Discrimination or Unobserved Differences in Characteristics?-An Empirical Study on Wage Inequality

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– An Empirical Study on Wage Inequality

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Abstract: We apply the discrimination search model with wage-tenure contracts to NLSY79 data to study race/gender wage inequality with a focus on distinguishing unobserved productivity differences from discrimination in the labor market and also simulating the pattern of wage dynamics. Our findings suggest that the productivity differential between black and white workers is 3% of white worker productivity while productivity differences between men and women are estimated to be 3% of male productivity. 91 % of firms are prejudiced towards black workers and 93% towards female workers. The distaste they hold towards black workers is about 70% of white worker productivity and towards women, 95% of male productivity. Compared to estimates in Bowlus and Eckstein (2002) and Flabbi (2010), we derive similar results on productivity differences, but much higher estimates on discrimination. In addition, our model predicts similar patterns of wage increases as observed from the data: First, the wage increases faster for men than women; second, the wage increases faster at low wages than high wages.

Key Words: Discrimination search model, unobserved difference, wage inequality

JEL Classification Numbers: J31, J64, J71

1. Introduction

One of the explanations for race and gender wage differentials, widely observed in the labor market, is the presence of differences in endowments of characteristics related to productivity and preferences; the remaining unexplained gap could be either due to unobserved productivity differences or discrimination against the minority group.[1] However, distinguishing these two effects is far from straightforward (Booth, 2009). To address this issue, Bowlus and Eckstein (2002) developed an equilibrium search model, which can separately identify discrimination from unobserved productivity differences because each of the two affects the earnings distribution differently. Using a sample of male high school graduates from the 1985-1988period, they find that blacks produced 3.3% less than whites, 56% of firms in the labor market had a prejudice against blacks, and the distaste was as high as 31% of the productivity of whites. Flabbi (2010), also studied gender wage inequality using maximum likelihood estimation in a search framework with matching and bargaining and concludes that female workers were 6.5% less productive than male workers and that half of employers discriminated against women in 1995.

This paper also belongs to this strand of literature. Based on a discrimination search model with wage-tenure contracts developed by Fang and Sakellariou (2013), we estimate productivity differences between blacks and whites, men and women and the existence of discrimination in the labor market during 1985-1988, using National Longitudinal Survey of

[1] Goldsmith et al. (1997) describe two mechanisms through which the psychological capital has impact on wages and Bowles et al. (2001) summarize the empirical evidence on the effect of personality and behavioural traits on earnings. However, in the wage decomposition literature, few researches have considered (or been able to control for) these factors in explaining the wage differentials. One example is Mueller and Plug (2006), who find that agreeableness, out of the five traits studied (extroversion, conscientiousness, neuroticism and openness to experience being the other four), has the greatest influence on earnings differences between men and women.

Youth 1979 (NLSY79). The blacks are estimated to be 3% less productive than whites and 91% of firms possess distaste against blacks. In the context of gender, the productivity gap between male and female workers is estimated to be 3%, while 93% of firms had a strong distaste against female workers; this is about 95% of men's productivity. Furthermore, by comparing the empirical hourly wage increase between genders/races with the predicted profiles, a certain correspondence between the two is observed, which to some extent supports the inference results and contributes to the literature on the tenure effect. [2]

The structure of the paper is organized as follows. Section 2 reviews the discrimination search model with wage-tenure contracts developed in Fang and Sakellariou (2013) and presents the equilibrium solution and properties that will be used in this paper. Section 3 applies the model to the same set of data as used in Bowlus and Eckstein (2002) and compares the inference results from the two models. Within the gender wage inequality framework, section 4 estimates the extent to which gender productivity differences and discrimination contribute to the wage differentials; subsequently, the difference in wage-tenure profiles for men and women is compared with the empirical estimates. Section 5 concludes and points out the limitations of the model and the findings.

2. Model

In this section we outline the search discrimination model with wage-tenure contracts and summarize the results which are derived from the empirical exercises[3]. The model is closely related to Burdett and Coles (2003), who first established a random search model with wage-

[2] Many studies have identified the positive effect of tenure on wages (Altonji and Shakotko, 1987; Topel, 1991; Altionji and Williams, 2005), but the empirical evidence on gender/racial disparity in wage returns to tenure is competing. For example, Light and Ureta (1995) and Munasinghe et al. (2008) find that women receive lower wage return to tenure while Becker and Lindsay (1994) and Hersch and Reagan (1997) find the opposite.

[3] For model details and further insight see Fang and Sakellariou (2013).

tenure contracts which is able to predict the wage increase due to not only job-to-job transition but also tenure effects. Fang and Sakellariou (2013) later extended this model to study discrimination and wage inequality.

In the model setting, there are two types of workers and firms: majority workers (A) and minority workers (B); discriminating firms (D) and non-discriminating firms (N). Workers are differentiated by the appearance only and are of the same productivity (P). They are finitely lived, with a death/birthrateδ. The newly born enter the labor force immediately as unemployed, receiving unemployment insurance b per period. All workers both employed and unemployed keep searching for the job that maximizes their expected lifetime utility. Their optimal strategy is to quit and accept the new offer if and only if the expected lifetime utility exceeds the value from the current job. A random search model is assumed here.

Firms, on the other hand, post two wage-tenure contracts, one for A-workers and the other for B-workers, described by $w_A^J(t)$ and $w_B^J(t)$, where t denotes tenure and J denote the type of firms, to maximize profit. As opposed to Bowlus and Eckstein (2002) where firms set a fixed wage, here wage increases for workers can be from not only job-to-job movements but tenure effects as well. Discrimination is presented in terms of offer arrival rates and distaste of discriminating firms. First, D-firms offer a job to A-workers at a rate of λ and to B-workers at a rate of $(1-k)\lambda$;N-firms treat both types of workers the same and offer a job at a rateλ. Second, D-firms experience a disutility d from hiring B-workers; that is, D-firms earn a profit of $P - w_B^D(t) - d$ per instant when hiring B -workers and a profit $P - w_A^D(t)$ when hiring A -workers.There are $(1-\theta)$ worker- Atypes and θ worker- B types, σD-firms and $(1-\sigma)$N-firms.

Workers' utility function is u(w), with $u' > 0, u'' < 0$.Firms cannot fire workers or counter-offer workers' new offer.

A baseline salary scale is used to describe the equilibrium solutions. That is, any wage-tenure contract $w(t|V_0)$, where V_0 is the starting expected lifetime value, can be expressed using the baseline salary scale, starting from a specific point t_0: $w(t|V_0) = w_s(t + t_0)$. So the equilibrium is to find three salary ranges $[\underline{w_A}, \overline{w_A}]$, $[\underline{w_B^D}, \overline{w_B^D}]$ and $[\underline{w_B^N}, \overline{w_B^N}]$ and the corresponding wage-tenure dynamics that can support the salary movements.[4] Proposition 1 below gives the equilibrium solutions:

Proposition 1: At the steady state equilibrium, the baseline salary scale for worker A satisfies:

$$\frac{P-\overline{w_A}}{P-\underline{w_A}} = \left(\frac{\delta}{\delta+\lambda}\right)^2 \quad (1)$$

$$u\left(\underline{w_A}\right) = u(b) - \frac{\sqrt{P-\underline{w_A}}}{2}\int_{\underline{w_A}}^{\overline{w_A}} \frac{u'(x)dx}{\sqrt{P-x}} \quad (2)$$

The optimal wage-tenure contract for worker A follows the dynamic path**:**

$$\frac{dw_A}{dt} = \frac{\delta(P-w_A)}{u'(w_A)}\int_{w_A}^{\overline{w_A}} \frac{u'(x)dx}{\sqrt{(P-\overline{w_A})(P-x)}} \quad (3)$$

For worker B, the baseline salary scale satisfies:

$$\frac{P-\overline{w_B^D}-d}{P-\underline{w_B^D}-d} = \left(\frac{\delta+(1-\sigma)\lambda}{\delta+(1-\sigma k)\lambda}\right)^2 \quad (4)$$

$$u\left(\underline{w_B^D}\right) = u(b) - \frac{\sqrt{P-\underline{w_B^D}-d}}{2}\int_{\underline{w_B^D}}^{\overline{w_B^D}} \frac{u'(x)dx}{\sqrt{P-x-d}} \quad (5)$$

$$\underline{w_B^N} = \overline{w_B^D} \quad (6)$$

[4]Fang and Sakellariou (2013) show that the upper bound cannot be reached, but an upper limit.

$$\frac{P-\overline{w_B^N}}{P-\underline{w_B^N}} = \left(\frac{\delta}{\delta+(1-\sigma)\lambda}\right)^2 \qquad (7)$$

And the dynamics of baseline salaries are:

$$\frac{dw_B^D}{dt} = \frac{(\delta+(1-\sigma)\lambda)(P-w_B^D-d)}{u'(w_B^D)} \int_{w_B^D}^{\overline{w_B^D}} \frac{u'(x)dx}{\sqrt{\left(P-\overline{w_B^D}-d\right)(P-x-d)}} \quad (8)$$

$$\frac{dw_B^N}{dt} = \frac{\delta(P-w_B^N)}{u'(w_B^N)} \int_{w_B^N}^{\overline{w_B^N}} \frac{u'(x)dx}{\sqrt{(P-\overline{w_B^N})(P-x)}} \qquad (9)$$

The conditions for the existence of the equilibrium, technical proof and detailed implication can be found in Fang and Sakellariou (2013).Only (1), (4), (6), and (7) are used in the identification steps. Wage dynamics (3), (8) and (9) are used to predict the wage-tenure effects, which can be used to test the estimates. Next, we highlight a few equilibrium properties that will be used in this paper.

First, at equilibrium, the earnings distributions $K_w^I(w)$, where I = A or B, are given by:

$$K_w^A(w) = \frac{\delta}{\lambda}\left[\sqrt{\frac{P-\underline{w_A}}{P-w}} - 1\right] \qquad (10)$$

$$K_w^B(w) = \begin{cases} \frac{\delta}{(1-\sigma k)\lambda}\left[\sqrt{\frac{P-\underline{w_B^D}-d}{P-w-d}} - 1\right], & \text{if } w \in [\underline{w_B^D}, \overline{w_B^D}] \\ \frac{\delta+(1-\sigma k)\lambda}{(1-\sigma k)\lambda}\sqrt{\frac{P-\overline{w_B^N}}{P-w}} - \frac{\delta}{(1-\sigma k)\lambda}, & \text{if } w \in [\underline{w_B^N}, \overline{w_B^N}] \end{cases} \qquad (11)$$

From the earnings distribution, we can then calculate the mean and median of wages.

Second, the unemployment rates of each type of workers are:

$$u_A = \frac{\delta}{\lambda+\delta} \qquad (12)$$

$$u_B = \frac{\delta}{\delta+(1-\sigma k)\lambda} \qquad (13)$$

and, the duration of unemployment is[5]:

$$\mathrm{UDur_A} = \frac{1}{\lambda}$$

$$\mathrm{UDur_B} = \frac{1}{(1-\sigma k)\,\lambda}$$

3. Racial wage discrimination

As abovementioned, one empirical difficulty in the discrimination literature is how to distinguish the unobserved productivity differences and discrimination in the residual wage gaps. Bowlus and Eckstein (2002) build a structural model that is able to identify both, due to the different impacts productivity differences and discrimination have on the earnings distribution. In this exercise, using the same data as Bowlus and Eckstein (2002) and similar identification strategy, we estimate the structural parameters of the wage-tenure discrimination model, and compare how the inferences on the extent of productivity differences versus discrimination in explaining racial wage gaps differ between the two models.

The data is from the NLSY79, covering the period from 1985 to 1988. The sample is restricted to "black and white males who graduated from high school between 1978 and 1984 and have not pursued further education nor served in the military over our sample period" (Bowlus and Eckstein, 2002). Table 1 is a summary of the data to be used in the estimation.

Table 1 Summary of NLSY data for male high school graduates, 1985-1988

	Whites	Blacks	Pooled
Unemployment rate	7.7%	15.7%	8.9%
Unemployment duration (weeks)	22.15	29.05	23.65
Minimum weekly wage	118.18	120.39	118.18
Maximum weekly wage	605.97	428.16	605.97
Mean weekly wage	273.90	230.96	268.03

[5]Proof and derivation can be found in Fang and Sakellariou (2013).

3.1 Identification

The model in the previous section assumes no differences between the two types of workers, except the observable characteristic which in this exercise refers to race. Now, to match the empirical observations in the data, we allow for racial differences in productivity P and death rateδ. The wage and unemployment data is used for identification. The following illustrates the identification in the most general case where both productivity difference and discrimination exist. Identification of the structural parameters in other cases is then straightforward.

First, using the unemployment duration, rate of unemployment and wage bound of whites λ, δ_A and $P_A$are identified as:$\mathrm{UDur_A} = \frac{1}{\lambda}$, $u_A = \frac{\delta_A}{\delta_A + \lambda}$ and the equilibrium condition $\frac{P_A - \overline{w_A}}{P_A - \underline{w_A}} = {u_A}^2$.

Next, σk and δ_B are identifiable using blacks' unemployment rate and duration of unemployment data as:$\mathrm{UDur_B} = \frac{1}{(1-\sigma k)\,\lambda}$and $u_B = \frac{\delta_B}{\delta_B + (1-\sigma k)\,\lambda}$. Note that hiring discrimination is key to matching the racial difference in unemployment duration and the varying death rate is crucial in determining the different unemployment rates.

Third, parameters associated with discrimination, d, σ, k and $\overline{w_B^D}$, and the productivity of black workersP_B are simultaneously identified from the system of equations: the estimated σk, two equilibrium conditions $\frac{P_B - \overline{w_B^D} - d}{P_B - \underline{w_B} - d} = \left(\frac{\delta_B + (1-\sigma)\lambda}{\delta_B + (1-\sigma k)\lambda}\right)^2$, $\frac{P_B - \overline{w_B}}{P_B - \overline{w_B^D}} = (\frac{\delta_B}{\delta_B + (1-\sigma)\lambda})^2$, the mean wage $Ew_B = \overline{w_B} + \frac{\delta_B}{(1-\sigma k)\lambda}(\overline{w_B} - \underline{w_B}) - \frac{2}{1-\sigma k}\left[\frac{\delta_B \sigma (1-k)}{\delta_B + (1-\sigma k)\lambda}\left(P_B - \underline{w_B} - d\right) + \frac{(1-\sigma)[\delta_B + (1-\sigma k)\lambda]}{\delta_B}(P_B - \overline{w_B})\right]$ and the median wage:

$$w_B^5 = \begin{cases} P_B - d - \left(P_B - \underline{w_B} - d\right)\left(\frac{\delta_B}{\delta_B + (1-\sigma k)\lambda q}\right)^2 & if\ \frac{\delta_B(1-k)\sigma}{(1-\sigma k)[\delta_B + (1-\sigma)\lambda]} > 0.5 \\ P_B - (P_B - \overline{w_B})\left(\frac{\delta_B + (1-\sigma k)\lambda}{\delta_B + (1-\sigma k)\lambda q}\right)^2 & if\ \frac{\delta_B(1-k)\sigma}{(1-\sigma k)[\delta_B + (1-\sigma)\lambda]} \leq 0.5 \end{cases}.$$

The estimation procedure is as follows: first, try the value of P_A as the estimate of P_B and derive all other parameters through the system of equations but the median one; then, predict the median wage according to the median wage equation; if it approximates the empirical median wage, keep all the parameter estimates, if not, modify the estimate of P_B accordingly and re-derive all the above until the predicted median wage tallies with the empirical one. One can also compare the predicted and empirical value at any other quantile to determine the appropriate estimates of parameters.

3.2 Estimation

We estimate the parameters in six versions from a simple case where there are no differences between whites and blacks, towards a complete model with both productivity difference and discrimination. In the simplest scenario where $P_A = P_B = P$; $\delta_A = \delta_B = \delta$ and no discrimination present $(d = k = 0, \sigma = 1)$, parameters λ and δ are solved from the pooled unemployment duration and rate of unemployment. Productivity level P is then identified from the equilibrium condition $\frac{P-\overline{w}}{P-\underline{w}} = \left(\frac{\delta}{\delta+\lambda}\right)^2$ where $\underline{w}$ and $\overline{w}$ are replaced with 118.18 (minimum wage of the pooled population) and 605.97 (maximum wage of the pooled population) respectively. The assumptions and estimation results are presented in column (1) of Table 2. In scenarios (2) and (3), we calculate δ_i and P_i using the separate unemployment rate and equilibrium condition by race instead. The productivity levels differ significantly between whites and blacks and $P_B/$

$P_A$ratios are indeed smaller than the mean wage ratio as predicted in Bowlus and Eckstein (2002). Varying δ is important in explaining the unemployment rate differential in the data.

Table 2 Parameter Estimates

Parameter	(1) $P_A = P_B$; no discrimination; $\delta_A = \delta_B$	(2) $P_A \neq P_B$; no discrimination; $\delta_A = \delta_B$	(3) $P_A \neq P_B$; no discrimination; $\delta_A \neq \delta_B$	(4) $P_A \neq P_B$; discrimination present ($k = 0$); $\delta_A \neq \delta_B$	(5) $P_A \neq P_B$; discrimination present; $\delta_A \neq \delta_B$	(6) $P_A = P_B$; discrimination present; $\delta_A \neq \delta_B$
$\boldsymbol{\lambda}$	0.0423	0.0423	0.0423	0.0423	0.0451	0.0451
$\boldsymbol{\delta_A}$	0.0041	0.0041	0.0035	0.0035	0.0038	0.0038
$\boldsymbol{\delta_B}$	0.0041	0.0041	0.0079	0.0079	0.0064	0.0064
$\boldsymbol{P_A}$	609.86	609.86	608.88	608.88	608.88	608.88
$\boldsymbol{P_B}$	609.86	430.62	435.94	537.21	591.02	608.88
$\boldsymbol{d}$	0	0	0	441	429.67	436.34
$\boldsymbol{k}$	0	0	0	0	0.2608	0.2580
$\boldsymbol{\sigma}$	1	1	1	0.8122	0.9106	0.9206
$\boldsymbol{\overline{w_B^D}}$	-	-	-	99	158.65	169.41

Scenario (4) begins to incorporate the assumption of discrimination by allowing for the disutility experienced by prejudiced firms from hiring black workers. P_B , d, σ and $\overline{w_B^D}$ are calculated simultaneously using two equilibrium conditions and the equations of mean and median wages for black workers. The disutility level is found to be 72.4% of the white workers' productivity, and 81.2% of the firms are prejudiced against black workers. When the restriction on equal hiring rate is relaxed in scenario (5), 91.1% of firms in the labor market have a distaste of 70.6% of the white productivity and offer to hire black workers at a rate 26.1% lower than the offer rate to whites.[6] The productivity of black workers is only 3% lower than their white

[6]These estimates are obtained to match the wage of black workers at the 10% percentile. When the median is matched in the estimation, the result implies black workers are more productive than whites and 96.5% of firms are

counterparts. In this estimation, the model can not only match the racial differences in unemployment rates but unemployment durations as well. Finally, we get the parameter estimates in the scenario of pure discrimination in column (6).The last row of Table 2 presents the estimate of $\overline{w_B^D}$ when there is discrimination present in the labor market.

The earnings distributions predicted in the pure productivity difference (scenario (3)), pure discrimination (scenario (6)) and mixed cases (scenario (5)) are shown in Figure 1, which clearly demonstrates the distinguishing effects productivity difference versus discrimination have on the earnings distribution. Furthermore, the wage-tenure discrimination model also allows for the depiction of wage dynamics. Figure 2 shows how the wage increase varies between blacks and whites at each wage level. In the case of pure productivity difference, the two lines have a similar shape and the blue line lies above the red one, suggesting a higher wage increasing rate for white workers compared to black workers at any wage level. In the case of pure discrimination, there is a striking gap between the blue line and the red line; moreover, the red line is discontinuous at the jump point. It indicates that discrimination is an influential factor in wage-tenure contracts, and the presence of discrimination leads to a sharp decrease in the wage increasing rate for blacks in both discriminating and non-discriminating firms. Intuitively, although non-discriminating firms do not discriminate against black workers, they have an incentive to offer a less attractive contract to black workers than otherwise, as there is now less competition among firms to hire black workers and black workers will be willing to stay and accept the less attractive contract because of no better options outside. When there are both

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prejudiced with a distaste as high as 97.5% of the white productivity and an offer rate 24.6% lower to blacks ($P_B = 812.41; d = 593.59; k = 0.2462; \sigma = 0.9649; \overline{w_B^D} = 215.04$).

productivity differences and discrimination in the labor market, the line indicating the wage dynamics of black workers is a combination of the two effects.

[Figure 1& Figure 2 about here]

3.3 Comparison

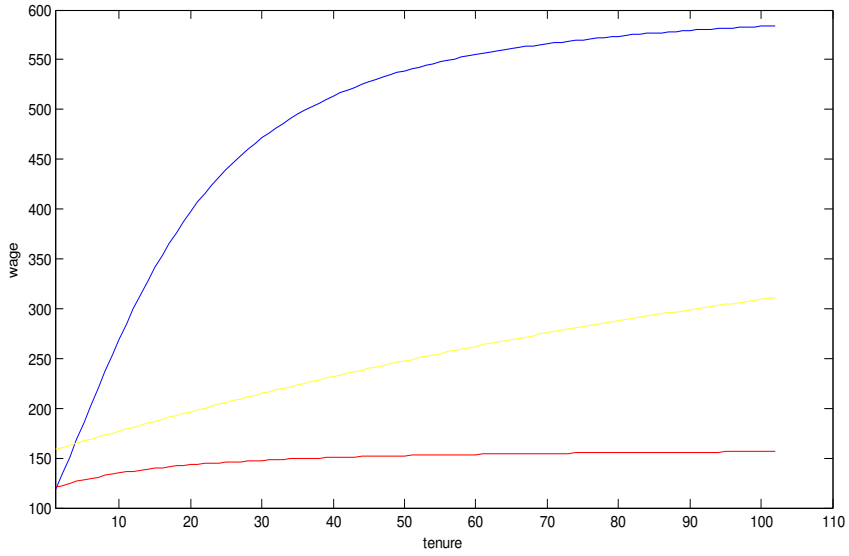
The estimation results imply that in the case of high school male graduates in 1985-1988, the productivity of black workers is 3% less than that of white workers and 91.1% of firms in the labor market have a distaste against black workers which is as high as 70.6% of whites' productivity. Furthermore, these firms offer to hire blacks at a rate 26.1% lower than the offer rate they send to whites. Compared with the results in Bowlus and Eckstein (2002), the same conclusion is drawn regarding the productivity differential between races. However, in this model, the fraction of discriminating firms in the labor market is higher, the disutility discriminating firms feel in hiring black workers is stronger, while the recruiting discrimination is not as severe as that predicted in Bowlus and Eckstein (2002). It may be because there are so many firms having a strong prejudice towards black workers that it turns out to be costly to have such a distaste and profitable to relax the discrimination a little during recruitment.

One should notice a few differences between these two models of Fang and Sakellariou (2013) (henceforth, FS) and Bowlus and Eckstein (2002) (henceforth, BE). First and foremost, a constant wage is assumed in BE while FS assumes wage changes with tenure. Therefore, except for using mean wages in estimation, we also utilize wage ranges. Second, productivity is different in interpretation. BE interpret P as the average productivity level in a market with firm heterogeneity, while P in FS model is the marginal productivity a worker brings to the firm

which does not vary across firms. It implies that P must be greater than the maximum wage observed in the data. The estimated P usingFSmodel is thus much greater than those in BE. Third, offer arrival rates are different among employed and unemployed workers in BE but they are the same in FS model; finally,δ is the destruction rate in BE but birth/death rate in FS model.

These simplifications of the FS model enable the estimation of different effects productivity differences and discrimination have on the wage gap and their respective wage dynamics. Figure 3 depicts how wage increases with tenure when there are both productivity differentials and discrimination in the labor market. The blue line represents the wage dynamics for white workers, the red line for black workers hired in discriminating firms and the yellow line for black workers hired in non-discriminating firms. Obviously, the slope of the blue line is greater than the slope of the yellow line, which is greater than that of the red line. It implies that white workers will experience a steeper wage increase with tenure, followed by the black workers in non-discriminating firms. Black workers employed in discriminating firms have to search for opportunities in non-discriminating firms after around 50 weeks otherwise the wage will stagger and remain almost unchanged. This supports the findings in Bratsberg and Terrell (1998) who conclude that the returns to actual experience are lower for blacks than for whites.

Figure 3 Wage dynamics



4. Gender wage discrimination

The second exercise is to estimate gender wage discrimination in the labor market andwhether the predicted pattern of wage dynamics matches the empirical one.

4.1 Data

The sample used is extracted from the NLSY79 for the period 1985-1987. To be included in the sample, an individual must be a white, either employed or unemployed in 1985, have graduated from high school and not enrolled in further education in the period 1985-1987. For the unemployed worker, we calculate the unemployment duration. There are two versions of unemployment duration. $DurU1$ is the period that dates back from the week the worker became unemployed (no earlier than year 1984) till the week he/she was either employed or out of labor force (no later than year 1987). $DurU2$ is the period that dates back from the week the unemployed worker became not employed (either unemployed or out of labor force, but no earlier than year 1984) till the week he/she was employed (no later than year 1987). Since $DurU2$ takes out-of-labor-force into the calculation of unemployment duration, it is greater than $DurU1$ which only counts the period of unemployment.[7] For the employed worker, we keep workers who have been employed continuously during 1985-1986, and calculate the increase in

[7]Bowlus (1997) built a three stage model (employment, unemployment and nonparticipation) to study the role of gender differences in behavior patterns on wage differentials. Our model, however, only allows for two stages, i.e., employment and unemployment. Therefore, when applying it to labor market differences on the basis of gender, "unemployment" refers to the status of unemployment or nonparticipation. $Dur1$(real unemployment duration) and $Dur2$(nonemployment duration) generate two groups of estimates that help us to compare the implications.

hourly wages. Table 3 summarizes the statistics that are useful in the estimation. Figure 4 plots the *cdf* and *pdf* distributions of hourly wage for both genders.

Table 3 Summary of NLSY data for high school white graduates, 1985-1987

	Male	Female	Pooled
Unemployment rate	4.314%	5.257%	4.749%
$DurU1$ (weeks)	29.237	19.668	24.237
$DurU2$ (weeks)	34.661	36.771	35.664
Wage range (hourly pay in cents)	[41, 1923]	[45, 1511]	[41,1923]
Average wage (hourly pay in cents)	823.3616	634.6458	743.4436
Median wage (hourly pay in cents)	769	591	682

[Figure 4 about here]

Next, we explore the difference in patterns of wage increase between men and women. Figure 5 includes two scatter plots to show the rough relationship between wage increase and the 1985 hourly wage(one is not weighted and the other weighted). It is found that points cluster in the lower middle part where the hourly wage is between $2.50 and $12.00 and the wage increase is below $5.00; and, substantially more "male" points lie at higher wages. The predicted lines describe the trends of wage increase over levels. To compare the wage profiles of men and women more clearly, Figure 6 plots the magnitude of average wage increase over twenty or forty wage categories for male and female workers. Numbers on X-axis represent the middle point of each wage category. It is observed that women's wage increase is generally smaller than men's wage increase, which is in consistent with the findings of Light and Ureta (1995) and Munasinghe et al. (2008). In addition, for both men and women, the magnitude of wage increase is much higher at low wages than at high wages. At very high wages (above $16.00), only male workers are observed. Since the identification strategy is the same as specified in the last exercise, the estimation results are presented directly.

[Figure 5& Figure 6 about here]

4.2 **Estimation**

Table 4 reports the estimation results in three scenarios under two measures of unemployment duration. Assuming no discrimination present in the labor market, the productivity of women is estimated to be 21% lower than that of men.[8] If discrimination is taken into account, the productivity gap shrinks to 3% of men's productivity, smaller than the 6.5% reported in Flabbi (2010) who used a sample of white, college graduates from CPS 1995. Looking at the estimates of discrimination parameters, one can see that k is negative under $DurU1$, suggesting that a job offer goes to women more frequently. This is completely opposite to our expectation and problematic. As a matter of fact, compared to men, women are more often ending the status of unemployment by not participating in the labor market rather than finding a job. Therefore, it results in a seemingly lower unemployment duration among unemployed females compared unemployed males, when it is measured by $DurU1$. $DurU2$, on the other hand, avoids this problem and is more appropriate in the situation of male-female discrimination. As indicated in column (5), when there is no productivity difference between men and women and all the gender wage gap is attributable to discrimination, about 94.3% of the firms are prejudiced against women, with a distaste as high as 94% of the productivity, and search for female workers is 6% less intensive than for male workers. If there are both productivity differential and discrimination, it is estimated that fewer firms (93.2%) have a slightly stronger distaste (96%) and stronger recruiting discrimination (6.1%) against women. The estimate of the fraction of discriminating firms is higher than the 52% found in Flabbi (2010) and 56% in Bowlus and Eckstein (2002).

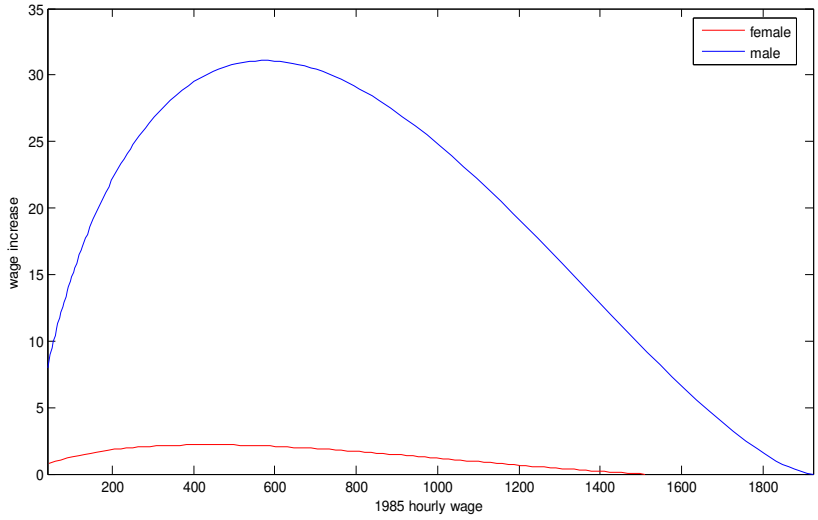
[8] Using a search model that does not allow for discrimination, Bowlus (1997) finds that the average gender productivity differences for college graduates is 17.1% and for high school graduates 25.3%.

Table 4 Parameter estimates

Parameter	$DurU1$			$DurU2$		
	(1)	(2)	(3)	(4)	(5)	(6)
	$P_A \neq P_B$; no discrimination; $\delta_A \neq \delta_B$	$P_A = P_B$; discrimination present; $\delta_A \neq \delta_B$	$P_A \neq P_B$; discrimination present; $\delta_A \neq \delta_B$	$P_A \neq P_B$; no discrimination; $\delta_A \neq \delta_B$	$P_A = P_B$; discrimination present; $\delta_A \neq \delta_B$	$P_A \neq P_B$; discrimination present; $\delta_A \neq \delta_B$
$\boldsymbol{\lambda}$	0.0413	0.0342	0.0342	0.0280	0.0289	0.0289
$\boldsymbol{\delta_A}$	0.0019	0.0015	0.0015	0.0013	0.0013	0.0013
$\boldsymbol{\delta_B}$	0.0023	0.0028	0.0028	0.0016	0.0015	0.0015
$\boldsymbol{P_A}$	1926.5	1926.50	1926.5	1926.5	1926.5	1926.5
$\boldsymbol{P_B}$	1515.1	1926.50	1863.4	1515.1	1926.5	1863.4
$\boldsymbol{d}$	0	1801.6	1851.2	0	1801.6	1851.2
$\boldsymbol{k}$	0	-0.5342	-0.5445	0	0.0608	0.0615
$\boldsymbol{\sigma}$	1	0.9107	0.8935	1	0.9434	0.9324
$\overline{\boldsymbol{w_B^D}}$	-	123.91	12.638	-	123.91	12.638

How well does the FS model match the empirical wage dynamics? Using the estimates in column (6) of Table 4, we plot the theoretical pattern of wage increases for both men and women in Figure 7, which also shows a greater wage increase among male workers than female workers and a steeper increase in the lower wages as in Figure 5 and Figure 6, although the magnitude of wage increase differs.

Figure 7 Predicted wage increase



5. Conclusion

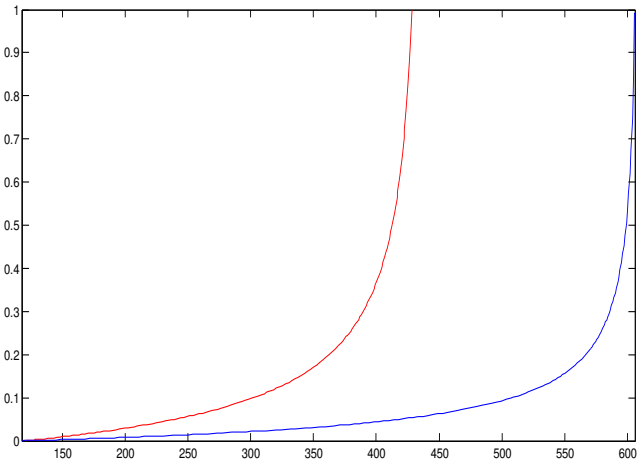
This paper applies the discrimination search model with wage-tenure contracts developed by Fang and Sakellariou (2013) to NLSY79 data to study the race/gender wage inequalities with an aim to distinguish the unobserved productivity differences from discrimination in the labor market and also simulate the pattern of wage dynamics. For the sample period of 1985-1988, productivity difference between black and white workers is estimated to be 3% of white worker productivity; productivity differences between men and women are estimated to be 3% of male productivity. Ninety-one % of firms are prejudiced towards black workers and 93% towards female workers. The distaste they hold towards black workers is about 70% of white worker productivity and that towards women is 95% of male productivity. Compared to estimates in Bowlus and Eckstein (2002) and Flabbi (2010), we derive similar results on productivity differences, but much higher estimates on discrimination. In addition, our model predicts similar patterns of wage increases as observed from the data. First, the wage increases faster for men than women; second, the wage increases faster at low wages than high wages.

However, there are some points noteworthy. Due to the model complexity and its own limitations such as the incorporation of tenure only rather than any other factors which also have an influence on the labor market outcome, the inference needs to be interpreted carefully. Although we have chosen race/gender groups with homogenous characteristics (i.e., education) with an aim to eliminate the effect of observed differences on earnings differentials and distinguish the extent to which discrimination and unobserved variables contribute to the residual gap, the estimate of productivity differences could not be interpreted exclusively as differences in unobserved attributes. It can be possibly explained by other controlling and observable factors.

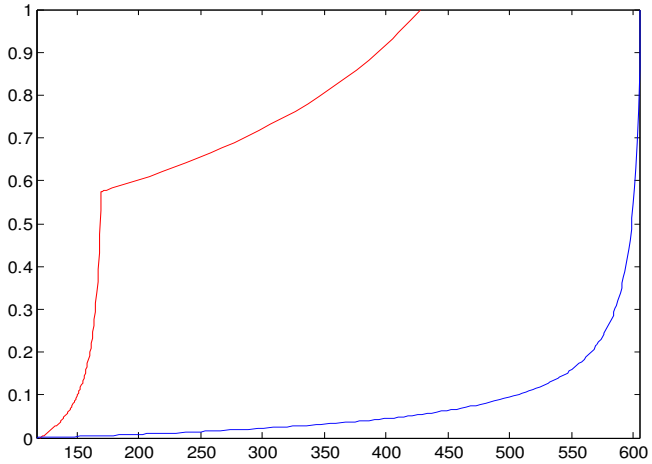
Third, one could construct an econometric model from Fang and Sakellariou (2013) to test the estimates.

Figure 1 Predicted earnings distributions

(a) Pure productivity difference



(b) Pure discrimination



(c) Mixed: productivity difference and discrimination

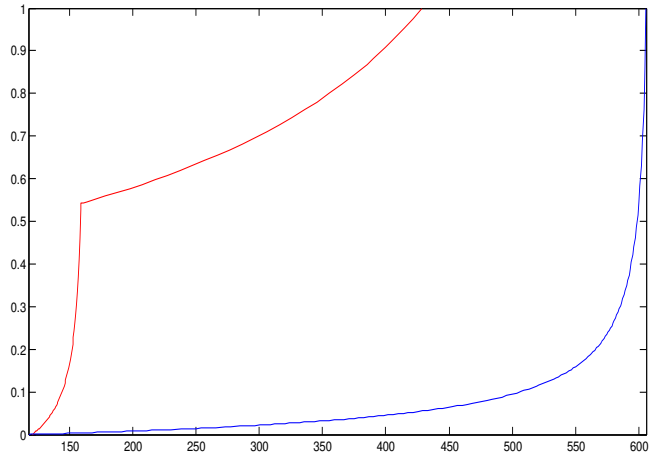
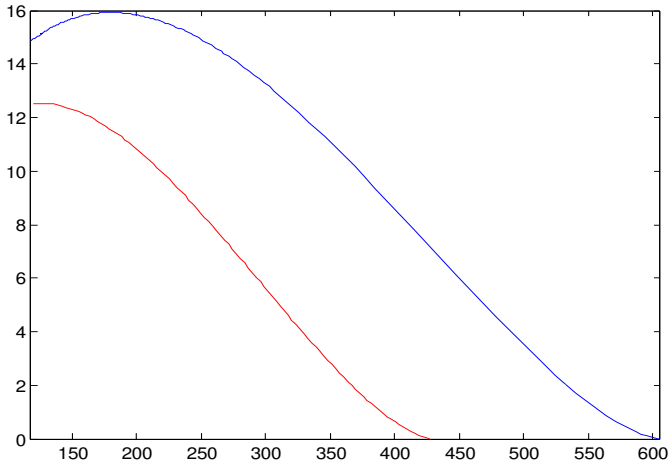
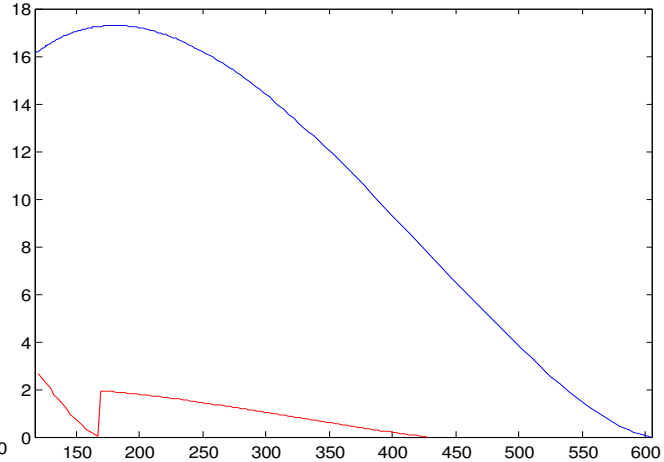


Figure 2 Predicted wage dynamics

(a) Pure productivity difference



(b) Pure discrimination



(c) Mixed: productivity differences and discrimination

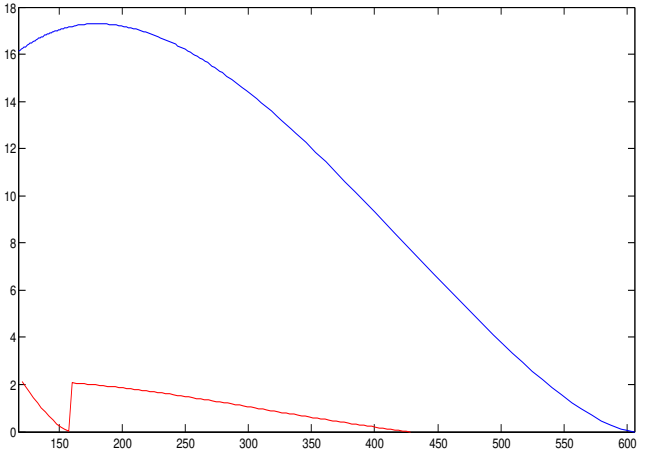
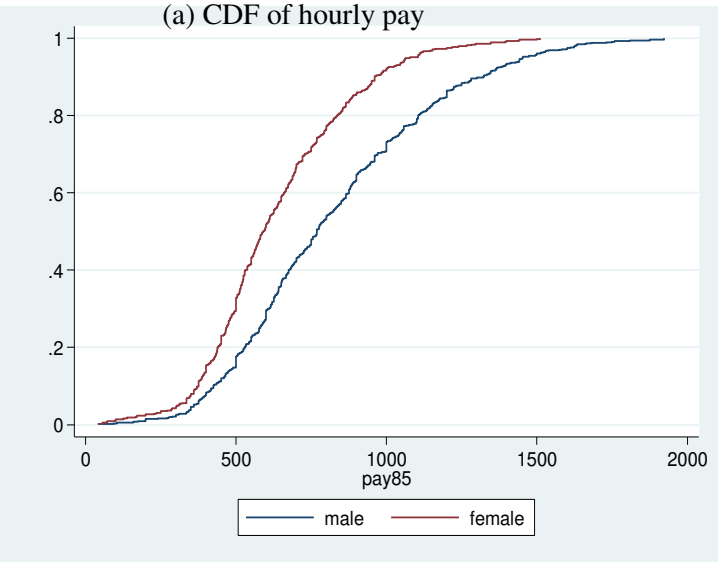


Figure 4 Hourly wage distributions



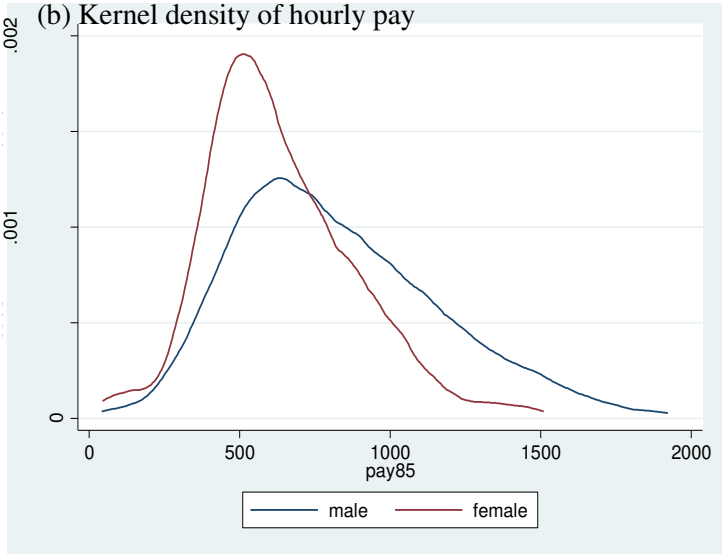
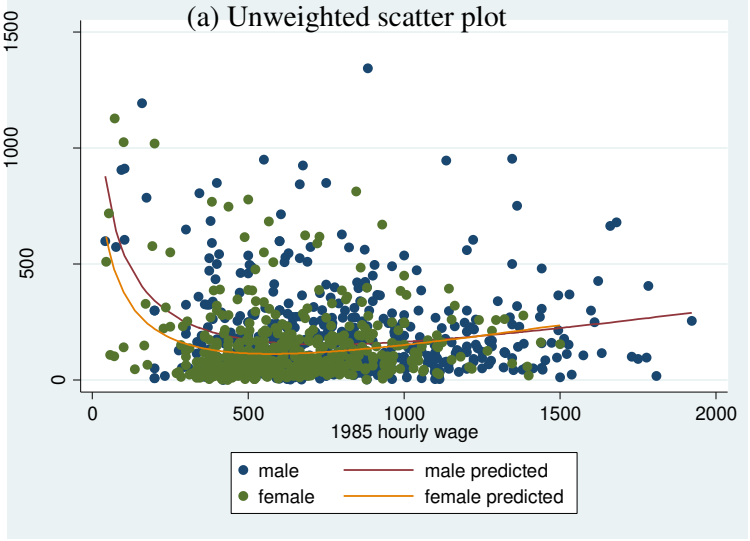


Figure 5 Scatter plots of wage increase and hourly pay



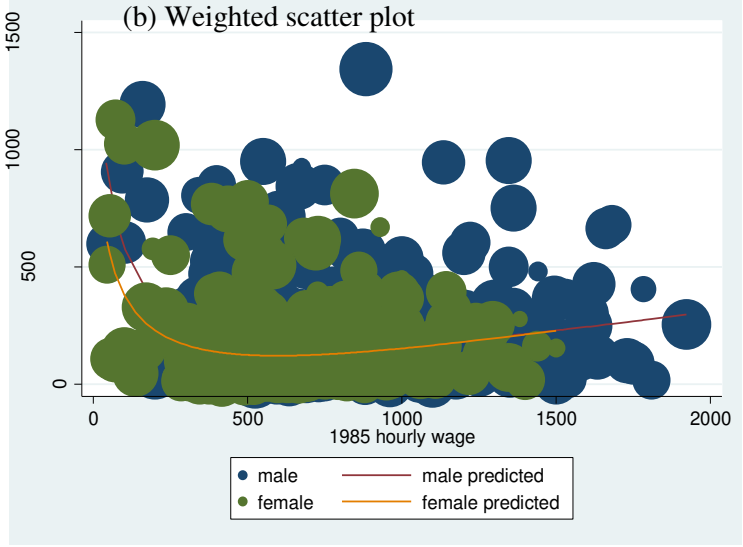
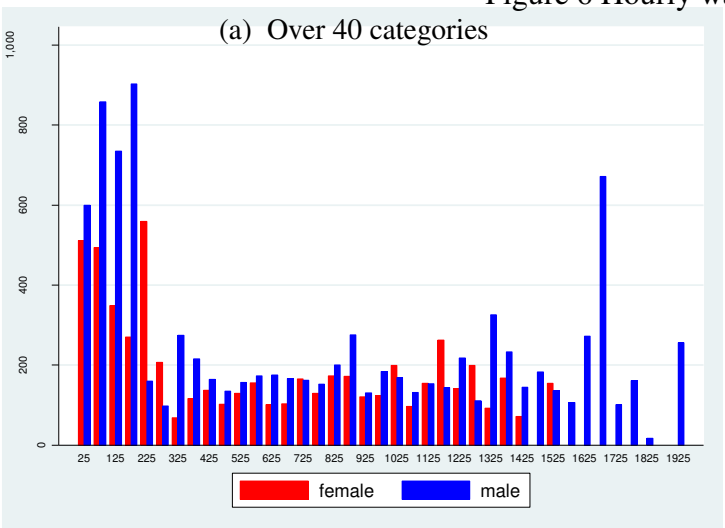
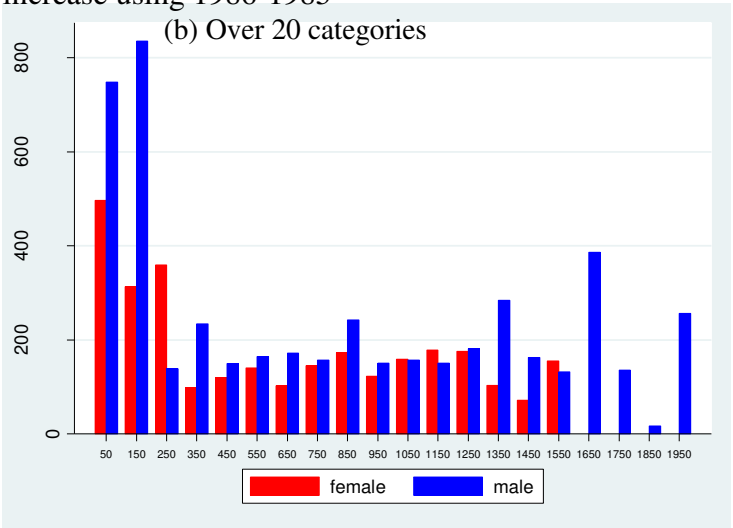


Figure 6 Hourly wage increase using 1986-1985





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