Training from Current Employer




Source: BLS 1995 Survey of Employer Provided Training -- Employer Results and Employee Results.
Note: (1) Direct costs (from the employer results) are selected expenditures per employee, including wages and salaries of in-house trainers, payment to outside trainers, tuition reimbursement, contribution to outside training funds and subsidies for training received from outside sources. They are measured for 1994. (2) The wage and salary costs (from the employee results) are indirect costs, measured in the compensation employees received during training periods. They are measured for May-October 1995.

Figure 2: Costs of Formal Training Per Employee in Dollars by Establishment Size




Source: BLS Survey of Employer Provided Training -- Employee Results.
Note: The numbers reported here are for the universe of employees who work at a private establishment with 50 or more employees.

Figure 3: Percent of Employees Who Have Received Formal Training by Occupation

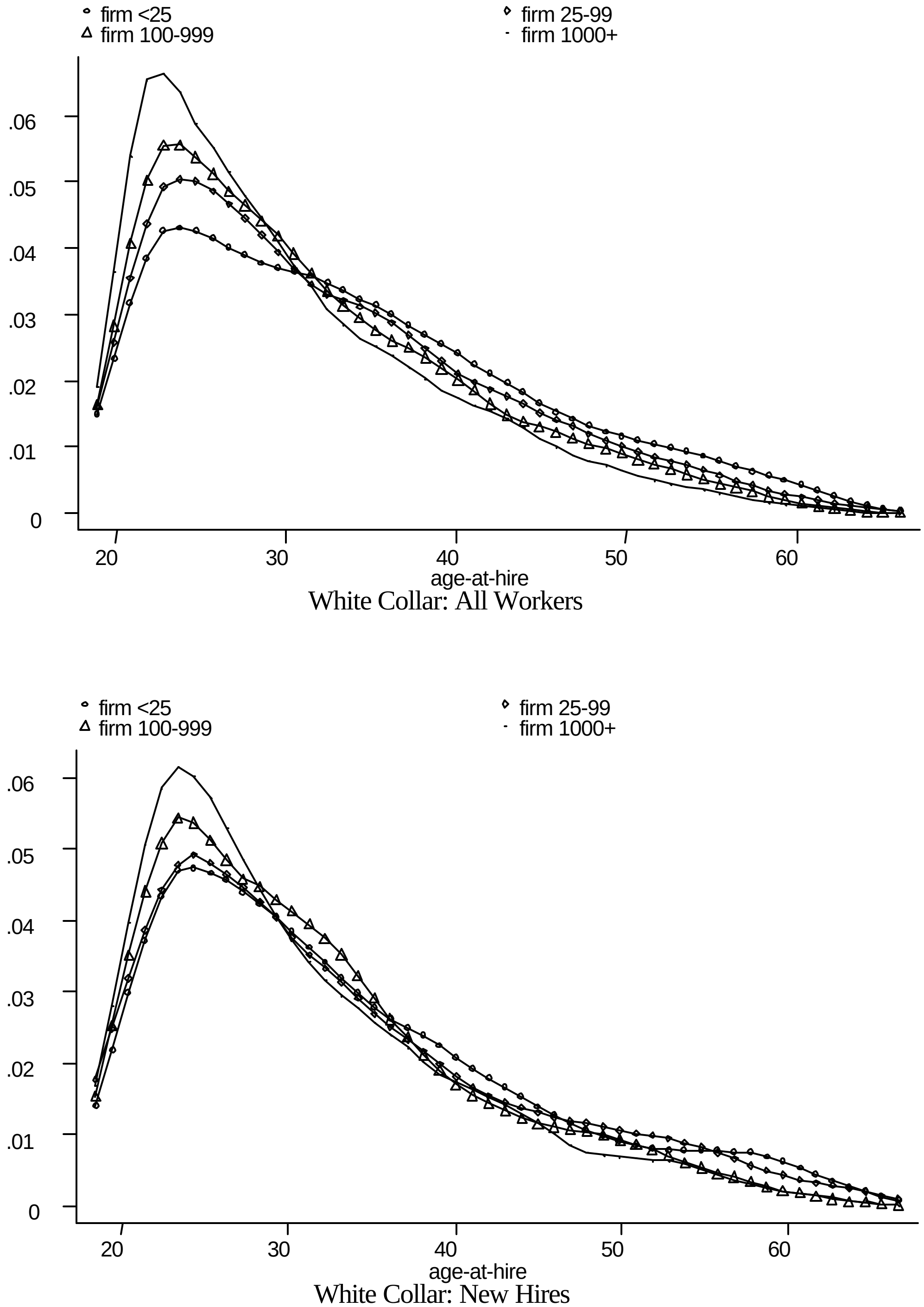
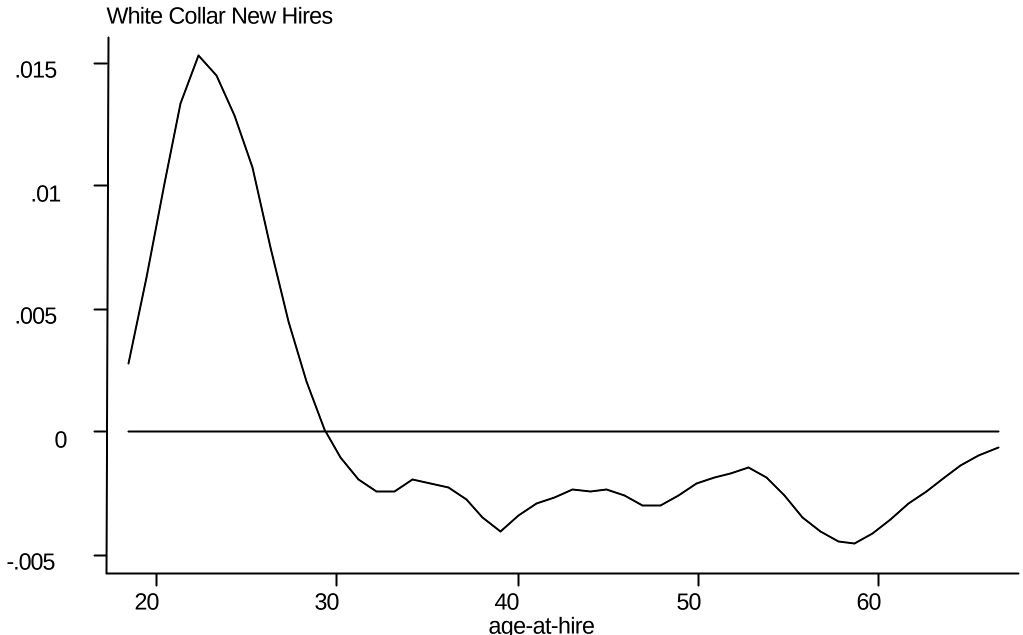
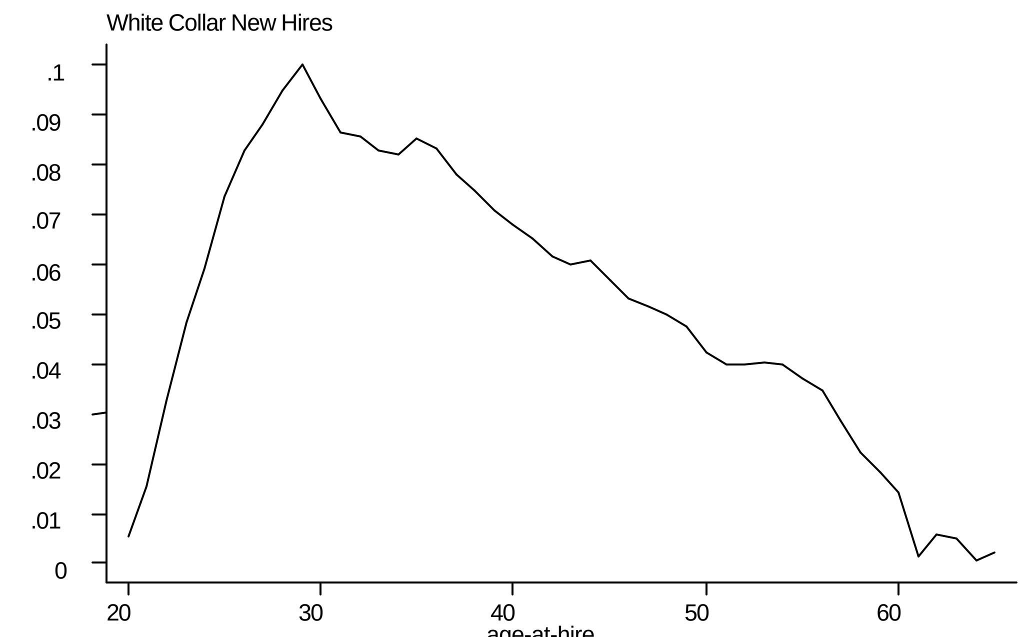



Figure 4a: Kernel Density Estimate of Age-at-Hire by Firm Size



Difference in Density Between Firm 1000+ and <25



Difference in Empirical CDF Between Firm 1000+ and <25

Figure 4b: Difference in Distribution of Age-at-Hire by Firm Size

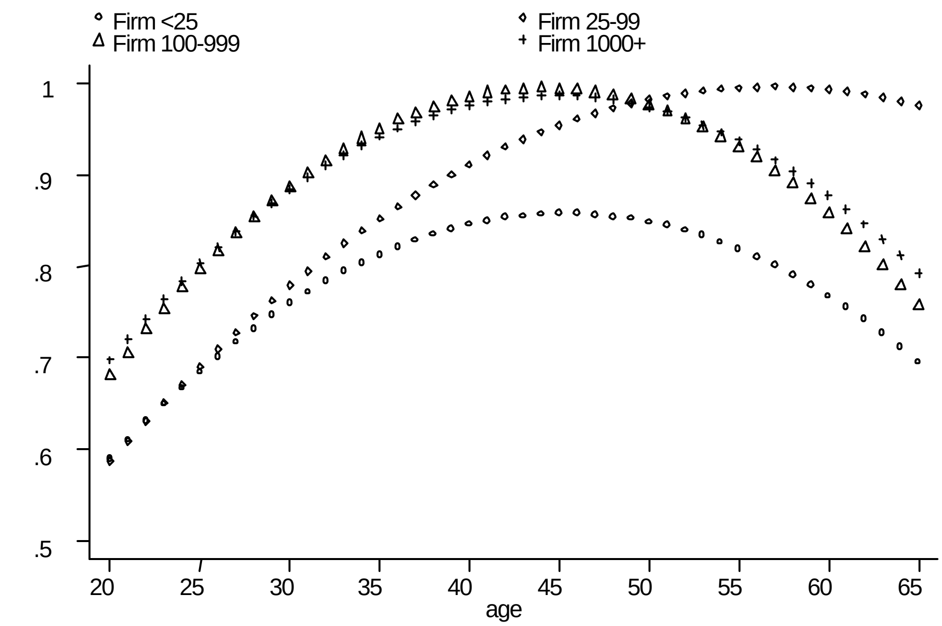



Figure 5a: Estimated Starting Wage-Age Profile: White Collar

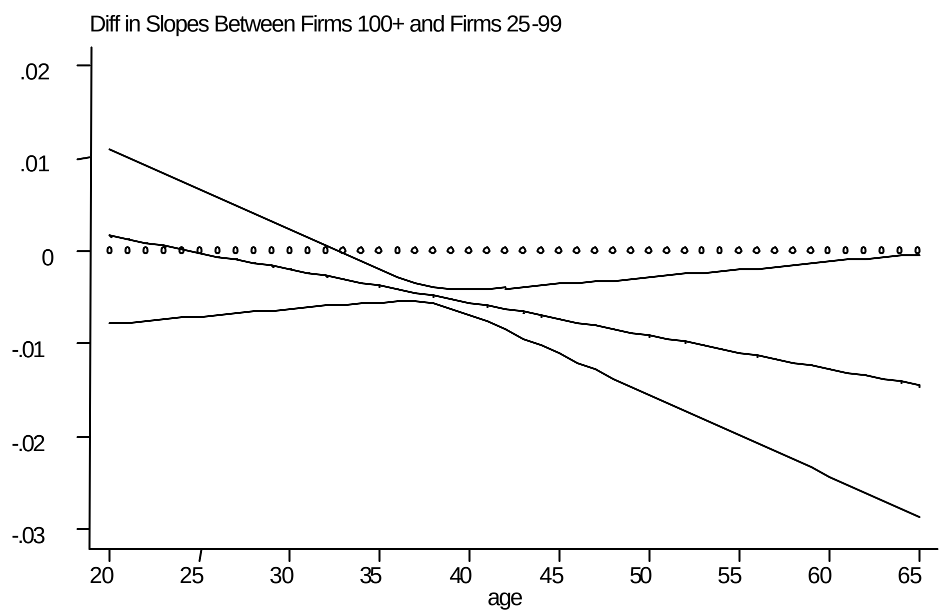



Figure 5b: Slope Differences in the Starting Wage-Age Profiles: White Collar

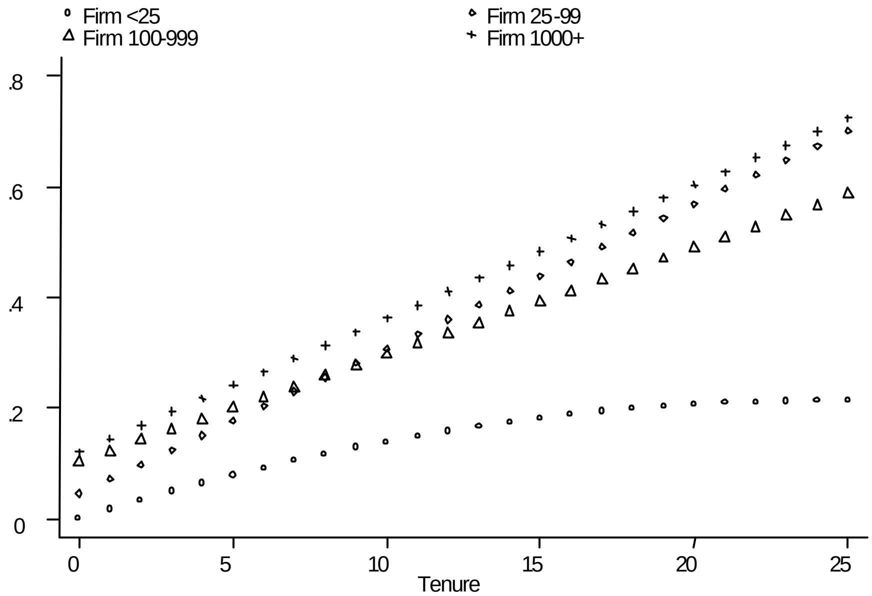



Figure 6: Estimated Wage-Tenure Profile: White Collar

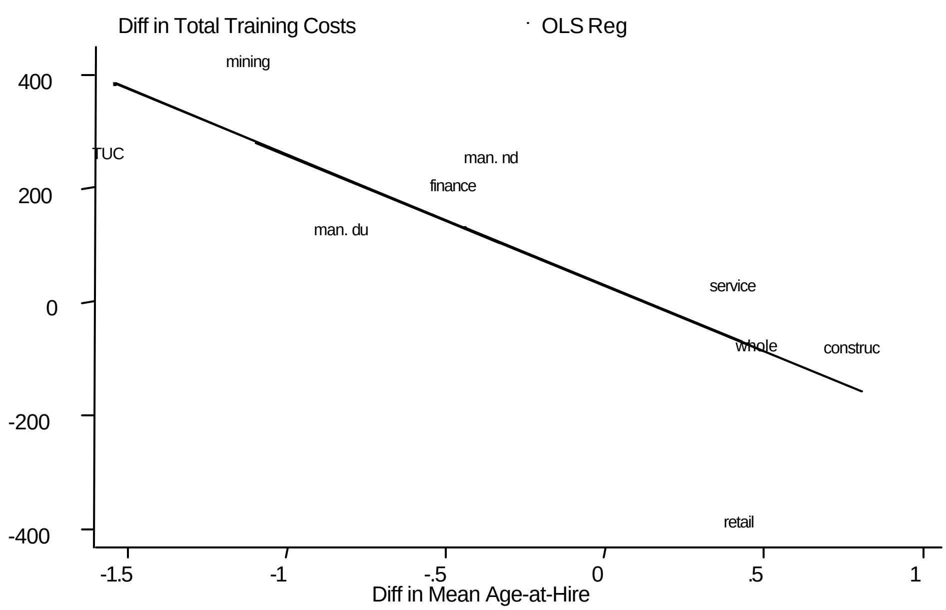



Figure 7a: Training Costs and Mean Age-at-Hire by Major Industry

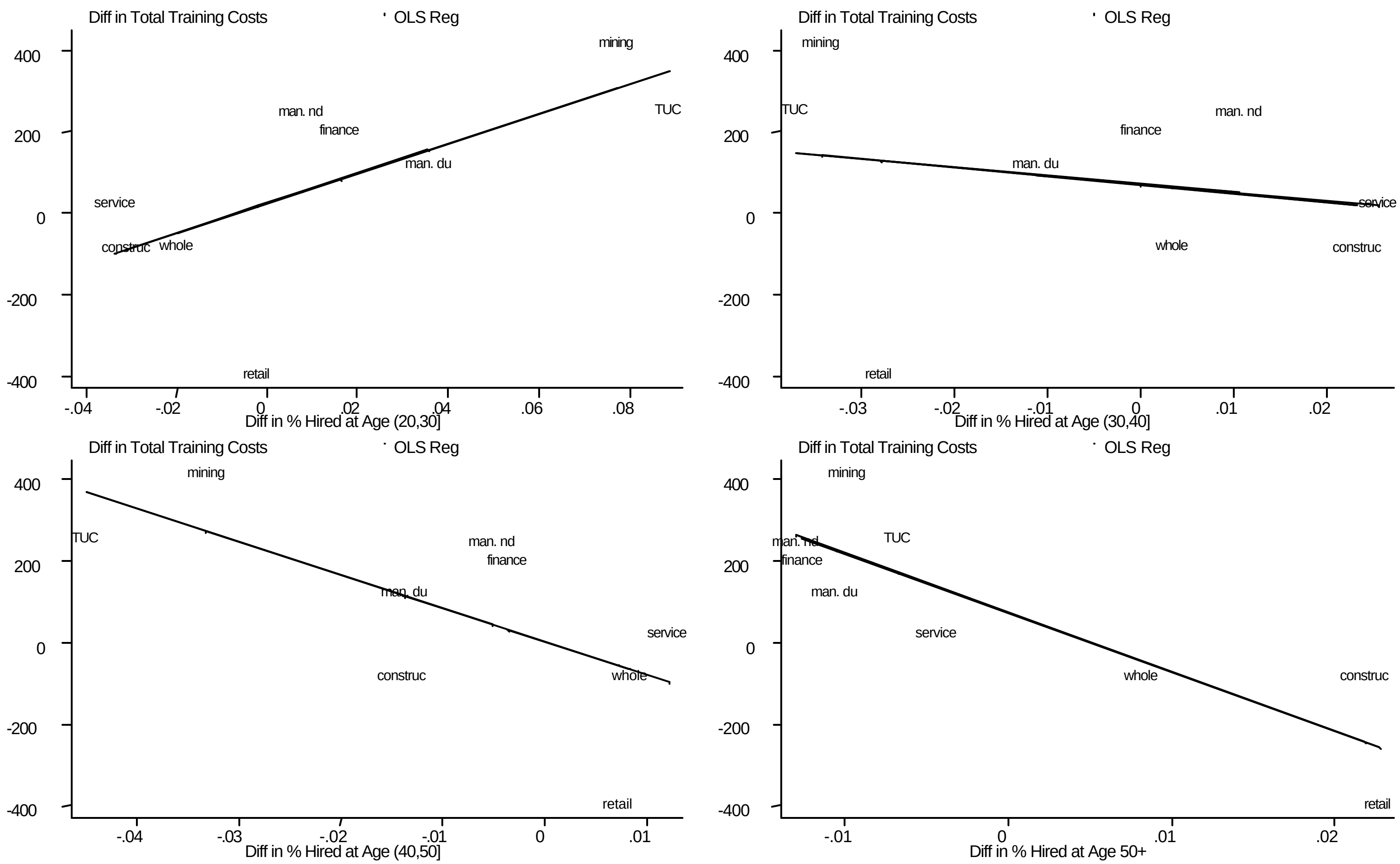



Figure 7b: Training Costs and Distribution of Age-at-Hire by Major Industry

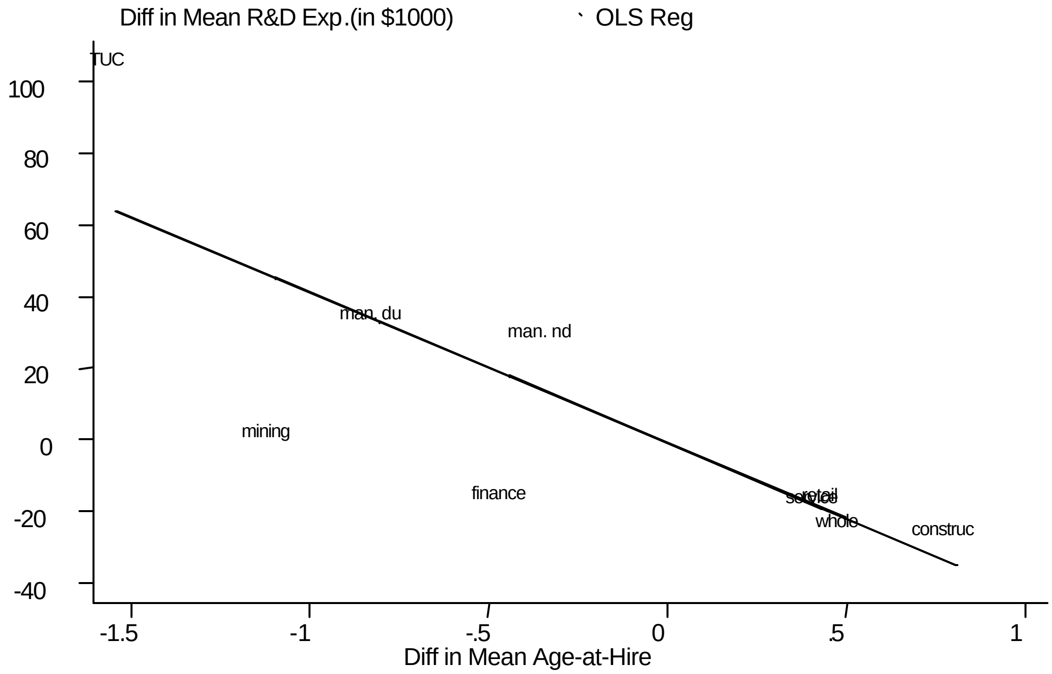



Figure 8a: R&D Expenditure and Mean Age-at-Hire by Major Industry

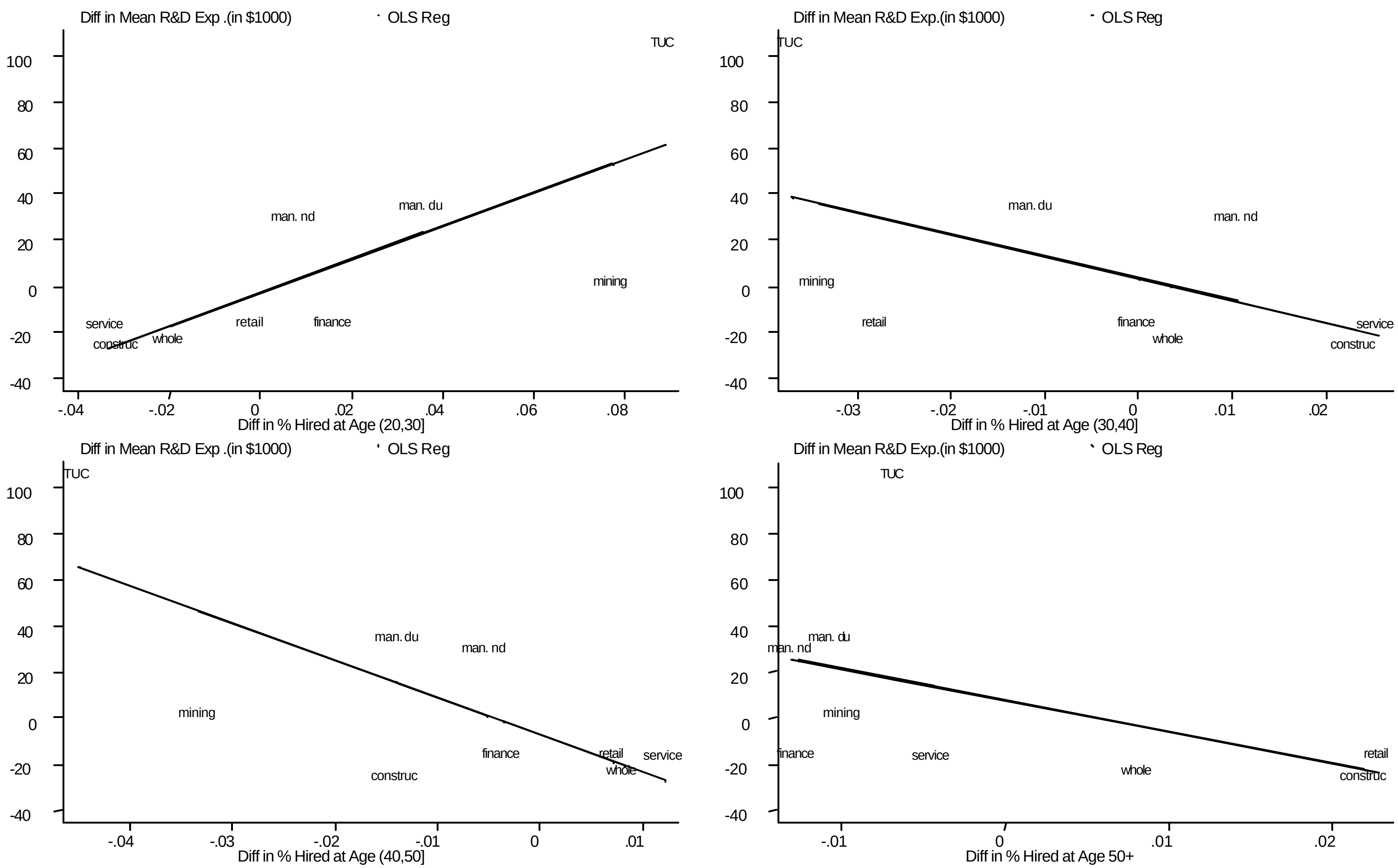
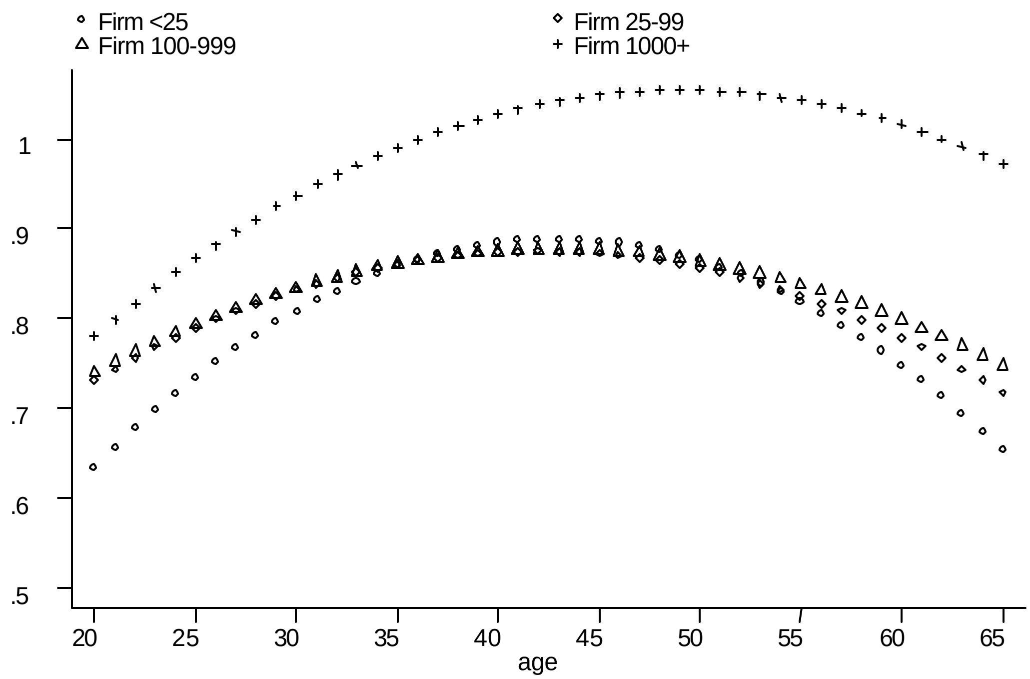



Figure 8b: R&D Expenditure and Distribution of Age-at-Hire by Major Industry




Appendix Figure 1: Estimated Starting Wage-Age Profile: Blue Collar

Table 1: Means of Age-at-Hire, Tenure and Education across Firm Sizes
CPS May 1979, 1983, 1988 and April 1993
(Standard Errors)

| | White Collar | | | | Blue Collar | | | |
|---|---|---|---|---|---|---|---|---|
| Firm Size | <25 | 25-99 | 100-999 | 1000+ | <25 | 25-99 | 100-999 | 1000+ |
| | | | | 1979 May CPS | | | | |
| Fraction | 0.251 | 0.142 | 0.195 | 0.412 | 0.252 | 0.162 | 0.184 | 0.402 |
| Age-at-Hire | 34.31 | 33.06 | 31.59 | 29.67 | 32.57 | 33.83 | 31.76 | 29.76 |
| | (0.26) | (0.34) | (0.29) | (0.20) | (0.28) | (0.35) | (0.33) | (0.22) |
| Tenure | 4.40 | 5.39 | 6.08 | 8.53 | 4.03 | 5.30 | 6.38 | 9.54 |
| | (0.20) | (0.27) | (0.23) | (0.16) | (0.22) | (0.28) | (0.26) | (0.17) |
| Education | 13.31 | 13.59 | 13.86 | 13.99 | 11.16 | 10.84 | 11.02 | 11.60 |
| | (0.060) | (0.079) | (0.068) | (0.047) | (0.070) | (0.087) | (0.082) | (0.055) |
| Obs. | 5,798 | | | | 5,091 | | | |
| | | | | 1983 May CPS | | | | |
| Fraction | 0.242 | 0.131 | 0.214 | 0.414 | 0.288 | 0.156 | 0.201 | 0.356 |
| Age-at-Hire | 33.64 | 32.27 | 31.41 | 30.04 | 32.10 | 32.57 | 31.67 | 29.46 |
| | (0.23) | (0.31) | (0.24) | (0.17) | (0.26) | (0.35) | (0.31) | (0.23) |
| Tenure | 4.46 | 5.17 | 5.96 | 8.14 | 4.10 | 5.39 | 6.61 | 9.81 |
| | (0.18) | (0.24) | (0.19) | (0.13) | (0.19) | (0.26) | (0.23) | (0.17) |
| Education | 13.66 | 13.84 | 14.10 | 14.29 | 11.33 | 11.30 | 11.59 | 11.89 |
| | (0.055) | (0.075) | (0.058) | (0.042) | (0.062) | (0.084) | (0.074) | (0.056) |
| Obs. | 6,983 | | | | 5,285 | | | |
| | | | | 1988 May CPS | | | | |
| Fraction | 0.215 | 0.147 | 0.218 | 0.421 | 0.242 | 0.156 | 0.214 | 0.387 |
| Age-at-Hire | 33.44 | 32.38 | 31.24 | 30.44 | 31.44 | 32.27 | 31.94 | 29.52 |
| | (0.24) | (0.29) | (0.24) | (0.17) | (0.28) | (0.34) | (0.29) | (0.22) |
| Tenure | 4.38 | 4.89 | 5.70 | 7.33 | 3.81 | 4.86 | 6.91 | 9.92 |
| | (0.18) | (0.21) | (0.17) | (0.12) | (0.23) | (0.28) | (0.24) | (0.18) |
| Education | 13.55 | 13.94 | 14.31 | 14.28 | 11.65 | 11.38 | 11.52 | 11.96 |
| | (0.058) | (0.071) | (0.058) | (0.042) | (0.065) | (0.081) | (0.069) | (0.051) |
| Obs. | 6,974 | | | | 4,905 | | | |
| | | | | 1993 April CPS | | | | |
| Fraction | 0.222 | 0.139 | 0.192 | 0.446 | 0.261 | 0.159 | 0.195 | 0.386 |
| Age-at-Hire | 34.34 | 32.41 | 32.26 | 30.49 | 32.54 | 33.22 | 32.04 | 30.11 |
| | (0.24) | (0.29) | (0.24) | (0.16) | (0.31) | (0.37) | (0.32) | (0.22) |
| Tenure | 6.25 | 6.39 | 7.36 | 9.15 | 5.49 | 6.83 | 7.72 | 10.20 |
| | (0.19) | (0.23) | (0.19) | (0.12) | (0.24) | (0.29) | (0.25) | (0.18) |
| Education | 13.62 | 13.85 | 14.04 | 14.11 | 11.68 | 11.42 | 11.67 | 12.12 |
| | (0.048) | (0.060) | (0.051) | (0.034) | (0.055) | (0.071) | (0.064) | (0.046) |
| Obs. | 6,907 | | | | 4,206 | | | |

Note: (1) Supplemental weights are used in all years; (2) Only private sector wage-salary workers age 20-65 are included; (3) Agriculture, Forestry, Fishing and Private household services workers are excluded. (4) White Collar includes professional, managerial, sales, and clerical; Blue Collar includes craft, operative, non-farm laborer, transport equipment movers and other services.

Table 2: Distribution of Age-at-Hire across Firm Size
White Collar Only
CPS May 1979, 1983, 1988 and April 1993
(Standard Errors)

| Dependent Variable: | Age-at-Hire | | Hired at Age [20-30] | | Hired at Age(30,40] | | Hired at Age (40,50] | | Hired at Age (50,65] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | New Hires* (1) | All Workers (2) | New Hires (3) | All Workers (4) | New Hires (5) | All Workers (6) | New Hires (7) | All Workers (8) | New Hires (9) | All Workers (10) |
| Mean of Dependent Variable | 32.07 | 31.86 | 0.515 | 0.504 | 0.272 | 0.289 | 0.125 | 0.143 | 0.087 | 0.063 |
| Firm 25-99 | -0.814<br>(0.525) | -1.350<br>(0.193) | 0.058<br>(0.029) | 0.064<br>(0.012) | -0.037<br>(0.025) | -0.024<br>(0.011) | -0.015<br>(0.020) | -0.018<br>(0.009) | -0.006<br>(0.018) | -0.022<br>(0.006) |
| Firm 100-999 | -1.668<br>(0.486) | -2.089<br>(0.173) | 0.050<br>(0.027) | 0.089<br>(0.010) | 0.012<br>(0.024) | -0.019<br>(0.010) | -0.025<br>(0.018) | -0.034<br>(0.008) | -0.037<br>(0.015) | -0.036<br>(0.005) |
| Firm 1000+ | -2.316<br>(0.427) | -3.233<br>(0.150) | 0.084<br>(0.024) | 0.143<br>(0.009) | -0.002<br>(0.021) | -0.042<br>(0.008) | -0.029<br>(0.016) | -0.052<br>(0.007) | -0.052<br>(0.013) | -0.050<br>(0.005) |
| Tenure | -- | -0.145<br>(0.008) | -- | 0.005<br>(0.0005) | | -0.0003<br>(0.0004) | -- | -0.002<br>(0.0003) | -- | -0.003<br>(0.0001) |
| Year Effects | Yes | Yes | Yes | Yes | | Yes | Yes | Yes | Yes | Yes |
| Obs. | 3,535 | 26,662 | 3,535 | 26,662 | 3,535 | 26,662 | 3,535 | 26,662 | 3,535 | 26,662 |

Note: see table 1. *New Hires are workers who have tenure less than one year with the current employer. Columns (1) and (2) are OLS regressions with dependent variable being age-at-hire. Columns (3) to (10) are linear probability regressions, for which heteroscedasticity consistent standard errors are reported in the parentheses. In all regressions, the omitted firm category is firm with number of employees under 25.

Table 3: Demographics -Adjusted Difference in Age-at-Hire across Firms
Newly Hired White Collar
CPS May 1979, 1983, 1988 and April 1993
Dependent Variable is Age-at-Hire
(Standard Errors)

| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** |
|---|---|---|---|---|---|---|---|
| **Firm 25-99** | -0.81 | -0.77 | -0.78 | -0.65 | -0.66 | -0.69 | -0.67 |
| | (0.52) | (0.53) | (0.52) | (0.54) | (0.54) | (0.54) | (0.54) |
| **Firm 100-999** | -1.67 | -1.60 | -1.61 | -1.40 | -1.41 | -1.69 | -1.60 |
| | (0.49) | (0.49) | (0.49) | (0.50) | (0.50) | (0.50) | (0.50) |
| **Firm 1000+** | -2.32 | -2.25 | -2.29 | -2.08 | -2.09 | -2.05 | -1.89 |
| | (0.43) | (0.43) | (0.43) | (0.44) | (0.44) | (0.45) | (0.45) |
| Education | | -0.14 | -0.18 | -0.19 | -0.19 | -0.34 | -0.35 |
| | | (0.08) | (0.08) | (0.08) | (0.08) | (0.09) | (0.09) |
| Female | | | -0.72 | -0.58 | -0.54 | -0.70 | -0.49 |
| | | | (0.36) | (0.37) | (0.37) | (0.39) | (0.40) |
| Union | | | | -1.38 | -1.38 | -1.06 | -0.96 |
| | | | | (0.78) | (0.78) | (0.79) | (0.79) |
| Full Time | | | | | 0.22 | -0.15 | -0.35 |
| | | | | | (0.42) | (0.44) | (0.44) |
| Industries (11) | | | | | | Yes | Yes |
| Occupations (3) | | | | | | | Yes |
| R-squared | 0.015 | 0.016 | 0.017 | 0.018 | 0.018 | 0.034 | 0.042 |
| obs | 3,535 | 3,534 | 3,534 | 3,374 | 3,374 | 3,312 | 3,312 |

Note: See table 1. New Hires have tenure less than one year. Each column is a separate regression. Year fixed effects are included in all regressions. The omitted firm category is firms with number of employees under 25. CPS supplement weights are used in the estimation.

Table 4: Relationship between Starting Wage and Age-at-Hire by Firm Size
Newly Hired White Collar Only
CPS May 1979, 1983, 1988 and April 1993
Dependent Variable is Log Hourly Earning
(Standard Errors)

| | Difference in Slope of the Wage-Age Profile | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| | Quadratic | Linear | Un-restricted |
| Large firm | -0.001 | 0.193 | -- |
| | (0.175) | (0.051) | |
| Age | 0.035 | 0.011 | -- |
| | (0.009) | (0.001) | |
| Age2 | -0.0003 | -- | -- |
| | (0.0001) | | |
| Age*Large firm | 0.009 | -0.003 | -- |
| | (0.010) | (0.001) | |
| Age2*Large firm | -0.0002 | -- | -- |
| | (0.0001) | | |
| 7 Age dummies | -- | | Yes |
| Large firm* Age[20,25] | -- | | 0.122 |
| | | | (0.028) |
| Large firm* Age(25,30] | -- | | 0.081 |
| | | | (0.032) |
| Large firm *Age(30,35] | -- | | 0.114 |
| | | | (0.040) |
| Large firm* Age(35,40] | -- | | 0.041 |
| | | | (0.044) |
| Large firm* Age(40,45] | -- | | 0.085 |
| | | | (0.055) |
| Large firm*Age(45,50] | -- | | 0.007 |
| | | | (0.064) |
| Large firm* Age(50,55] | -- | | -0.014 |
| | | | (0.068) |
| Large firm* Age>55 | -- | | -0.159 |
| | | | (0.083) |
| P-value (F-test: coeff. on age*large and age2*large equal zero) | 0.0028 | | |
| R-squared | 0.435 | 0.428 | 0.436 |
| Obs. | 3,730 | 3,370 | 3,730 |

Note: Newly hired sample includes tenure less than or equal to one year. Each column represents a separate regression, each of which includes controls for year fixed effects, tenure, education , dummies for region (3), smsa (2), married, female, nonwhite, full time, union, industries (11) and occupation(3). "Large firm" is an indicator variable for firms with number of employees >=100. The omitted category is firm with number of employees 25-99. CPS supplement weights are used in the estimation.

Table 5: Wage-Tenure Profile by Firm Size
White Collar Only
CPS May 1979, 1983, 1988 and April 1993
Dependent Variable is Log Hourly Earning
(Standard Errors)

| | Difference in Slope of the Wage-Tenure Profile | |
|---|---|---|
| | (1) | (2) |
| | Quadratic | Linear |
| Firm 25-99 | 0.046 | 0.068 |
| | (0.014) | (0.011) |
| Firm 100-999 | 0.106 | 0.109 |
| | (0.013) | (0.010) |
| Firm 1000+ | 0.121 | 0.140 |
| | (0.011) | (0.009) |
| Tenure | 0.018 | 0.009 |
| | (0.002) | (0.001) |
| Tenure2 | -0.0004 | -- |
| | (0.0001) | |
| Tenure * Firm 25-99 | 0.009 | 0.002 |
| | (0.003) | (0.001) |
| Tenure2 * Firm 25-99 | -0.0003 | -- |
| | (0.0001) | |
| Tenure * Firm 100-999 | 0.002 | 0.002 |
| | (0.003) | (0.001) |
| Tenure2 * Firm 100-999 | 0.0000 | -- |
| | (0.0001) | |
| Tenure * Firm 1000+ | 0.007 | 0.004 |
| | (0.003) | (0.001) |
| Tenure2 * Firm 1000+ | -0.0000 | -- |
| | (0.0001) | |
| P-value (F-test: coeff. on interactions of tenure , tenure2 and firm sizes equal 0) | 0.000 | 0.003 |
| P-value (F-test: coeff. on interactions of tenure, tenure2 and firm sizes are all equal) | 0.001 | 0.124 |
| R-squared | 0.4748 | 0.4719 |
| Obs. | 24,160 | 24,160 |

Note: Each column represents a separate regression, each of which includes controls for year fixed effects, experience, experience-squared, education , dummies for region (3), smsa (2), married, female, nonwhite, full time, union, industries (11) and occupation(3). The omitted category is firm with number of employees under 25. CPS supplement weights are used in the estimation.

Appendix Table 1: Starting Wage and Age-at-Hire Profile by Firm Size
Newly Hired White Collar Only
CPS May 1979, 1983, 1988 and April 1993
Dependent Variable is Log Hourly Earning
(Standard Errors)

| | Difference in Slope of the Wage-Age Profile | |
|---|---|---|
| | (1) | (2) |
| | Quadratic | Linear |
| Firm 25-99 | 0.023 | -0.144 |
| | (0.187) | (0.055) |
| Firm 100-999 | -0.055 | 0.052 |
| | (0.182) | (0.053) |
| Firm 1000+ | 0.043 | 0.056 |
| | (0.158) | (0.047) |
| Age | 0.038 | 0.0054 |
| | (0.006) | (0.0010) |
| Age2 | -0.0004 | -- |
| | (0.0001) | |
| Age * Firm 25-99 | -0.004 | 0.0056 |
| | (0.010) | (0.0015) |
| Age2 * Firm 25-99 | 0.0001 | -- |
| | (0.0001) | |
| Age * Firm 100-999 | 0.010 | 0.0022 |
| | (0.010) | (0.0016) |
| Age2 * Firm 100-999 | -0.0001 | -- |
| | (0.0001) | |
| Age * Firm 1000+ | 0.004 | 0.0021 |
| | (0.009) | (0.0014) |
| Age2 * Firm 1000+ | -0.0001 | -- |
| | (0.0001) | |
| P-value (F-test: coeff. on interaction of ages and firm sizes equal 0) | 0.017 | 0.005 |
| P-value (F-test: coeff. on all firm size variables equal 0) | 0.000 | 0.0000 |
| R-squared | 0.4158 | 0.4070 |
| Obs. | 5,413 | 5,413 |

Note: Newly hired sample includes tenure less than or equal to one year. Each column represents a separate regression, each of which includes controls for year fixed effects, tenure, education , dummies for region (3), smsa (2), married, female, nonwhite, full time, union, industries (11) and occupation(3). The omitted category is firm with number of employees under 25. CPS supplement weights are used in the estimation.

Appendix Table 2: Difference in Age-at-Hire across Industries
CPS May 1979, 1983, 1988 and April 1993
White Collar Only
(OLS Standard Errors)

| | Hire Age | Hire Age Distribution | | | |
|---|---|---|---|---|---|
| | | Age [20,30) | Age [30,40) | Age [40,50) | Age over 50 |
| Mean of dependent variables | | 0.505 | 0.239 | 0.143 | 0.063 |
| Construction | 0.808 | -0.031 | 0.023 | -0.014 | 0.022 |
| | (0.706) | (0.037) | (0.034) | (0.026) | (0.018) |
| Manufacturing Durables | -0.803 | 0.036 | -0.011 | -0.014 | -0.011 |
| | (0.625) | (0.033) | (0.030) | (0.023) | (0.016) |
| Manufacturing Nondurables | -0.329 | 0.008 | 0.011 | -0.005 | -0.013 |
| | (0.635) | (0.033) | (0.030) | (0.024) | (0.016) |
| Transportation, Utility & Communication | -1.540 | 0.089 | -0.037 | -0.045 | -0.007 |
| | (0.640) | (0.034) | (0.031) | (0.024) | (0.016) |
| Whole Trade | 0.499 | -0.020 | 0.003 | 0.008 | 0.008 |
| | (0.639) | (0.034) | (0.031) | (0.024) | (0.016) |
| Retail Trade | 0.445 | -0.002 | -0.028 | 0.007 | 0.023 |
| | (0.618) | (0.033) | (0.030) | (0.023) | (0.016) |
| Finance | -0.443 | 0.016 | -0.000 | -0.004 | -0.013 |
| | (0.622) | (0.033) | (0.030) | (0.023) | (0.016) |
| Services | 0.431 | -0.033 | 0.026 | 0.012 | -0.004 |
| | (0.612) | (0.032) | (0.029) | (0.023) | (0.016) |
| Weighted Average of Differentials | 1.096 | -0.077 | 0.034 | 0.033 | 0.010 |
| P value for F-test that all coeff on ind. dummies equal 0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| obs. | 28,839 | 28,839 | 28,839 | 28,839 | 28,839 |

Note: (1) Each column represents a separate regression of dependent variable on tenure, 3 year dummies and 8 industry dummies. The omitted industry category is mining. Numbers reported in each column are deviations of coefficients on industry dummies from the employment weighted average of the differentials. However, standard errors are unadjusted OLS standard errors.