# Earnings Disparities: The Role of Internal Promotions and Job Performance Evaluations

Heather Krull

A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Economics.

Chapel Hill
2007

Approved by:

Dr. Donna Gilleskie, Advisor

Dr. William Darity, Committee Member

Dr. David Guilkey, Committee Member

Dr. Thomas Mroz, Committee Member

Dr. Helen Tauchen, Committee Member

ABSTRACT

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(Under the direction of Donna Gilleskie)

This study utilizes a unique data set containing detailed labor market information for individuals employed by the state of North Carolina over ten years. The inclusion of the state's promotion decisions and each worker's annual performance evaluations allow for an empirical test of the presence of statistical discrimination that has not been possible in previous studies. Statistical discrimination is said to exist if, in the absence of perfect information about a worker's productivity, an employer uses characteristics of that worker's (race or gender) group to substitute for individual-specific information missing from a signal of the worker's productivity. If the signal is "noisier" for blacks or women than it is for white men, equally productive workers may be paid differently. If, however, performance evaluation serves as a suitable proxy for individual productivity and if statistical discrimination exists at the point of hiring, then the significance of observable characteristics (race and gender) in explaining wage or promotion disparities should diminish with tenure.

Results suggest that blacks may be statistically discriminated against at the time of hire, but that men and women are not treated differently. This outcome elicits further investigation into how statistical discrimination affects other labor market outcomes which differ across groups, including wage disparities and the rate at which promotions are realized. Equations explaining the dynamic employment process approximated by the wage and salary grade, performance evaluation, promotion, and quit probabilities of North Carolina state employees are estimated jointly to allow for correlation in unobserved permanent and time-varying heterogeneity factors affecting each outcome.

When controlling for measures unique to these data, such as performance evaluation and promotion history, women and black men are not shown to be significantly more or less likely to be promoted than white men. After controlling for unobserved heterogeneity,

endogeneity of relevant explanatory variables, and performance and promotion history, wage gaps effectively disappear. Consistent with the result that statistical discrimination may exist at the time of hire, tenure interacted with race and/or gender produces negligible or insignificant coefficients in all equations, suggesting that after controlling for performance, race and gender do not independently influence employment outcomes.

ACKNOWLEDGEMENTS

The completion of this thesis would not have been possible without the contributions of many individuals. First and foremost, I owe a considerable debt of gratitude to my advisor, Donna Gilleskie. In the early stages of this project, she was instrumental in helping me acquire data and develop a research agenda. Throughout, she has been a source of encouragement, advice, and has served as a role model in demonstrating how to conduct careful, meaningful research.

I would also like to thank the other members of my committee for the input they have provided: William Darity, David Guilkey, Tom Mroz, and Helen Tauchen. Additionally, I appreciate the comments Wilbert van der Klaauw offered during the early stages of this research. Comments and suggestions provided by participants of the Labor Economics workshop helped guide this project, and for that feedback, I am truly appreciative.

The data used in this project are from the North Carolina Office of State Personnel. I am grateful for their willingness to provide the data and especially for the follow-up support provided by Charles Chapman and John Wei. Debbie Edwards was also gracious in offering assistance as I gathered information to develop an understanding of the State's employment system. Computing resources to support the data used in this project were made available by Paul Mitchell and Steven Fishback at UNC's Information Technology Services and by Jon Crabtree and Rodney Hodson at UNC's Institute for Research in Social Sciences. Their accommodations are greatly appreciated and made this research possible.

Finally, my friends and family have made this experience enjoyable and unforgettable. In particular, my parents have displayed unwavering encouragement and patience, and their confidence in me has always been evident at the times I needed it most. I am forever grateful for the support they offered during my time at UNC and always.

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# 1 Introduction

To explain earnings disparities across gender or race, wage differential studies typically focus on a combination of explanatory variables including differences in the quantity or quality of education, labor force attachment, pre-market factors, geographic location, the returns to education, tenure, experience, and affirmative action. The most obvious source of wage variation absent from this research is worker productivity. This information is seldom, if ever, available in nationally representative data sets and is often proxied by such variables as schooling, tenure, experience. Also lacking from many wage differential studies, but highlighted by McCue (1996) and others as a significant source of wage growth, is the incidence of internal mobility, including promotion. She finds that approximately 15% of the wage growth enjoyed by men throughout the lifecycle can be attributed to internal mobility, with a smaller contribution for women. Furthermore, better paid workers have a higher probability of being promoted and generally advance their positions early in their career.

It is important to distinguish between "statistical discrimination" and the more commonly referenced "taste discrimination" when evaluating reasons for earning disparities among groups (e.g., gender, race, or age). One approach to examining racial or gender wage differentials involves a theory of discrimination, whereby differences in wages are decomposed into "explained" productivity attributes and "unexplained" differences, commonly cited as prejudice against women or racial minorities. This prejudice is of the "taste discrimination" form and assumes what cannot be explained with education, occupational choice, work experience, etc., is the result of disutility experienced by employers who hire women or minorities.[1] Alternatively, an employer that statistically discriminates judges an individual on the basis of the average characteristics of the group to which she belongs rather than upon her own personal characteristics. Statistical discrimination may happen if a supervisor with

[1]See, for example, Becker (1971), Black (1995), Eckstein and Wolpin (1999), and Flabbi (2005).

particular characteristics has more reliable information at the onset of employment about a similar worker than about a worker belonging to a different group. The information disparity may be due to either differences in networking strategies across groups or a greater likelihood of miscommunication between members of different groups than between members of like groups (Lang, 1986). As more information becomes available about a worker's ability (i.e. productivity), statistical discrimination should diminish.

This research furthers the investigation of the earnings gap with a focus on possible differences due to statistical discrimination. The contributions are two-fold: 1) The analyses benefit from the availability of a uniform measure of a worker's productivity, and 2) The analyses seek evidence of disparities in wages even after controlling for endogenous tenure, promotion, and productivity. Support for the presence of statistical discrimination in the promotion process, for example, may be evidenced by changes in the size and statistical significance of coefficients measuring the influence of individual characteristics on the probability of promotion as a worker's tenure with a firm increases. Put differently, over the course of a worker's tenure with an employer, there may be significant differences across races in which characteristics are influential in the promotion process and when these attributes play an increasingly important role. That is, a firm may place more emphasis on the race and gender of a minority worker than on potentially less reliable observables such as education and labor market experience in the early stages of the worker's employment. Over time, however, the shift toward relying on worker performance may be much greater for minorities than for workers who are more prominently represented with the firm, which might suggest evidence of statistical discrimination. Hence, accurate measurement of the effects of these characteristics in explaining wages and promotion is necessary to verify their importance. The data used in this work allow for better measurement of these effects.

This work makes use of a rich and comprehensive data set from the North Carolina Office of State Personnel (hereafter referred to as the NC OSP) that is not publicly available. The data contain two features not available in nationally-representative data sets commonly used to study longitudinal employment behavior: a uniform measure of worker performance and an unambiguous definition of promotion (demotion). First, the state's system of annual evaluation provides a measure of performance comparable across workers and time. While

worker effort is difficult to measure in general, a firm's evaluation of effort is more readily obtained. Such an evaluation, however, can only be used if comparable across individuals or when provided by a single firm. Usually this results in a small sample size. The state of NC, however, employs over 100,000 people each year. Secondly, previous studies have relied on a worker's self-reported promotion, change in tasks, or unusually large increase in wages (or a combination thereof) as an indication that a promotion has occurred. The state of NC, however, employs a salary grade system similar to the General Schedule (GS) pay scale utilized by the federal government. A promotion (demotion) is defined as an increase (decrease) in salary grade, accompanied by a change in the worker's position-specific personnel number. The clarity of this definition leaves no room for arbitrary interpretation as deemed necessary by the data used in most other studies.

This paper proceeds as follows. Section 2 summarizes the literature. The data are described in Section 3. Section 4 describes the theoretical and empirical models. The estimates of the empirical model are provided in section 5, Section 6 contains the results of simulations, and Section 7 concludes.

# 2 Related Empirical Literature

The study that most closely resembles the research undertaken in this project is Blau and DeVaro's (2006) examination of promotion and wages. They utilize the Multi-City Study of Urban Inequality to estimate the gender differential in (expected) promotions and wage growth due to, and independent of, promotions. Included in these data is a measure of worker productivity reported by supervisors who are asked to rank the performance of their most recently-hired worker. The authors estimate, separately for men and women, the probability of promotion for the most recently-hired worker, the expected promotion for this worker within the next five years, the wage growth already experienced by the most recently hired worker, the within-job wage growth attainable in the starting position in the absence of a promotion (for any worker), and the expected wage growth associated with an expected promotion.

While men and blacks are consistently and significantly predicted to be promoted with greater frequency than women (by 2-3 percentage points), the results are generally insensitive to the addition of performance evaluation, firm characteristics, and occupational controls compared to a baseline specification which includes race, gender, age, tenure, and education. Men are only statistically significantly expected to be promoted more often than women in the baseline and performance evaluation specifications. However, a previous realized promotion has a much larger impact ($\sim 25\%$) on the probability of an expected future promotion.

In addition to promotions, the authors analyze wage growth. The coefficient on "promoted already" in the wage growth since hire equation suggests that earnings grow by 7-8% with a promotion for both men and women, holding all else constant. An equation estimating wage growth in the absence of a promotion reveals almost no difference between the outcomes of men and women. However, since the question asked of supervisors referred to any

employee, if the answer was provided for a hypothetical male worker, but the most recently hired employee is female, the results may underestimate the gender gap in wage growth. The difference in expected wages for workers expected to be promoted within the next five years is trivial and does not consistently favor one gender. Finally, Blau and DeVaro use information on the gender of a worker's supervisor to consider whether men are less likely to promote female (than male) subordinates and find no evidence to support this notion.

One limitation of the study conducted by Blau and DeVaro is the lack of a control for unobserved heterogeneity. If the same unobserved factors affect both wages and promotions (ability, for instance), workers who experience a promotion are likely the same workers who would have earned higher wages even in the absence of a promotion. This selection bias may understate the extent to which women are at a disadvantage in terms of wage gains associated with promotions. The current study makes use of an estimation technique that controls for this potential correlation between the error terms in the wage and promotion equations.

While the work of Blau and DeVaro serves as a convenient framework to which results of this study can be compared, this research makes use of, and contributes to, three bodies of literature: wage differentials, promotions, and statistical discrimination. Each is considered.

## 2.1 Wage Differentials

Black-white wage differential studies have unanimously documented a narrowing of the wage gap between roughly the 1940s and 1980, at which time progress began to slow. Smith and Welch (1987) find that in 1940, the average black man earned 43% of the wages the average white man earned, and black women earned 40% of the average white woman's earnings. That gap had closed to 73% and 99% for men and women, respectively, by 1980. Like many other studies, they attribute the gains to additional years of schooling coupled with improved quality of schooling, migration from the rural south to northern cities, and affirmative action (though Smith (1993) later cites that blacks are only a minority of the 75% of the population protected by affirmative action, with women benefitting the most in terms of improved economic status and higher wages). They suggest that the halted progress is the result of the accelerated break-up of the American family, rising rates of black unemployment, a weak

attachment to the labor force among blacks, and a slow-down in American economic growth. This study explores whether there exists a potential difference in the rate at which whites and blacks are promoted, and if so, what role that difference contributes to the wage gap.

Ginther and Hayes (1999) use the Survey of Doctorate Recipients to examine gender salary and promotion differentials of academics in the humanities. They improve upon previous studies by controlling for productivity with measures including journal and book publications, in addition to demographic characteristics, primary work activity, and employer characteristics. An Oaxaca decomposition of the wage differential suggests that the earnings gap virtually disappears when estimated separately by for tenured and tenure-track faculty to account for the endogeneity of rank.

Long (1976) examines racial and gender differences in earnings and employment using the 1970 Census. Using standard earnings equation explanatory variables and productivity indicators, defined as years of education, experience, location, and work preferences, he estimates a black/white male earnings ratio of 75.8% and a female/male earnings ratio of 73.9%. Disaggregating the samples, he finds that the subset of 18-34 year old black men fare the best, as do single women. Both blacks and women (relative to whites and men, respectively) enjoy earnings ratios that are considerably larger in the federal sector than private. Contrary to Ginther and Hayes, Long concludes that a significant earnings gap exists even after controlling for productivity factors. Finally, Long esimates the probability of being employed in the federal sector and finds that blacks are more likely than whites, and women are less likely than men, which he attributes to the high concentration of black men, and low concentration of women, in the postal service. Ultimately, he concludes that discrimination against black men occurs in hiring or being promoted to well-paying positions, and that women have faced difficulty in being hired by the federal government, followed by modest rates of promotion and pay.

## 2.2 Promotions

The focus of most previous studies of promotions has been gender differences. They are generally conducted in the form of static logit regressions, where the occurrence of a promotion is explained by personal observable characteristics and other variables specific to the

employer or available data. Eberts and Stone (1985) estimate a multinomial logit regression using longitudinal data of public educators and determine that men are promoted at a faster rate than women initially (at the beginning of the 1970s) but that women enjoy significant gains throughout the decade as a result of the federal Title IX Equal Employment Opportunity legislation. They also find that more highly educated workers are more likely to be promoted and that promotion probabilities decline with experience for both men and women. Cannings (1988) analyzes managerial promotions within four of the 400 largest Canadian corporations. She finds that women, on average, receive 0.56 fewer promotions per year than men even when holding constant "career-relevant" factors. Thus, she concludes, women are promoted less often as the result of being born women. Jones and Makepeace (1996) find that the proportion of women who reach managerial ranks falls short of the fraction of men who, in reality, are promoted to such positions, even when women are "treated" the same as men. However, unlike Cannings' evidence that women face a "glass ceiling," they find that the differential treatment is minimal when compared to labor market characteristics, particularly experience.

Olson and Becker (1983) make use of the Quality of Employment Panel data to examine both wage and promotion differentials by gender. They theorize that discrimination need not manifest itself in the form of lower wages or promotion rates. Alternatively, women may be promoted as often as men, but the job level gain (and associated wage gain) from a promotion may be smaller than that of men. Similarly, women may be afforded fewer general and job specific training opportunities if the firm anticipates women are more likely to attrit.

The authors estimate a stay/leave equation, a promotion equation for those workers who choose to stay, and then use the selection-bias variables from these two equations in a wage regression to control for the possible correlation between promotions, attrition, and the error term. They find that women are less likely than men to be promoted, and conditional on having been promoted, women enjoy only a slightly (insignificant) larger wage gain than men. If women were held to the same promotion standard as men, nearly 32% would have been promoted rather than the observed 19%. Furthermore, a decomposition of the wage differential reveals that the observed 6% decline in the wage gap would have been roughly

9% if men and women were subject to the same promotion standards. The hypothesis that women and men are evaluated on the same basis, but that women are paid less when promoted, is rejected. Instead, Olson and Becker conclude that men and women face different promotion processes and that unequal access to opportunities is what constitutes the difference in employment outcomes. Worth noting is the fact that the authors do not have access to job level data but identify this as a source of discrimination. The data used in this study include the worker's position, or level within the salary grade hierarchy, and as a result, it is this avenue of discrimination that is considered.

Spurr (1990) focuses on the gender differential in promotion rates among lawyers. After controlling for school rank, academic achievement, location, and firm characteristics, both logistic and hazard results suggest that women are less likely to be promoted to partner than men. For both genders, the conditional hazard of leaving a firm peaks during or immediately after the probability of promotion reaches its maximum. Additionally, more years of experience increases the probability of being promoted, up to a certain point, after which the partnership is less likely. To examine the possibility that the reason women are promoted less frequently than men is because affirmative action only affects the hiring process, but not promotions, Spurr considers an attorney's law school rank and the probability of achieving honors while in school. Because the gender differential in both is statistically insignificant, he concludes that different rates of promotion cannot be attributed to affirmative action. Finally, Spurr uses the Yule Birth Process to determine whether women are held to a higher promotion standard. Though this method reveals no significant difference in productivity across gender, he finds that women are held to a promotion standard 56 to 72% higher than that of men. In sum, he finds evidence of discrimination in the promotion process to partnership, though cannot rule out the possibility that different levels of effort are exerted or that firms statistically discriminate against women due to a belief that they may leave.

Hersch and Viscusi (1996) consider how a woman's promotions may be related to having recently terminated her current employment to follow her husband to a new job. Regressing the number of promotions on various demographic characteristics and two mobility variables (moved for a better job and moved because of spousal relocation), they find that women are promoted more frequently, most likely the result of accepting a lower level job than she is

qualified for. Hersch and Viscusi also consider differences in promotion across races. They find that the negative impact of being white on the number of promotions is insignificant and likely the result of the extremely small number of blacks in the sample. The effect of the number of promotions on wages is half again as large for men as it is for women.

Killingsworth and Reimers (1983) estimate a logit regression of the probability that workers are assigned to a particular rank at a point in time. The results are then used to estimate the conditional (on the current period's rank) and unconditional likelihood of promotion. Using data on the civilian employees at a large U.S. Army base in the Southeast, they find that nonwhites tend to be employed in lower paid types of positions (blue collar "wage" versus white collar GS position) and lower paid levels within each type. Women are more likely to be in higher paid types of positions (white collar) but at lower paid levels. When these results are used to simulate promotion probabilities, they determine that more nonwhites would be employed in GS positions rather than "wage" (blue collar) jobs, whereas whites would be more likely to be in wage plans and lower GS positions. Furthermore, a larger percentage of nonwhites would be promoted out of GS 1-4 positions and into GS 7-9 or GS 11-16 if they were white, while a smaller percentage of whites would be promoted if they were nonwhite. Thus, Killingsworth and Reimers conclude that race is associated with both different ranking probabilities and different probabilities of change in rank.

Ginther and Hayes (1999) find that proportional hazard estimates of promotion differ by race and gender, even after controlling for productivity (journal and book publications), which is found to be an insignificant covariate. Based on this result, together with their wage analysis, they conclude that female academics in the humanities face a glass ceiling.

McCue (1996) deviates from traditional wage growth studies that examine workers not changing positions or those that change employers altogether. Instead, she considers internal mobility and uses a first differenced wage equation approach to estimate the contribution of promotions and other types of mobility to wage growth. She finds that excess wage growth from position changes contributes 9-18% of total wage growth during the first decade in the labor market. Wages grow most quickly for inexperienced workers. To examine the incidence of internal promotions (that she defines as categorization of a reported position change by respondents, ignoring measured wage changes), McCue estimates a hazard function where

workers are at risk of leaving their current position. Black men and women are less likely to leave their current positions than are white men and women. Higher wages, more education, and less labor market experience and job tenure are associated with an increased likelihood of internal moves.

## 2.3 Statistical Discrimination

Discrimination, in its most basic form, is said to exist if workers belonging to different (racial or gender) groups are otherwise observationally equivalent but treated differently by virtue of their race or gender, which alone does not directly affect productivity (Heckman, 1998). Darity and Mason (1998) offer a comprehensive summary of evidence suggesting that, while discrimination has declined in recent decades, largely as a result of the Civil Rights Act of 1964, it remains prevalent today. They cite pre-Civil Rights advertisements that explicitly discriminate against women and racial minorities in housing and employment. More recent wage disparity studies consistently document a statistically significant negative effect on earnings of being female and/or non-white.

Apart from taste-based discrimination, statistical discrimination is said to exist if two equally productive groups of workers are observed differently, where the individual productivity of members of one group is observed with more error than the other. As a result of uncertainty, employers estimate productivity to be a weighted sum of mean group and individual characteristics. More emphasis is placed on group characteristics for workers belonging to the group whose productivity is measured less accurately. Thus, seemingly high-(low)-productivity workers in the group whose signal is noisier earn less (more) than equally-productive members of the other group. Both groups receive the same average compensation, but equally-productive individuals belonging to the two groups are not compensated the same.

Fryer (2002) describes a dynamic model in which a firm's beliefs about the two groups of workers may flip. The group that is originally discriminated against in the hiring process will ultimately have more talent (the "talent effect"), on average, as a result of having faced a more stringent hiring standard. Thus, under certain conditions (simply, that the positive talent effect outweighs the negative "investment effect," whereby the discriminated

against group may under-invest in human capital as a result of the stricter hiring threshhold and/or the belief that promotions will likewise be difficult to achieve), it may be this group that is favored in the second-stage promotion process. As a result, some workers who face statistical discrimination in the hiring process may benefit in the form of a greater likelihood of promotion in stage two. It is unlikely, though, that the average group payoff from statistical discrimination will improve.

In a different theoretical approach, Oettinger (1996) and Goldsmith, Hamilton, and Darity (2006) develop a framework in which workers who are statistically discriminated against tend to benefit more by staying with a single firm and gaining experience, whereas favored groups experience larger wage gains by seeking and accepting better outside offers.

Particularly relevant to this research is Oettinger's (1996) consideration of the effect of statistical discrimination on early career evolution and the racial wage gap. He develops a 2-period model of statistical discrimination in which a firm imperfectly observes worker productivity, where the signal for a black worker is "noisier" than that of a white worker ($\sigma^2_{v,b} > \sigma^2_{v,w}$) Both individuals and firms learn a worker's true productivity after the first period, and employees are faced with the decision to stay or leave. The model predicts the absence of a black-white wage gap at labor force entry followed by the emergence of an earnings differential as experience accumulates, mostly because blacks enjoy smaller benefits from job mobility. Whites are expected to experience larger wage gains for leaving, whereas blacks receive more substantial gains for staying, thus a distinction between experience and tenure is necessary. His empirical work with the NLSY data provides support for some of the model's predictions.

Like Oettinger, Goldsmith et al. (2006) describe a "theory of ability misperception," characterized by two propositions: 1) employers reward nonwhites less than whites for previous experience as a result of an inaccurate belief that nonwhites acquire less knowledge from previous employment, and 2) employers learn about workers by observing them on the job and update their beliefs in such a way that the racial difference in the return to tenure is less than that of experience. When comparing white and black men from the Multi City Study of Urban Inequality, they find evidence of proposition 1 and week support of proposition

2. When the sub-samples of black and white men are further disaggregated into groups defined by job characteristics or other workplace settings, they find overwhelming support for both propositions. Robustness checks using samples of women and Latinos generally provide additional evidence of their theory of ability misperception, particularly in the context of different workplace settings. Their results are largely consistent with Oettinger's dynamic statistical discrimination hypotheses.

Other empirical studies of statistical discrimination have considered a variety of environments including the labor market (Lundberg and Startz, 1983), traffic stops (Knowles, Perisco, and Todd, 2001), mortgage lending (Berkovec, et. al., 1998), automobile purchases (Goldberg, 1996), as well as other consumer markets (Yinger, 1998).

# 3 Data Description

The data, provided by the NC OSP, contain basic demographic characteristics about every employee covered by the State Personnel Act, including information such as age, race, gender, and education level, as well as detailed job information each year the individual is employed with the state.[2] Perhaps most importantly, the data include job performance and promotion indicators not typically found in standard individual-level data sets.

Specifically, the state of North Carolina annually evaluates the performance of each of its employees. The worker's performance is measured on a 1-5 scale, where "1" indicates "unsatisfactory" and "5" represents "outstanding." Typically, each worker's performance is evaluated on either March 31 or June 30. This Performance Management System date is described as the "Effective Date of Performance Management System Rating," indicating that the evaluation refers to the worker's perceived performance during the previous year, and the salary and salary grade take effect as of the date reported (and are thus valid for the next period). More commonly-used economic data sets (such as the CPS or NLSY) randomly sample individuals who do not work for the same employer, thus making a uniform comparison of worker performance an impossibility.

[2]The complete list of variables includes: Person-Specific Identification Number, Position-specific Personnel Number, Position-Career Status Code, Position Manager-Supervisor Code, Employee Position-Career Status Code, Employee Manager-Supervisor Code, Standard Occupational Category Code, Sex, Age, Race, Federal EEO Category Description, Employee Job Title Code, Employee Job Title Description, 5-digit Budget Code, Handicap Status, University Budget Source, Employment Status, Performance Management System (PMS) Code, Effective Date of Performance Management System Rating, Department/Division Description, Education Level Required, Veteran Status, Employee Aggregate Service in Months as of End of Last Complete Month, Employee Grade, T-Grade Designation, Employee Step in Salary Range, Employee Annual Salary or Hourly Wage, Federal EEO Category Code, Employee Education Level, Race Description of Employee, Position Type, Appointment Type, Position Months Per Year, Employee's Date of Birth, Employee's Entry on Duty (EOD) Date, County Code Representing Location of Position, Filler, Account Filler, Account Object, Budget Code of Position, Responsibility Cost Center of Position, Position Fund Code, Position Object Code, Budgeted Salary of Position, Position FLSA Code, Employee FLSA Code, Last Personnel Action on Employee, Date of Last Employee Action, Position Job Title Code, Position Job Title, Position County Name, Employee's Longevity Payment Due Date, Employee Part-Time Hours, Position (or budgeted) Grade Level, Position Part-Time Hours.

Additionally, previous studies of this nature rely on arbitrary definitions of a promotion (demotion), generally characterized as a self-reported change in tasks or an unusually large increase (decrease) in earnings. According to the state of North Carolina, a worker is promoted (demoted) if his salary grade increases (decreases) and position-specific personnel number changes. The NC OSP data set used in this study also contains a variable detailing the worker's most recent personnel action, including a promotion (demotion) code. This variable, supplemented with a researcher-constructed indicator of promotion/demotion based on salary grade and personnel number, should reasonably accurately capture the realized promotions (demotions).

Of the 1,081,533 employment positions offered by the state over a ten year period (1994-2003), 114,060 are vacant positions, leaving 967,473 valid filled positions (in some cases, a worker may hold multiple jobs in a single year). Of those, 190,784 are unique individuals. 857 workers are dropped from the sample because they held multiple jobs with the state in at least one of the ten sample years. 25,422 workers are dropped due to age restrictions, 25,079 of which were less than 25 years of age when first observed, 22 had no age information available, and 321 had missing or invalid birthdates (from which age could not be calculated manually). 283 workers are excluded from the sample due to inconsistent reports of race, as well as the small sample (5,410 total) of the workers whose race is listed as "other" (American-Indian, Asian-American, Spanish-American, or "other"). 22 individuals have an equal number of male and female reports of gender. If the number of male and female codes is not equal, the gender most commonly-reported is used. 1,349 individuals are dropped because of education, 831 of whom have no education information, 374 workers are reported to experience a decrease in education, and the remaining 144 reportedly have a multi-level increase in education. 83,820 individuals are dropped due to invalid tenure data (unavailable in all employment years) or because tenure exceeds 12 months at the time the individual is first observed. In addition to missing or invalid demographic or socioeconomic data (age, gender, race, education), other unavailable independent variables that resulted in a worker being dropped from the sample include hourly wage earnings (7,162 individuals), EEO category (57 workers), and job location (eight individuals). Finally, 43,271 workers are eliminated due to missing dependent variables (salary grade and/or performance evaluation).

The sample used in estimation contains 23,123 unique black or white individuals, each with a valid set of dependent variables. The composition of individuals dropped based on the above exclusion restrictions is detailed in Appendix B.

Each year, an employee's continuous years of service with the state of North Carolina can be categorized as a one-year spell, a multi-year spell, the longest spell, and/or the first spell. The descriptive statistics provided in Appendix C make use of the worker's first spell with the state. Even if an employee has two spells during the 10-year time frame, or the first spell is not the longest, only one spell (the first) per worker is used in estimation. Tables C.1 - C.7 provide descriptive statistics of the final sample.

## 3.1 Descriptive Statistics

According to Table C.1, the average worker in the sample is 37 years old at the time of hire. Nearly 60% of the sample is female, and 70% is white. The average performance evaluation is more than four, representing better than "very good." 63% of the reported employment-year education levels involve more than a high school diploma. The average annual salary is slighly less than $30,000. Finally, the average length of first spells with the state is roughly three years, and more than 50% of the sample is employed in professional or office and clerical positions.

White men enjoy the greatest earnings, followed by white women. Black men and women earn roughly the same annual salary, which is approximately $4,000 less than white women. White women receive the most favorable performance evaluations, on average. Finally, there is little variation across race or gender in the rate at which promotions and demotions occur.

As Table C.3 depicts, the majority of all four demographic groups has earned a high school education, and whites, particularly white women, are most likely to bring to the labor market an advanced degree. White men and women are much more likely to be employed in professional positions, whereas blacks more frequently work in service and maintenance or as technicians. Men of both races are more likely to be employed in protective service and skilled craft, whereas women are much more likely to work in office and clerical positions.

One of the goals of this study is to analyze the way in which promotions happen within the state of North Carolina. Previous studies report that men are often observed to be promoted more frequently than women (Spurr, 1990; Jones and Makepeace, 1996; Cannings, 1988), and whites more often than blacks (Killingsworth and Reimers, 1983). Explaining these gaps is difficult, in part because data relevant to the prevalence of promotions is seldom available. This study makes use of an employer's perception of individual performance on the job, and one hypothesis is that workers may be under-placed at the onset of employment but later enjoy promotions in a sort of "catch up" effect. If that is the case, one would expect that blacks and women, most likely, would enjoy early promotions with potentially greater rewards. In order to unconditionally examine this possibility, Appendix Tables C.3 - C.5 describe a worker's initial placement with the state, information about the time of promotions, and the corresponding grade increases that accompany promotions.

Black men begin their employment spell with the state at the lowest salary grade, on average. They are assigned to a grade more than five levels below that of their white male counterparts. Though the vast majority of the sample is never promoted, and fewer still experience a demotion, the demographic group most frequently promoted in the second year of employment is black men. On the other hand, white men have the most amount of tenure at the time of the first promotion. Furthermore, black men enjoy the largest positive grade change, on average, when promoted. To be discussed in more detail later, these patterns are consistent with the possibility that the state may initially under-predict the ability and performance of blacks, but after observing them on the job, correct for this miscalculation by promoting them more often and with greater reward when promoted.

While most of the individuals in the sample ($\sim 95\%$) had one continuous employment spell between 1994 and 2003, consideration must be given to treatment of those who left the state and later returned during the ten-year period. As an alternative to using multiple spells for these individuals, either the first or longest spell seems most appropriate. In order to accurately capture the true distribution of unobserved heterogeneity, to be discussed in detail later, one approach is to use in estimation only individuals who are new state employees at the time they are first observed. Both entry date and aggregate months of service are available, so an accurate construction of tenure is possible. Thus, only those individuals who

have zero to twelve months of service when first observed are included in estimation, and only their first spell is utilized. Descriptive statistics of the sample's employment spells are detailed in Tables C.6 and C.7.

While the NC OSP data contain variables not found in standard economic data sets, the econometrician nonetheless faces empirical issues that must be dealt with. These include issues related to outside employment alternatives, the reported incidence of involuntary termination, candidate pool for potential hires, the worker's wage and outside earnings potential, the potential lack of supervisor information, and the specific nature of the data. Information regarding each of these, and efforts to deal with them, are presented in Appendix D.

# 4 Model

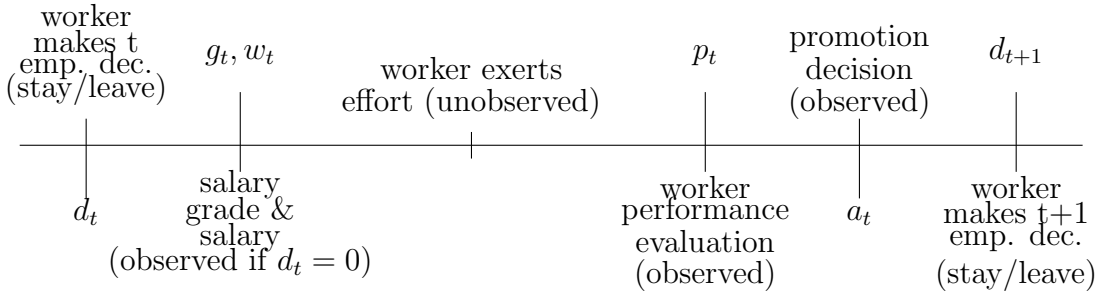
## 4.1 Dynamic Model of Labor Supply Decisions and Employment Outcomes

### 4.1.1 Introduction

The theoretical model is framed with data from the state of North Carolina in mind. That is, a snap shot of ten years of positions and their occupants (i.e. employees) is available. Information on an individual is known only when he is working with the state. While full spells with the state may be observed for a particular individual over the ten years, it is more common to have left- or right-censored spells. Slightly more than half (57%) of the estimation sample is observed to be working during the final year of available data. Furthermore, the sample used in this dissertation is restricted to tenure with the state of one year or less when first observed.

Conditional on having been hired, a worker makes the decision to continue working for the state or to leave ($d_t$) based on demographic characteristics and lagged variables, including whether or not he was promoted at the end of the previous period ($a_{t-1}$), how his work performance was evaluated ($p_{t-1}$), and his new wage ($w_t$) and salary grade offer ($g_t$). During each period, an employee exerts effort on the job. At the end of the period, the state assesses the worker's effort level in the form of a performance evaluation. With an evaluation of the individual's performance, the state decides whether or not to promote the worker. Since a promotion is defined as a simultaneous change in personnel number and increase in salary grade, once a promotion decision has been made, next period's salary grade and salary (within that salary grade) are announced. The employee uses all of this information to make his employment decision at the start of the next period.

Specifically, timing is as follows:




In this model, the individual makes two choices, whether or not to continue to work for the state and the level of effort to exert. The former is observed by the econometrician; the latter is not. Each decision depends upon exogenous variables and lagged or realized values of the endogenous variables. Conditional on choosing to continue working for the state, the terms of the employment contract are salary grade and salary, which are partly determined by employee characteristics such as education, performance, and tenure. The performance evaluation and promotion decision represent probabilistic outcomes that are influenced by employee behavior. Tenure with the state is defined by the employee's decision to stay or leave.

### 4.1.2 Per-Period Discrete Choices

At the beginning of the period, with knowledge of last period's performance evaluation and promotion outcome, as well as his current salary grade and wage offer, the worker decides whether or not to continue his employment with the state. In addition to his current employment outcomes, factors that influence the probability of terminating his tenure with the state include the unemployment rate, the presence of alternative job offers, and private sector wages. No distinction is made between full- and part-time employment; thus, two mutually-exclusive choices are available: $d_t = 0$ if he chooses to continue working for the state and $d_t = 1$ if he leaves.

Conditional on choosing to stay ($d_t = 0$), the worker is paid according to the salary grade and wage offers that were announced at the end of period $t - 1$, following his realized performance evaluation and promotion decision. At that point, the worker decides to exert some effort level, $f_t$. While this is not an outcome observed in the data, one would assume

the worker chooses his current work effort so as to maximize his current value of lifetime utility.

Both per-period decisions depend upon a set of variables that define a worker's employment history with the state. These "state" variables include lagged performance evaluation ($p_{t-1}$), last period's promotion decision ($a_{t-1}$), as well as current salary grade ($g_t$), salary ($w_t$), and current tenure ($x_t$). Since salary grades are directly tied to promotions, in that a promotion is defined as a change in personnel position number and an increase in salary grade, and wages are positively correlated with salary grades, it is reasonable to assume that when the worker makes her employment decision, he is made aware of his next-period earnings. Thus, the state vector at the beginning of period $t$ is

$$z_t = (p_{t-1}, a_{t-1}, g_t, w_t, x_t, X_t, Z_t) \ , \tag{4.1}$$

where $X_t$ is a vector containing exogenous individual demographic characteristics, and $Z_t$ contains exogenous market characteristics.

### 4.1.3 Performance Evaluation

At the end of the period, after the state has had the opportunity to observe an employee, his performance is formally evaluated. He receives a score of 1-5, where 1 represents "unsatisfactory" and 5 reflects "outstanding" performance on-the-job. The probability of earning a performance rating of $p$ in period $t$ is given by

$$\pi_t^p = P\left(p_t = p | p_{t-1}, a_{t-1}, f_t, x_t, X_t\right) \tag{4.2}$$

The vector, $X_t$, contains exogenous demographic characteristics that potentially affect a worker's performance evaluation, including race, gender, age, education level, and occupational assignment. Lagged performance evaluation is a determinant of current evaluation in that workers whose performance on the job was recognized last period as favorable, for instance, will likely continue to perform well, as within-firm upward mobility and promotions are likely tied to the way performance is perceived by one's supervisor. Last period's promotion decision presumably affects current performance. If a worker was promoted last

period, he is relatively new in his current position and may under-perform relative to another employee whose skills in that particular position are more developed to do well on the job. Finally, tenure with the state may also play a role in a worker's performance evaluation.

### 4.1.4 Promotion

After being observed and evaluated in the current position, the state makes a decision regarding whether or not to promote a worker. Those who provided more effort in period $t$, and who likely received better performance ratings, are the employees who are most likely to be moved to a higher ranking position. Thus, the probability of being promoted as the end of period $t$ nears is

$$\pi_t^a = P\left(a_t = a | p_t, a_{t-1}, f_t, x_t, X_t\right) \tag{4.3}$$

Last period's promotion decision affects the probability of being promoted in much the same way it affects current performance evaluation. Workers who recently enjoyed a promotion to a new position are not likely to be performing at such a high level that there is reason to promote them again. Rather, those who have done well at their current job and who would benefit (both personally, and the state) by moving to a more demanding position are likely the individuals who will be promoted this period.

An individual's length of time with the state is also likely to affect promotion decisions. Previous studies show that workers are most likely to be promoted early in their careers, so the longer someone is with the state, perhaps the less likely it is that they will be promoted. This may be due, in part, to sorting into positions that best suit both the worker and employer. Additionally, if the reliability of information in a worker's signal at the time of hire differs by race or gender, certain workers may be more likely to be promoted as the state has more time to observe them. Specifically, if the firm statistically discriminates against blacks at the time of hire due to a weak signal, it is those workers who may be promoted more frequently over time if the state is using performance evaluations to better its information about the worker's ability. Therefore, tenure with the state may influence

promotion decisions for all workers as they sort themselves into suitable matches, as well as differentially by race and/or gender as the state learns about workers.

### 4.1.5 Per-Period Utility and Budget Constraint

State employees are assumed to derive utility from consumption and effort exerted at work (the latter having a negative affect on utility). Demographic variables may also shift utility, which is denoted $U(C_t, f_t, X_t, \xi_t^f)$, where $\xi_t^f$ is a random error component that varies with time and effort level. In this simple model, savings is not considered, so consumption equals employment income. That is, $C_t = w_t(f_{t-1}, p_{t-1}, a_{t-1}, x_t, X_t)$.

### 4.1.6 The Optimization Problem

The problem each employee faces at the beginning of every period can be represented by a value function, in the form of Bellman equations. At the end of a period, the worker makes a decision regarding whether or not to work for the state in the next period. Conditional on choosing to stay, he exerts some unobserved (by the researcher) effort level. This effort is evaluated by his supervisor in the form of a 5-outcome performance evaluation at the end of period $t$. After evaluating a worker, the employer decides whether or not to promote him to a new position. If so, the worker is informed of a higher salary grade and wage offer, which subsequently affect his stay decision.

The value of choosing to continue to work for the state and exert effort level $f_t = f$ in period $t$ is

$$V_f^0(z_t, \xi_t^f) = U(C_t, f_t, X_t, \xi_t^f) + \beta \left[\Sigma_{p=1}^5 \Sigma_{a=0}^1 \pi_t^p \pi_t^a V(z_{t+1})\right], \ \forall t \ , \ \forall f \tag{4.4}$$

where $\beta$ is the discount rate and $V(z_{t+1})$ is the maximal value of future utility. The maximal value of lifetime utility at the start of period $t+1$ is the expected maximum between staying with the state or leaving. That is,

$$V(z_{t+1}) = E_t \left[\max V^0\left(z_{t+1}\right), V^1(z_{t+1})\right], \tag{4.5}$$

where the value of staying, unconditional on effort is

$$V^0(z_{t+1}) = E_t \left[ \max_{f'} V^0_{f'} \left( z_{t+1}, \xi^f_{t+1} \right) \right], \forall t, \tag{4.6}$$

and the value of leaving is

$$V^1(z_{t+1}) = g\left(x_{t+1}, X_{t+1}, Z_{t+1}\right) + u^d_{t+1} \tag{4.7}$$

The value of the non-state option (which does not distinguish between working elsewhere, being unemployed, or being out of the labor force) is approximated by the function $g(\cdot)$ that depends on total work experience, demographic characteristics, and exogenous employment market characteristics, $Z_t$. Total work experience equals tenure with the state, $x_t$, plus work experience prior to employment with the state.[3]

Hence, the probability of choosing to continue to work for the state in period $t+1$ is

$$\begin{aligned} P\left(d_{t+1}=0\right) &= P\left(V^0(z_{t+1}) > V^1(z_{t+1})\right) \\ & P\left(V^0\left(z_{t+1}\right) > \overline{V}^1\left(z_{t+1}\right) + u^d_{t+1}\right) \\ & P\left(u^d_{t+1} < V^0\left(z_{t+1}\right) - \overline{V}^1\left(z_{t+1}\right)\right) , \end{aligned} \tag{4.8}$$

where $\overline{V}^1(z_{t+1}) = g(x_{t+1}, X_{t+1}, Z_{t+1})$ is the deterministic component of $V^1(z_{t+1})$. Note that $V^0(z_{t+1})$ can be approximated by an $\mathrm{n}^{\mathrm{th}}$ order Taylor series expansion in the state variables.

## 4.2 Empirical Specification

The dynamic employment model suggests five outcomes of interest: salary grade, annual earnings, performance evaluation, the occurrence of a promotion, and the worker's decision to continue working for the state. The empirical specification of each is considered in turn. The particular nature of the data require small deviations from the theory above, and will be noted below.

[3]Because total experience is not available within the NC OSP data, it is treated as exogenous (and is included in $X_1$) for simplicity.

### 4.2.1 Salary Grade and Salary

At the beginning of a period, conditional on not having terminated the current employment spell, a worker's salary grade, $g_t$, and associated salary, $w_t$, are observed. Workers are paid according to the state's salary hierarchical structure, where salary grades range from 50-96. There is a monotonic relationship between salary and salary grade, detailed in Appendix Table G.2. However, because of the overlap of salaries across grades, modeling the outcomes for both variables is necessary.

Though salary grades are technically discrete values, the wide range (47 outcomes) allows for estimation as a continuous index. Thus, conditional on having decided to continue working for the state, salary grade is specified as

$$g_t = \delta_0 + \delta_1 X_t + \delta_2 g_{t-1} + \delta_3 w_{t-1} + \delta_4 p_{t-1} + \delta_5 a_{t-1} + \delta_6 x_t + u_t^g \ , \tag{4.9}$$

where $X_t = (r, f, c_t, ed_t, o_t)$ is a vector of demographic characteristics including race ($r$), gender ($f$), age ($c_t$), education level ($ed_t$), occupational category ($o_t$). The endogenous variables that influence salary grade determination, and whose specification is detailed below, include previous salary grade ($g_{t-1}$), previous salary ($w_{t-1}$), lagged performance evaluation ($p_{t-1}$), promotion history ($a_{t-1}$), and current tenure with the state ($x_t$). Also included are interactions involving these variables. The error term, $u_t^g$, represents unobservable information that determines grade and is explained in more detail later.

A worker's earnings level is positively correlated with salary grade. Once the salary grade has been assigned, a wage offer therein is presented to the employee.

$$w_t = \beta_0 + \beta_1 X_t + \beta_2 g_t + \beta_3 w_{t-1} + \beta_4 p_{t-1} + \beta_5 a_{t-1} + \beta_6 x_t + u_t^w \ , \tag{4.10}$$

where $X_t$ is defined as above. Current earnings are a function of, and determined after, current salary grade, so $g_t$ enters the wage equation rather than $g_{t-1}$. Variation in the natural log of earnings, rather than levels, is explained in estimation.

### 4.2.2 Performance Evaluation

After having observed a worker's performance on the job, the employee's supervisor conducts an evaluation at the end of the period. All workers are evaluated annually on a scale ranging from "unsatisfactory" ($p_t$=1) to "outstanding" ($p_t$=5). The probability of observing performance evaluation $m$ is given by

$$P(p_t = m) = \frac{exp\left\{\gamma_{0m} + \gamma_{1m}X_t + \gamma_{2m}g_t + \gamma_{3m}w_t + \gamma_{4m}p_{t-1} + \gamma_{5m}a_{t-1} + \gamma_{6m}x_t\right\}}{\sum_{m'=1}^{5} exp\left\{\gamma_{0m'} + \gamma_{1m'}X_t + \gamma_{2m'}g_t + \gamma_{3m'}w_t + \gamma_{4m'}p_{t-1} + \gamma_{5m'}a_{t-1} + \gamma_{6m'}x_t\right\}}, \tag{4.11}$$

where $m$ takes on values 1, ..., 5. As with earnings, according to the timeline defined above, current salary grade and current earnings influence performance ratings, rather than lagged values of these variables.[4]

### 4.2.3 Promotion

At the end of a period, after having observed the worker's performance in his current position, the state decides whether or not a worker should be promoted.[5] Many of the same variables that influence the other observed outcomes will affect which action the firm takes. One contribution this study makes to the empirical promotion literature is the inclusion of the worker's performance evaluation in the firm's promotion decision. Therefore, assuming a logistic error, $u_t^a$, the probability that the state agency chooses to promote the worker, $a_t = 1$, at the end of period $t$, is

$$P(a_t = 1) = \frac{exp\left\{\eta_0 + \eta_1 X_t + \eta_2 g_t + \eta_3 w_t + \eta_4 p_t + \eta_5 a_{t-1} + \eta_6 x_t\right\}}{1 + exp\left\{\eta_0 + \eta_1 X_t + \eta_2 g_t + \eta_3 w_t + \eta_4 p_t + \eta_5 a_{t-1} + \eta_6 x_t\right\}}, \tag{4.12}$$

where all variables are defined as above.

[4]Of the 62,057 observations, 31 performance evaluations are 1 ("unsatisfactory") and 330 are 2 ("below good"). As a result, only a 4-outcome model is estimated, where 1s and 2s are combined. Furthermore, while consideration was given to including all five levels of evaluation when used as an explanatory variable, that there are only 31 reports of unsatisfactory makes this an impossibility, and only four outcomes are included.

[5]The equation was originally estimated as a polychotomous outcome, where the state promoted, demoted, or made no change to the worker's status. However, of the 62,057 observed outcomes, only 429 (0.19%) reflect demotions. Thus, demotions are ignored in favor of a dichotomous outcome equation.

### 4.2.4 Tenure Decision

Finally, a worker's tenure is accumulated as he makes employment decisions each period. Theory suggests that, with his current wage offer, salary grade, and promotion decision in hand, an employee chooses to stay with the firm for one more year or quit in favor of a different alternative. Specifically, the probability of continuing to work for the state, $d_{t+1} = 1$, assuming a logistic error $u^d_{t+1}$, is given by equation 4.8,

$$\begin{aligned} P\left(d_{t+1}=0\right) &= P\left(u^d_{t+1} < V^0\left(z_{t+1}\right) - \overline{V}^1\left(z_{t+1}\right)\right) \\ &= P\left(u^d_{t+1} < V^0\left(z_{t+1}\right) - g\left(x_{t+1}, X_{t+1}, Z_{t+1}\right)\right) \end{aligned}$$

The right-hand side of the inequality is approximated by a Taylor series expansion of the observable variables at the beginning of period $t+1$, $(g_{t+1}, w_{t+1}, p_t, a_t, X_{t+1}, Z_{t+1})$, assuming $u_t$ has a logistic distribution. Thus,

$$P(d_{t+1}=1) = \frac{exp\left\{\tau_0 + \tau_1 X_t + \tau_2 g_t + \tau_3 w_t + \tau_4 p_t + \tau_5 a_t + \tau_6 x_t + \tau_7 Z_t\right\}}{1 + exp\left\{\tau_0 + \tau_1 X_t + \tau_2 g_t + \tau_3 w_t + \tau_4 p_t + \tau_5 a_t + \tau_6 x_t + \tau_7 Z_t\right\}} \quad (4.13)$$

Note that in the specification of Equation 4.13, all variables entering a worker's decision to stay or leave come from the current period. Specifically, $w_t$ and $g_t$ are used instead of $w_{t+1}$ and $g_{t+1}$, as wages and salary grade are only observed if the worker chooses to continue working for the state and are unavailable if they do not appear in the data in period $t+1$.

### 4.2.5 Unobserved Heterogeneity

Unobserved permanent or time-varying individual heterogeneity that influences one or more of the above outcomes reveals itself as correlation among the error components of each equation, $u^e_t$, for $e = g, w, p, a, d$. For example, highly motivated workers likely bring to the labor market a more enhanced set of human capital and thus are assigned higher salary grade and earn higher wages; they also probably perform better on the job and are rewarded in the form of better performance evaluations and promotions. This unobserved correlation between equations is an example of permanent individual heterogeneity.

Additionally, during the course of an individual's tenure with the state, unobserved, changing factors may influence observed decisions. For instance, an unobserved shock to one's health, or changes in family structure, such as the birth of a child (unobserved in the data) may influence a worker's employment choices for a temporary period of time. Alternatively, as workers sort themselves into positions within the state that improve the employer-employee match, their individual quit propensities may decline due to factors unobserved by the econometrician. These unobserved, changing factors are captured as a time-varying component of the error term.

Failure to model this correlation results in biased estimates of the marginal effects of these variables when they are used as explanatory variables in the dynamic employment process.[6] To model these unobservables, the error terms, $u_t^e$, are decomposed into a permanent individual heterogeneity component, $\mu$, a time-varying individual heterogeneity component, $\nu_t$, and an i.i.d. error, $\epsilon_t^e$, where

$$u_t^e = \rho_e \mu + \omega_e \nu_t + \epsilon_t^e \tag{4.14}$$

where the i.i.d. error is normally distributed, $\epsilon_t^e \sim N(0, \sigma_e^2)$ for continuous equations and logistic or extreme value distributed for logit and multinomial logit equations. The factor loadings on $\mu$ and $\nu_t$ are $\rho_e$ and $\omega_e$, respectively, and are parameters to be estimated in the empirical model. The probability weight on the $k^{th}$ support for a given factor is specified as a multinomial logit,

$$\psi_k = \frac{e^{\vartheta_k}}{\left(1 + \Sigma_{k=1}^{K-1} e^{\vartheta_k}\right)} \tag{4.15}$$

[6] In a slightly different context, Black, et al. (1990) test two hypotheses that attempt to explain the negative relationship between tenure at a firm and quit propensities: state dependence (i.e., the conditional quit rate for a group of workers declines with tenure because of a decrease in individual quit propensities over time) and heterogeneity (i.e., observationally equivalent workers have different quit propensities due to individual preferences, and the conditional quit rate declines over time as workers sort themselves into good worker-firm matches according to these preferences). They find that a model with a heterogeneity specification better predicts the observed outcomes than one without, which illustrates the need to control for unobserved characteristics.

for $K$ supports, where $\vartheta_k$ is the estimated parameter. The locations of the points of support, $\mu_k$, are constant across equations, bound by zero and one, and are estimated using logits,

$$\mu_k = \frac{e^{\varpi_k}}{(1 + e^{\varpi_k})}, \quad k = 2, \ldots, K-1 \tag{4.16}$$

where $\varpi_k$ is the parameter to be estimated. For identification, two points of support on each factor are fixed at values of zero and one. If the number of supports for a given factor is greater than two, the non-normalized points lie between zero and one. A differential effect of the unobserved heterogeneity in each equation is measured by the equation- and outcome-specific factor loadings on the unobserved heterogeneity mass points. The mass point locations $\nu_{\ell t}$, and the probabilities of each mass point, $\varrho_\ell$, for each of the $L$ mass points in the time-varying heterogeneity distribution are estimated analogously.

### 4.2.6 Initial Conditions

In addition to these five outcomes, initial conditions are introduced to the empirical specification. First, one goal of this study is to explore whether added information about a worker's on-the-job ability influences the way the state makes post-hiring decisions regarding wages, salary grade, promotions, and performance evaluations. Second, if, according to theory, salary grade, earnings, and performance evaluations are endogenous in the period $t > 1$ equations, then they are endogenous in the period $t = 1$ equations as well. That is, the period $t = 1$ values reflect the terms of the employment offer at the time of hire. The first period outcomes of salary grade and salary depend on the basic information available to the state at the time of hire (specifically, race, gender, age, and education). First period performance evaluation is also estimated differently from evaluations in subsequent periods because lagged performance evaluation is not available.

While a five-category measure of education is used in period $t > 1$ equations, the state has access to more detailed information about a new hire's education. Therefore, finely-defined educational dummies are used to identify the three initial conditions, salary grade, earnings, and performance evaluation. Since promotions are defined as an increase in salary grade relative to the previous period, it is not possible for individuals to observe a promotion

in their first year of employment. Additionally, it is assumed that the same current variables that affect the decision to stay in periods $t > 1$ also affect the first period decision. Thus, initial conditions for promotion and the decision to stay are not estimated. The three initial conditions are presumably affected by the same permanent individual heterogeneity that is included in subsequent periods, and it is thus included in estimation of the period $t = 1$ equations. A worker's initial salary grade is modeled continuously, as in later periods, and is specified in its reduced form as

$$g_1 = \varphi_0^1 + \varphi_1^1 X_1 + \varphi_2^1 E_1 + \rho_g \mu + \epsilon_1^g, \tag{4.17}$$

where $X_1 = (r, f, c_t)$ is a vector of demographic characteristics including only race $(r)$, gender $(f)$, and age $(c_t)$ at the time of hire. $E_1$ is a vector of education dummies observed by the state when the worker is hired and includes indicators for less than ninth grade, more than ninth grade but less than a high school diploma, high school plus one year, high school plus two years, high school plus three years, an associate's degree, a four-year college degree, a master's degree, and professional degree, including individuals employed as a Ph.D., dentist, medical doctor, or lawyer. The excluded category is a high school diploma.

First period earnings are also estimated as a continuous variable and defined in reduced form as

$$w_1 = \varphi_0^2 + \varphi_1^2 X_1 + \varphi_2^2 E_1 + \rho_w \mu + \epsilon_1^w, \tag{4.18}$$

where $X_1$ and $E_1$ are defined as in the salary grade equation.

Finally, the reduced form probability of receiving a performance rating of $m$ in the first period is given by

$$P(p_1 = m) = \frac{exp\left\{\varphi_{0m}^3 + \varphi_{1m}^3 X_1 + \varphi_{2m}^3 E_1 + \rho_{pm}\mu\right\}}{\sum_{m'=1}^{5} exp\left\{\varphi_{0m'}^3 + \varphi_{1m'}^3 X_1 + \varphi_{2m'}^3 E_1 + \rho_{pm'}\mu\right\}}, \quad \forall m = 1\ldots, 5. \tag{4.19}$$

All nine education variables (relative to a high school diploma) are statistically significant in the initial earnings and salary grade equations, and at a minimum, high school plus

three years, college, master's, and professional degree are statistically significant in the each of the three performance evaluation outcome equations.

The set of dynamic equations is estimated jointly to allow for the correlation across equations. No distributional assumption is imposed on the permanent and time-varying individual components. Rather, their distribution is estimated using the discrete factor random effects estimation method.[7] This method approximates the distribution of the permanent heterogeneity by a finite number of mass points, $\mu_k$, and their accompanying probability weights, $\psi_k, k = 1, \ldots, K$. Similarly, the distribution of time-varying heterogeneity is estimated with mass points, $\nu_{\ell t}$, and probability weights $\varrho_\ell, \ell = 1, \ldots, L$.

The likelihood function for individual $n$, which represents the probability of observing realized salary grade, annual earnings, performance evaluation, promotion decision, and choices of effort (assumed, for simplicity and without loss of generality, to be high effort ($f = 1$)or low effort ($f = 0$)) and continuation or termination of employment with the state, is given by

$$
\begin{aligned}
L_n\left(\Theta|\mu,\nu_t\right) \;=\; & \left\{\sum_{k=1}^{K}\psi_k\left(\phi_{g_1}(\cdot|\mu_k)\phi_{w_1}(\cdot|\mu_k)\prod_{m=0}^{3}Pr(p_1=m|\mu_k)^{\mathbf{1}(p_{n1}=m)}\right.\right. \\
& \cdot\prod_{j=0}^{1}Pr(a_1=j|\mu_k)^{\mathbf{1}(a_{n1}=j)}\prod_{q=0}^{1}Pr(d_1=q|\mu_k)^{\mathbf{1}(d_{n1}=q)} \\
& \left.\cdot\prod_{y=0}^{1}Pr(f_1=y|\mu_k)^{\mathbf{1}(f_1=y)}\right) \qquad (4.20) \\
& \cdot\prod_{t=2}^{T_n}\left[\sum_{\ell=1}^{L}\varrho_\ell\left(\phi_g(\cdot|\mu_k,\nu_{\ell t})\phi_w(\cdot|\mu_k,\nu_{\ell t})\prod_{m=0}^{3}Pr(p_t=m|\mu_k,\nu_{\ell t})^{\mathbf{1}(p_{nt}=m)}\right.\right. \\
& \cdot\prod_{j=0}^{1}Pr(a_t=j|\mu_k,\nu_{\ell t})^{\mathbf{1}(a_{nt}=j)}\prod_{q=0}^{1}Pr(d_t=q|\mu_k,\nu_{\ell t})^{\mathbf{1}(d_{nt}=q)} \\
& \left.\left.\cdot\prod_{y=0}^{1}Pr(f_t=y|\mu_k,\nu_{\ell t})^{\mathbf{1}(f_{nt}=y)}\right)\right]\Bigg\},
\end{aligned}
$$

where $\Theta$ is the vector of parameters to be estimated, $\Theta = (\delta, \beta, \gamma, \nu, \tau, \varphi, \rho_e, \omega_e, \psi, \Theta)$, with $\varphi = (\varphi^1, \varphi^2, \varphi^3)$ representing the vector of coefficients from the initial conditions, and $\phi_g(\cdot)$ and $\phi_w(\cdot)$ are continuous density functions. The likelihood function for a sample of N workers

[7] See Heckman and Singer (1984), Mroz and Guilkey (1992), and Mroz (1999).

is

$$L_n(\Theta) = \prod_{n=1}^{N} L_n(\Theta) \ . \tag{4.21}$$

### 4.2.7 Identification

Identification in the current model comes from variation in a number of sources. First, Bhargava and Sargan (1983) and Arellano and Bond (1991) argue that in estimation of dynamic models using panel data, identification rests on the availability of exogenous variables conditional on unobservable individual effects. In the present context, exogenous variation comes from private sector wages, percentage of job vacancies in the state, and unemployment rates. Furthermore, lagged endogenous variables enter each of the five equations in the system and aid in identification since controlling for unobserved individual heterogeneity removes serial correlation from the errors. In addition, interactions of lagged variables with exogenous variables, as well as other lags, are present in every equation. Second, the non-linear functional form of several equations further assists in identification. Finally, the three initial conditions are estimated using nine education dummy variables which are excluded from the time $t > 1$ equations.

## 4.3 Statistical Discrimination Model

### 4.3.1 Static Statistical Discrimination Model

In addition to allowing for a formal model of wage determination that accurately controls for promotions, performance on the job, and unobserved heterogeneity, the data used in this study provide an opportunity to explore whether gender and racial differentials can be explained by something other than an employer's distaste for employing certain workers. Specifically, the early statistical discrimination literature suggests a simple test of the existence of such discrimination. Before evaluating results of the full five-equation model specified above, this test of statistical discrimination will be described and conducted as a preliminary exploration of what evidence exists to support the notion that the portion of a

wage differential not captured by explanatory variables may not necessarily be attributed to taste discrimination.

A formal model of statistical discrimination, first developed by Phelps (1972), Arrow (1973), and Aigner and Cain (1977), and subsequently expanded and tested in a variety of contexts,[8] is used as the starting point here. The basic static model assumes that firms do not observe a worker's true productivity, $\alpha$. Instead, a noisy signal, $s$, is observed, where

$$s = \alpha + v. \tag{4.22}$$

True productivity, $\alpha$, is assumed to be normally distributed with mean $m$ and variance $\sigma_\alpha^2$, i.e., $\alpha \sim N(m, \sigma_\alpha^2)$. Suppose initially that different groups of workers are equally productive, on average. Independent of $\alpha$, $v$ is normally distributed, $v \sim N(0, \sigma_v^2)$. A signal of the worker's productivity may consist of a single observable measure such as a test score, but more realistically may be multi-dimensional and include information conveyed on a resumé (education level, job market experience), as well as worker characteristics observed by a firm during an interview (gender, race, age).

The model of statistical discrimination rests on the assumption that a black worker may send an employer a noisier signal than a white worker, i.e. $\sigma_{v,b}^2 > \sigma_{v,w}^2$. One argument justifying this claim involves the sociological observation that workers belonging to different groups are more likely to miscommunicate than workers in the same group (Lang, 1986). Suppose, for instance, that a firm employs predominantly white managers. A black job applicant may have a more difficult time communicating his ability to a potential supervisor than would a white applicant. The white manager may then rely on past experiences with black subordinates to compensate for the communication, and thus, information, gap. Relative to a white job candidate, the manager may place added emphasis on what he has observed in previous black employees and less on this particular individual's signal. A second explanation for the existence of statistical discrimination is that white workers more frequently network for jobs using personal contacts, a method which allows for the acquisition of additional information about the quality of a candidate by the firm (Holzer, 1987).

[8] See Knowles, Perisco, and Todd, 2001, as one example.

A firm making a hiring, wage, or promotion decision, observing only a worker's signal, uses that information to predict the employee's unobserved productivity.[9] The expected value of a worker's ability, given his signal, is

$$\hat{\alpha} = E(\alpha|s) \quad = \quad (1-\lambda^2)m + \lambda^2 s, \tag{4.23}$$

where

$$\lambda^2 \quad = \quad \frac{\sigma_\alpha^2}{\sigma_\alpha^2 + \sigma_v^2} \tag{4.24}$$

is the square of the correlation coefficient between the signal and the true productivity and measures the reliability of the signal. In this basic static framework, the presence of statistical discrimination, $\sigma_{v,b}^2 > \sigma_{v,w}^2$, suggests that the state will place more emphasis on average group performance than an individual's personal signal if the worker is black, per equation 4.23. This conditional expectation reveals itself in the wage determination process, assuming firms pay workers according to their expected marginal productivity (i.e., $w = \hat{\alpha} = E(\alpha|s)$).[10] If average productivity, $m$, is identical across groups, all workers will receive the same earnings. If $m$ differs across groups, a wage differential will necessarily exist.

One would imagine, however, that as the state observes a worker's productivity, the employer is able to update his beliefs about the worker's ability using both the employee's signal and previous evaluations of his performance on the job. Thus, given the availability of data that reflect on-the-job performance, a dynamic model of statistical discrimination is considered in which the firm observes a simple signal at the time of hire, and adds to that information observations of a worker's performance as tenure is accrued.

### 4.3.2 Dynamic Statistical Discrimination Model

Consider now a dynamic framework. As in the static model, at the beginning of the first period, neither the worker or the firm knows the worker's productivity. The firm, however,

[9] The terms 'skill,' 'ability,' and 'productivity' will be used synonymously here.

[10] Oettinger assumes workers are paid a weighted average of expected marginal productivity and piece rate wages. This specification produces the same average wage ($m$) but is not used here because of the nature of the data used in estimation, whereby workers are almost certainly not paid piece rate wages.

receives a noisy signal about the worker's skill, where

$$s_t = \alpha + v_t \ . \tag{4.25}$$

Consistent with the static model, $\alpha \sim N(m, \sigma_\alpha^2)$, and independent of $\alpha$, $v \sim N(0, \sigma_v^2)$ and is i.i.d. The worker's (unconditional and conditional (on $\alpha$)) signal is distributed normally, where

$$s \sim N(m, \sigma_\alpha^2 + \sigma_v^2) \tag{4.26}$$

$$s|\alpha \sim N(\alpha, \sigma_v^2) \ . \tag{4.27}$$

At the beginning of the first period, the state's beliefs about a worker's ability can only be conditioned on the first observed signal. That is,

$$\alpha|s \sim N\left((1-\lambda^2)m + \lambda^2 s, \sigma_\alpha^2(1-\lambda^2)\right), \tag{4.28}$$

where $\lambda$ is defined as in Equation 4.24.[11]

At the end of the first period (and at the end of every subsequent employment year), the state evaluates the worker's performance in his current position. Like a worker's signal, observed performance, $p_t$, is also a noisy measure of the worker's true ability. Thus,

$$p_t = \alpha + \kappa_t, \tag{4.29}$$

where, independent of $\alpha$, $\kappa \sim N(0, \sigma_\kappa^2)$. Similar to a worker's signal, performance evaluation is distributed normally, both conditionally and unconditionally.

$$p \sim N(m, \sigma_\alpha^2 + \sigma_\kappa^2) \tag{4.30}$$

$$p|\alpha \sim N(\alpha, \sigma_\kappa^2) \ . \tag{4.31}$$

[11] See Appendix E for full derivation of these results.

Additionally, given that $\alpha$ and $v$ are uncorrelated, as are $\alpha$ and $\kappa$, it must be the case that $s$ and $p$ are orthogonal, conditional on $\alpha$.

At the beginning of the next period, after evaluating a worker's performance, the state updates its beliefs about a worker's ability by conditioning on both the current signal and last period's performance evaluation.[12] Using Bayes' Rule, it can be shown that, conditional on both the signal and previous evaluation, the variance of worker ability is[13]

$$\text{var}(\alpha|s,p) = \frac{\sigma_\alpha^2\sigma_v^2\sigma_\kappa^2}{\sigma_s^2\sigma_p^2 - \sigma_\alpha^4} \ . \tag{4.32}$$

Comparing the period two prior (period one posterior) belief about the variance of ability to the period one prior information, it is clear that the additional information about a worker's performance decreases the conditional variance of ability. Specifically, $\text{var}(\alpha|s,p) < \text{var}(\alpha|s)$ if

$$\begin{aligned} \frac{\sigma_\alpha^2\sigma_v^2\sigma_\kappa^2}{\sigma_s^2\sigma_p^2 - \sigma_\alpha^4} &< \sigma_\alpha^2(1-\lambda^2), \\ \text{or } \frac{\sigma_\alpha^2\sigma_v^2\sigma_\kappa^2}{\sigma_s^2\sigma_p^2 - \sigma_\alpha^4} &< \frac{\sigma_\alpha^2\sigma_v^2}{\sigma_\alpha^2+\sigma_v^2} \\ 0 &< \sigma_\alpha^4\sigma_v^4 \end{aligned} \tag{4.33}$$

Since $\sigma_\alpha^4\sigma_v^4$ is always positive, the conditional variance of ability will decrease with the addition of new information (the worker's performance evaluation) each period. The posterior information at the end of period $t$ will become the prior belief of the state at the beginning of period $t+1$. As a worker's tenure with the state increases, beliefs about ability will evolve in this manner according to Bayes' Rule.

[12]For examples of Bayesian updating in models with dynamic learning, see Crawford and Shum (2005), Hamilton and Chan (2005), and Mira (2005).

[13]For probability density function, $f(\cdot)$, $f\left(\alpha|s,p\right) = \frac{f(\alpha)f(s,p|\alpha)}{f(s,p)} = \frac{f(\alpha,s,p)}{f(s,p)}$ since, by Bayes Rule, $f(s,p|\alpha) = \frac{f(\alpha,s,p)}{f(\alpha)}$. Like $\alpha|s$, the derivation of $E(\alpha|s,p)$ and $var(\alpha|s,p)$ can be found in Appendix E.

In addition to examining the evolution of the conditional variance of ability, the state's conditional expectation of ability will yield information regarding how changing beliefs influence wage, promotion, performance evaluation, and promotion decisions, as reflected in the equations estimated in the model. Specifically, the posterior mean of ability (conditioned on both the original signal and the worker's performance evaluation) will be larger than the prior (conditioned on only the signal) if the following is true:

$$\frac{p\sigma_\alpha^2\sigma_v^2 + m\sigma_\kappa^2\sigma_v^2 + s\sigma_\alpha^2\sigma_\kappa^2}{\sigma_s^2\sigma_p^2 - \sigma_\alpha^4} > (1-\lambda^2)m + \lambda^2 s,$$

$$\text{or} \quad \frac{p\sigma_\alpha^2\sigma_v^2 + m\sigma_\kappa^2\sigma_v^2 + s\sigma_\alpha^2\sigma_\kappa^2}{\sigma_s^2\sigma_p^2 - \sigma_\alpha^4} > \frac{m\sigma_v^2 + s\sigma_\alpha^2}{\sigma_\alpha^2 + \sigma_v^2},$$

which can be shown to simplify to

$$(p-s)\sigma_\alpha^2 > (m-p)\sigma_v^2 \,. \tag{4.34}$$

While nothing definitive can be said about the theoretical relationships between $p$ and $s$ or between $m$ and $p$, one can conclude that the larger is the variance of the signal error ($\sigma_v^2$), ceteris paribus, the more likely it is that the posterior belief about ability will exceed the prior. In fact, one may even assume that $p$, $s$, $\sigma_\alpha^2$, and $m$ do not differ by race. Thus, since the underlying statistical discrimination assumption is that $\sigma_{v,b}^2 > \sigma_{v,w}^2$, this result suggests that blacks are more likely than whites to benefit from the added information. This is consistent with the conclusions drawn by Oettinger (1996) and Goldsmith, et al. (2006), who suggest that black workers benefit from continuing to work for their present employer, while whites can often better themselves by seeking outside wage offers.

By allowing the state's expectation of a worker's productivity in a potentially new position to be conditioned on his current signal *and* known (perceived) performance in previous periods, Bayesian updating describes how the state's productivity beliefs evolve. If the state is observed to statistically discriminate, one might expect more favorable outcomes for a discriminated against worker as his tenure with the state increases, as the new information increases the state's expectation of a worker's ability the larger is the original signal variance.

As this new information is used in future employment decisions, a black worker or woman should be observed to be more likely to experience outcomes which are positively correlated with expected ability.

### 4.3.3 Empirical Test of Statistical Discrimination

Aigner and Cain (1977) describe an empirical test of statistical discrimination, whereby performance evaluation is regressed on individual and group characteristics. This procedure is possible using data from the state of North Carolina because of the inclusion of annual performance evaluation. Specifically, the state's estimate of worker ability, $\hat{\alpha}$ can be thought of as a least squares prediction, where the worker's productivity is expressed in terms of a group effect, $(1-\lambda^2)m$, an individual effect, $\lambda^2 s$, and an error term, $\varepsilon$. That is,

$$\alpha \;=\; (1-\lambda^2)m + \lambda^2 s + \varepsilon \;. \tag{4.35}$$

This equation is estimable if a worker's end-of-period performance evaluation, for example, is treated as a measure of ability and is regressed upon individual characteristics, including group (race or gender), $X_t$.[14] That is,

$$p_t \;=\; (1-\lambda_{pt}^2)m + \lambda_{pt}^2 X_t + \varepsilon_t^p, \tag{4.36}$$

Different signal error variances across groups support there being evidence of statistical discrimination.[15] Since $\sigma_\kappa^2$ is imbedded in $\lambda_p^2$ (analogous to equation 4.24), if equation 4.36 is estimated separately for two groups, different $\lambda_p^2$s imply differences in either the variance of the signal error ($\sigma_\kappa^2$) or the variance of the group's productivity ($\sigma_\alpha^2$). Specifically, consider estimating equation 4.36 separately for blacks and whites (or males and females) such that

[14]Note that here the performance evaluation equation is specified as an OLS regression, but may also be estimated using multinomial logit. For the purposes of testing for statistical discrimination, OLS is used.

[15]Here, signal refers to the worker's performance evaluation, according to the test proposed by the authors, but will also be conducted using beginning-of-period wages to reflect the state's expectation of productivity before observing the worker.

$$p_w = (1-\lambda_{pw}^2)m_w + \lambda_{pw}^2 X_{pw} + \varepsilon_w \tag{4.37a}$$

$$p_b = (1-\lambda_{pb}^2)m_b + \lambda_{pb}^2 X_{pb} + \varepsilon_b \tag{4.37b}$$

Here, the "group effect," $(1-\lambda^2)m$, is simply the constant term. From that parameter estimate, $\lambda^2$ can be extracted, and conclusions can be drawn regarding $\sigma_\kappa^2$ and $\sigma_\alpha^2$.

The individual component, $X_t$, consists of the employee's race ($r$), gender ($f$), age ($c_t$), education level ($ed_t$), occupational category ($o_t$), and months of tenure at the time of evaluation ($x_t$) when estimated in the first period of employment to determine whether the state statistically discriminates before beginning to learn about a worker's performance.

# 5 Results

## 5.1 OLS Results of Testing for Statistical Discrimination

Before addressing results from the jointly estimated set of equations described in section 4.2, a preliminary test of statistical discrimination is conducted, as described in Section 4.3.3, to determine if there is evidence supporting the presence of statistical discrimination. Specifically, suppose equation 4.36 is estimated separately for blacks and whites (or males and females), where

$$\begin{aligned} p_w &= (1-\lambda_{pw}^2)m_w + \lambda_{pw}^2 X_{pw} + \varepsilon_w \\ p_b &= (1-\lambda_{pb}^2)m_b + \lambda_{pb}^2 X_{pb} + \varepsilon_b \ . \end{aligned}$$

Theory predicts that a finding where $\lambda_{pw}^2 \neq \lambda_{pb}^2$ suggests that either $\text{var}(\alpha^b) \neq \text{var}(\alpha^w)$ or $\text{var}(\kappa^b) \neq \text{var}(\kappa^w)$, though it may not be possible to identify the source of the variation in signal quality.

The inclusion of a worker's performance evaluation in this data set allows for estimation that was only previously a theoretical possibility. Because workers are evaluated after current-period salary grade and wages are determined and after the worker has been observed, this equation can be thought of as end-of-period. One would expect that performance evaluations would reflect the updating of information on the part of the state, seen as a reduction in the difference between the signal error variances across groups if certain workers are, in fact, statistically discriminated against.

At the beginning of a period, however, before having observed workers, signal error variances would differ if the state has less information about a particular group. Therefore, if employees are paid according to their expected marginal productivity, earnings can also be regressed on a group effect and an individual effect, where the same interpretation of

the group effect is possible. The results of the earnings equation should provide additional information about the practice of statistical discrimination, as the worker has not yet been observed when the state makes initial predictions about his ability.

In practice, then, the test of statistical discrimination described by Aigner and Cain (1977) involves estimation of a beginning-of-period earnings equation and an end-of-period performance evaluation equation. Both are regressed separately for blacks and whites, and for men and women. The included covariates are standard wage equation variables: female or black indicators, education, occupation, age, tenure, year dummies, interactions, and specific to this framework, salary grade ("basic signal"). Should statistical discrimination exit, to test whether or not the signal differential at the beginning of the period diminishes as a worker continues to be observed, earnings and performance evaluations are also estimated with lagged performance evaluation included as an independent variable ("updated signal"). Each of the independent variables is measured as the deviation from the variable mean.

The "group effect," $(1-\lambda^2)m$, when estimated separately, is the regression constant. If $E(\alpha) = m$, where empirically $\alpha$ is earnings or performance evaluation, a vector containing the average of the dependent variable can be included rather than a vector of ones. Then, the slope on the constant (in this case, the group mean of the dependent variable in question) is (1-$\lambda^2$), from which $\lambda^2$ can be calculated. Estimates of the constants in separate OLS regressions of both performance evaluation and earnings, by race and gender, in the worker's first year of employment, are reported in Table 5.1:

Table 5.1: Test of Equal Signal Quality Across Groups: First Employment Year

| | Annual Earnings | | | | Performance Evaluation | | | |
|---|---|---|---|---|---|---|---|---|
| | Avg. ln(Salary) (s.d.) | Constant (s.e.) | $\lambda^2$ | z | Avg. Eval. (1-5) (s.d.) | Constant (s.e.) | $\lambda^2$ | z |
| Whites | 10.156 (0.345) | 0.711 (0.003) | 0.289 | -2.512 | 3.004 (0.707) | 0.151 (0.088) | 0.849 | 1.051 |
| Blacks | 9.961 (0.288) | 0.725 (0.005) | 0.275 | | 2.697 (0.691) | -0.031 (0.149) | 1.031 | |
| Men | 10.150 (0.342) | 0.723 (0.003) | 0.277 | 5.333 | 2.843 (0.702) | -0.209 (0.133) | 1.209 | -2.904 |
| Women | 10.055 (0.334) | 0.698 (0.004) | 0.302 | | 2.961 (0.723) | 0.265 (0.094) | 0.735 | |

In the beginning-of-period earnings equations, z-scores reject the null hypothesis of equal signal qualities across both race and gender in the first period of employment. By the end of the first period, the state has observed and evaluated the worker's performance, and tests of equal signal quality do not provide evidence of statistical discrimination against blacks (the difference between men and women still holds). This suggests that, at the time of hire when a wage decision is made, the state may have different information about black and white workers, but that information disparity seems to have disappeared after observing workers. Because performance evaluations of one ("unsatisfactory") and two ("below good") are rarely given, consideration must be given to the fact that, even in the presence of "noisy" information about blacks, the gap may not be reflected in the form of a poor performance evaluation.

To further investigate whether statistical discrimination has disappeared completely by the end of the first year of employment, this same test is conducted for all levels of tenure with the state. Table 5.3 reports the z-statistics for each both genders and races, across time, for both earnings and performance evaluation.

Table 5.2: Statistical Discrimination Test: Updated Signal

| | Race | | Gender | |
|---|---|---|---|---|
| | Earnings | Evaluation | Earnings | Evaluation |
| 1 Year | -2.512 | 1.051 | 5.333 | -2.904 |
| 2 Years | -8.331 | -2.029 | 0.229 | -0.565 |
| 3 Years | -3.299 | 0.238 | 1.662 | 0.107 |
| 4 Years | -3.666 | -0.093 | 0.542 | 0.255 |
| 5 Years | -1.069 | -1.554 | 0.762 | 0.875 |
| 6 Years | -3.253 | -1.215 | -0.408 | -0.354 |
| 7 Years | -1.722 | -0.770 | 0.902 | 1.305 |
| 8 Years | -0.838 | -0.836 | 0.358 | -2.959 |
| 9 Years | -1.703 | -0.890 | 0.632 | 0.308 |
| 10 Years | -1.536 | -1.201 | -0.653 | -0.001 |

Note
The numbers reported in this table represent z-scores from a test of the null hypothesis that $\lambda$ does not differ by group.

Results indicate that the information disparity across races persists in wages through at least the first four years of employment with the state, despite there being no evidence of it in performance evaluations.[16] This conclusion is consistent with the hypothesis that "learning" takes place as the employer observes workers through annual performance evaluations. Contrary to the results for whites and blacks, there exists no consistent pattern of statistical discrimination for men and women. The first year of employment reveals a statistically significant difference in signal quality, but not thereafter.

Table 5.3 reveals that even when a worker's performance evaluation is excluded from the wage and performance evaluation equations, thereby removing the vehicle through which learning takes place, the patterns persist. There is a statistically significant difference in signal quality across race at the beginning of the period for the first several years, but this disparity is not present in the end-of-period measure. With regard to gender, more periods reflect a difference in signal quality in earnings, though the results are somewhat scattered, and no significant differences exist in performance evaluations.

As suggested, an employer who has the opportunity to observe and formally evaluate a worker will presumably use this information about an individual's performance on the job when making future promotion, wage, etc. decisions. Thus, to measure performance evaluations and wages in reduced form, and without controls for previous outcomes (namely current salary grade, and in later periods, current or lagged salary, promotion history, tenure with the state, and lagged performance evaluations), will result in biased estimated coefficients due to omitted variable bias. As such, in order to accurately test for the existence of statistical discrimination, the five equations must be estimated jointly to allow the endogenous variables to enter as explanatory variables that may be correlated with the error terms (and to model that error correlation).

[16]It has been noted that the statistically significantly different $\lambda^2$'s in early years may be due to sample size. Specifically, 23,123 workers are observed in the first employment year, but this number decreases to 702 by year ten, where as few as 213 observations are used in the equations for blacks in year 10. However, if the results are due entirely to large sample sizes at early points of tenure, one would expect similar patterns across equations and demographic groups. Alternatively, the result may be driven by selection given that modeling of the tenure (stay/leave) decision is not incorporated.

Table 5.3: Statistical Discrimination Test: Basic Signal

| | Race | | Gender | |
|---|---|---|---|---|
| | Earnings | Evaluation | Earnings | Evaluation |
| 1 Year | -2.512 | 0.997 | 5.333 | -0.176 |
| 2 Years | -2.204 | -2.278 | 1.482 | -0.447 |
| 3 Years | -2.312 | -2.295 | 3.026 | 0.420 |
| 4 Years | -2.140 | -1.100 | 2.020 | 0.995 |
| 5 Years | -1.712 | -0.822 | 1.721 | 1.009 |
| 6 Years | -1.838 | -1.632 | 1.285 | 1.970 |
| 7 Years | -2.061 | -1.673 | 0.752 | 0.813 |
| 8 Years | -2.540 | -1.581 | 0.554 | -0.284 |
| 9 Years | -3.482 | -0.137 | 0.634 | -1.051 |
| 10 Years | -2.544 | -0.825 | -0.701 | -0.251 |

Note
The numbers reported in this table represent z-scores from a test of the null hypothesis that $\lambda$ does not differ by group.

## 5.2 Results of Five-Equation Model with Controls for Unobserved Heterogeneity

As described above, the full empirical model estimates five equations: salary grade, earnings, performance evaluation, the probability of being promoted, and the decision to stay with the state or leave. While no general rule exists for determining the exact number of points of support for each type of heterogeneity, the final specification is chosen based on the value of the likelihood function and the significance of the heterogeneity coefficients. The final specification contains both permanent and time-varying unobserved individual heterogeneity involving a permanent factor with two points of support and a time-varying factor with two points of support. Results controlling for heterogeneity are reported in Appendix Table F.1-F.2. Additionally, results from estimation of the five equations separately (i.e. not correlated by permanent or time-varying unobserved individual heterogeneity) are similarly found in Appendix Table F.3-F.4.

## 5.3 Analysis of Estimates

Of primary interest in this study is the influence performance evaluations and promotions have on racial and gender wage differentials. After controlling for both of these variables, the "effect" of being black and/or female effectively disappears.[17] A higher current salary grade, more favorable performance evaluations, and having been promoted last period are positively correlated with earnings. Last period's salary is the strongest determinant of current salary.

If an employer statistically discriminates against blacks or women, one would expect that observing the worker over time would allow for learning and the reduction or elimination of ability misperceptions the employer has about these workers. That is, it would seem that as tenure increases, being black or female should influence wages to a lesser degree. In the earnings equations, these predictions hold in the form of small, insignificant coefficients on interactions of tenure with race and gender. The coefficients that capture the effect of tenure for blacks and women are not significantly different from zero, suggesting that as a worker's tenure with the state increases, being black or female has no effect on earnings.

A more comprehensive approach to testing for the presence of statistical discrimination involves interacting a worker's signal at hire with his race and gender and seeing how this changes over time. If statistical discrimination exists, the signal will become less influential in the determination of wages as the marginalized worker's tenure with the state increases. Specifically, in addition to race and gender, one signal employers have at the time of hire is information about a worker's education. While important before observing the worker, this information should be less valuable in an employer's future decisions regarding such outcomes as earnings and salary grade. Thus, the preferred model is estimated with the addition of four-way interactions between race, gender, education, and tenure. The full results of this model are found in Appendix Table F.5.

The race, gender, and tenure interactions remain insignificant, as are all of the new interactions. With regard to statistical discrimination, the coefficients on the interactions of race and gender with education (but not tenure) in the earnings equation are negative.

[17] Specifically, the total effect of being black and/or female (taking into account the linear dummy variables as well as their interactions with tenure, performance evaluation, etc) on ln(annual earnings) ranges from -0.00428 for white women to -0.00114 for black women, which translates to a difference of $35 to $133, compared to the average salary of white men.

This provides some evidence that, at the time of hire, when tenure is zero, the signal sent by blacks and women negatively affects earnings, if at all (recall that the coefficient is not significantly different from zero). Then, as tenure increases, the effect of education shrinks, as one would expect if the employer is observing and learning about the worker firsthand. Therefore, though all of the coefficient are insignificant, if anything is to be taken from the signs and magnitudes of the interaction coefficients, it is that the results are consistent with the existence of statistical discrimination against blacks and women at the time of hire. Because of the insignificance of all of these variables in determining wages, and because a study of wage differentials does not call for their inclusion, the preferred model does not include these variables, and the remaining analysis will be on the more simple specification found in Table F.1.

Because salaries are driven by, and highly correlated with, salary grade, and because being assigned to a higher salary grade is positively and significantly associated with higher earnings, the determinants of salary grade are important in understanding variables that indirectly affect earnings. Furthermore, perhaps learning that takes place on the part of the state manifests itself through other mechanisms such as salary grade determination, performance evaluations, and promotions.

Controlling for performance evaluation and promotion and jointly estimating to model possible correlation with unobservables, this model predicts that being black or being female has very little effect on the salary grade to which one is assigned. Specifically, all else equal, black men experience a salary grade 0.01 levels lower than white men, on average, white women enjoy a grade increase of 0.07, and black women are assigned a salary grade 0.05 lower than white men. Furthermore, the coefficients on tenure and black/female interactions are all insignificant, which suggests that as a worker's tenure with the state increases, and as the state continues to evaluate their performance, being black or being female has no affect on salary grade. None of the interactions involving past performance evaluations and female/black interactions is significant, so no meaningful comparison can be made between the importance of more current or more dated performance evaluations in the determination of salary grade.

All period $t-1$ endogenous variables are significant in the salary grade equation. Specifically, a better lagged salary grade, higher lagged earnings, better lagged performance, and having been promoted last period all positively influence current salary grade. Workers with more education also work at a higher salary grade, and workers in all occupational categories other than officials and administrators work at a lower salary grade.

The next chronological outcome in the model that may yield information about statistical discrimination and the welfare of blacks is performance evaluation. The comparison group in estimation is a performance rating of "outstanding." Consistent with the unconditional means presented in Appendix Table C.2, white women are more likely than white men to be evaluated favorably, all else constant. More educated workers are less likely to earn less than an outstanding rating, as are workers who received favorable evaluations in the last period, suggesting, perhaps, that it takes time to learn about a job and perform well at it. Finally, for a given salary grade, workers who enjoy relatively higher annual earnings are less likely to receive poor evaluations.

The results of many previous empirical studies of promotion are mirrored in this analysis. Older workers and those with more tenure are less likely to experience a promotion. This supports the notion that workers are most likely to experience internal mobility early in their careers. Individuals earning higher salaries and those operating at a higher salary grade are more likely to be promoted (perhaps reflecting better quality work compared to equally qualified workers), even after controlling for selection into those higher positions. Those workers promoted last period who experienced a relatively large increase in salary grades are less likely to be promoted in the current period. This variable, as well as interactions including it, will be discussed in more detail. Finally, workers who begin their employment spell with the state at a higher starting salary grade are less likely to be promoted. This is likely due to the fact that there is potentially less room for upward mobility when starting out higher in the hierarchy.

Finally, a worker's decision to continue working for the state or leave is estimated. This decision is important for a number of reasons, including the fact that if the state does statistically discriminate, part of the "group" information used to compensate where individual signal gaps exist may be the probability that the worker will leave. Results indicate

that women and blacks are more likely than white men to discontinue their employment with the state, as are more highly educated workers and those who start out at a higher salary grade, likely due to outside employment opportunities. Employees who enjoy more favorable outcomes for the other endogenous variables, i.e. higher salary grade, higher earnings, better performance evaluation, and a promotion in the current period, are less likely to terminate their employment with the state. Those with more tenure are also less likely to leave, which may be due, in part, to the opportunity to earn a longevity pay after ten years of state service.

Olson and Becker (1983) recognize that even if women are promoted with the same probability as men, discrimination might occur in the gains from promotion. Specifically, if men experience a larger change in position, conditional on being promoted, and especially if wages are correlated with job level, it is possible that discrimination occurs through that avenue. One feature of the data used in this study is the individual's salary grade, which represents job level within the state hierarchy. Therefore, to consider the possibility that women or blacks are discriminated against in the form of smaller gains to promotion, included in all five equations is a variable that measures the change in salary grade, given a promotion, as well as the change in salary grade interacted with race and gender dummy variables. The grade change variable, not interacted with race or gender, is significant in three of the five equations (positive in salary grade and negative in earnings and promotions), and salary grade change, interacted with female, is significant in only the salary grade equation. Therefore, with the exception of the one interaction, there does not seem to be evidence suggesting that discrimination manifests itself in smaller gains to promotion for women and blacks. Olson and Becker were not able to measure job level, but did not find that women were paid less when promoted, which is analogous to and consistent with this result.

In summary, then, the model reinforces many findings in the earnings and promotion literatures. More educated workers fare better than those with less human capital. Older, more experienced workers are less likely to be promoted, as are those who start at a higher position within the salary grade range. Blacks and women are more likely to terminate their employment with their employer. Specific to this study, workers who receive favorable evaluations are more likely to enjoy higher earnings in future periods.

However, one result generated by this model, which is seldom reported in the wage differential literature, is that blacks and women are not more likely to be assigned to a lower salary grade, and after controlling for performance evaluation and promotions, black men and women are not predicted to earn less than white men. The coefficients on black and female in both the earnings and salary grade equation are most frequently not significantly different from zero, and in some cases even positive. This result is important in that it confirms the need to accurately control for the occurrence of promotions (which is usually done using a worker's self-reported change in tasks or an unusually large wage increase) and performance on the job[18].

To evaluate the impact on wage differentials of including a measure of promotion and performance on the job, models have been run in the absence of these variables and will be compared to models incorporating these measures one at a time. Table 5.4 contains predicted wage differentials as each measure is considered in turn. Specifically, Model 1 is a model with controls for permanent and time-varying heterogeneity, where the decision to stay, earnings, and salary grade are endogenized, but both promotion and performance evaluation are excluded. Model 2 introduces performance evaluations but excludes promotions, and Model 3 does the reverse. Finally, Model 4, the preferred model, controls for unobserved heterogeneity and simultaneously estimates the decision to stay, earnings, salary grade, performance evaluations, and promotions.

Consistent with the results in Table F.1, and compared to those in the wage differential literature,[19] controlling for heterogeneity, performance evaluations, and promotions reduces the wage differential by between four and eight percentage points. As coefficients from the preferred five equation model suggest, simply being black or being female has little to no impact on wage determination. Thus, despite the fact that blacks and women still earn less

[18]While it is the case that discrimination may occur via performance evaluations, it is not possible to test that hypothesis without race and gender information about the worker's supervisor. Blau and DeVaro (2006) are able to test for this and do not find evidence of discrimination in performance ratings.

[19]Long (1976), finds a black-white ratio of 0.76 and a female-male ratio of 0.74, the former being consistent with these results. Smith (1993) finds a range of 0.68 to 0.86 for the black-white male wage ratio. Other studies report negative coefficients on black and/or female dummy variables. Oettinger (1996) estimates a black dummy variable coefficient ranging between -0.08 and -0.01. Neal and Johnson (1996) study race and gender differentials and find a coefficient of -0.24 to 0.07 for men and -0.19 to 0.04 for women.

Table 5.4: Wage Ratios with Various Controls

| | Model 1 Neither | Model 2 No Promotion | Model 3 No Evaluation | Model 4 Both |
|---|---|---|---|---|
| Black/White | 0.73 | 0.74 | 0.77 | 0.79 |
| Female/Male | 0.79 | 0.80 | 0.87 | 0.87 |
| Black/White Males | 0.69 | 0.68 | 0.70 | 0.75 |
| Black/White Females | 0.80 | 0.82 | 0.85 | 0.84 |
| White Female/Male | 0.79 | 0.79 | 0.86 | 0.86 |
| Black Female/Male | 0.91 | 0.95 | 1.04 | 0.97 |

than white men, the difference is substantially reduced by controlling for variables that seem theoretically relevant.

The above exercise demonstrates the importance of controlling for (an employer's perception of) productivity and the occurrence of promotions when drawing conclusions about the existence or magnitude of discrimination. While discrimination appears to be less prevalent after measuring these endogenous variables, that a wage differential exists yet today calls for an exploration into what might motivate the convergence of earnings. Therefore, section 5.4 evaluates the fit of the entire model, after which simulations are run to determine conditions under which blacks and/or women would enjoy outcomes more similar to those of white men.

## 5.4 Fit of the Model

Goodness of fit tests are performed on the model to evaluate how well the model's predictions match the observed data. To evaluate the fit, the coefficient estimates and observed values of explanatory variables for the entire sample of 23,231 workers are used to calculate predicted probabilities of the outcomes by allowing random draws to determine the simulated outcome. Uniform random errors are used to assign outcomes from dichotomous and polychotomous alternatives. A normal random error (i.e. $N \sim (0, 1)$) that is scaled by the estimated

standard deviation is added to a continuous prediction to obtain simulated continuous values. This procedure is done with and without controls for unobserved heterogeneity, and the results are presented in columns two and four of Table 5.5 (no updating). Alternatively, the initial ($t = 1$) values of explanatory variables are used for all individuals in the sample, but simulated outcomes are used in calculation of subsequent outcomes. That is, the endogenous explanatory variables are updated to reflect simulated previous period outcomes. These averages are listed in columns three and five (updating).

Table 5.5: Goodness of Fit Tests: Model vs. Observed Outcomes

| Outcome (N) | Full Sample (Observed) | Models Without Heterogeneity | | Models with Heterogeneity | |
|---|---|---|---|---|---|
| | | No Updating | Updating | No Updating | Updating |
| Earnings | 28,673 | 28,610 | 28,439 | 28,835 | 29,195 |
| Salary Grade | 63.07 | 63.07 | 63.02 | 63.09 | 63.06 |
| Promotion Probability | 8.93 | 9.14 | 7.58 | 9.03 | 8.14 |
| Performance Evaluation | 3.21 | 3.20 | 3.18 | 3.20 | 3.18 |
| 1-2 | 0.58 | 0.61 | 0.76 | 0.60 | 0.73 |
| 3 | 13.20 | 13.37 | 14.40 | 13.62 | 14.58 |
| 4 | 51.18 | 50.98 | 50.51 | 50.81 | 50.36 |
| 5 | 35.04 | 35.05 | 34.33 | 34.97 | 34.32 |
| Leave Probability | 14.67 | 14.47 | 14.54 | 16.05 | 16.24 |
| Spell Length | 3.68 | 3.35 | 6.30 | 3.25 | 6.40 |
| 1 Year | 25.43 | 19.00 | 19.02 | 20.26 | 20.26 |
| 2 Years | 17.48 | 27.27 | 10.69 | 29.08 | 10.16 |
| 3 Years | 13.93 | 17.53 | 6.41 | 16.26 | 5.72 |
| 4 Years | 10.41 | 12.17 | 4.89 | 11.58 | 4.24 |
| 5 Years | 9.42 | 7.85 | 3.62 | 7.46 | 3.07 |
| 6 Years | 6.61 | 5.63 | 2.47 | 5.63 | 1.99 |
| 7 Years | 5.45 | 3.49 | 1.91 | 3.30 | 1.44 |
| 8 Years | 4.82 | 2.56 | 1.95 | 2.41 | 1.23 |
| 9 Years | 3.41 | 2.02 | 1.64 | 1.94 | 1.11 |
| 10 Years | 3.04 | 2.48 | 47.40 | 2.08 | 50.78 |

Clearly, with and without heterogeneity, and with and without updating, the model predicts the observed outcomes quite well. When the observed data are used (i.e. no updating), the probability of being promoted is over-predicted, and when the predicted outcomes are used to update the explanatory variables in subsequent periods, the promotion probability is under-predicted, regardless of whether or not heterogeneity is included. Worth

noting here is the apparent under-prediction of spell lengths in the case of updating. The predicted mean of the stay/leave (0/1) variable is nearly identical to that observed in the data. However, when spell lengths are calculated without updating, by necessity, the model slightly under-predicts. This goodness of fit procedure without updating does not allow for prediction outside the time frame the employee actually spends with the state. Therefore, if an employee is observed in the data for six years, this methodology permits, at most, six years of predicted outcomes. Spell lengths are only predicted to be the same as, or less than, what is actually observed in the data, which will necessarily cause an under-prediction of spell length. This is only true in the no updating case, and as shown, when workers are permitted to work outside the time frame they are observed in the data (updating), spell lengths are over-predicted.

Note here, also, that workers in the entire sample are observed to work as many as ten years, but only if they begin their employment spell in 1994, the first year of observation. Thus, the length of the employment spell for most workers is, by nature of the data, observed and predicted to be less than ten years. In the simulations that follow, only individuals who begin working for the state in 1994 are considered; thus employment spells are observed and predicted to be longer, on average, as all workers have the opportunity to be employed for as many as ten years.[20]

[20]This is also the scenario in updating for goodness of fit tests reported in Table 5.5. When workers are permitted to work longer than observed, the upper bound is ten possible years of employment.

# 6 Simulations

Having established that the model fits the observed data well, it can be used to predict how certain outcomes of interest would change with the imposition of certain restrictions. For instance, of particular importance is how blacks or women would fare in terms of earnings if they were instead white and/or men.

To simulate the impact particular restrictions or interventions would have on the outcomes of certain workers, and to maintain the actual correlation among independent variables (such as education and occupation), an evaluation data set is created from the original data set of NC state employees. In an effort to avoid simulating behavior of individuals beyond their observed employment spell and needing to fill in the missing exogenous information for those observed to no longer work for the state, the evaluation sample is restricted to those at risk for employment with the state for the longest observable length of time. In other words, only the 2,338 employees who begin their employment spell in 1994 are included in the simulation exercises. Characteristics of these workers are displayed in Table 6.1.

To compare the observed outcomes of only workers who began their employment with the state in 1994 with the simulated outcomes for the same sample, Table 6.2 contains summary statistics in the absence of an intervention. The "observed" columns represent means of the outcomes of interest in the actual data for the four race-gender demographic groups. The "evaluation" columns reflect results from the same updating procedure described above in Section 5.4, making use of the evaluation data set detailed in Table 6.1. The numbers in parenthesis represent standard deviations for the mean predicted outcomes of 250 random parameter draws.

Again, the model performs quite well even when the data are disaggregated by race and gender. However, the earnings of women are over-predicted (particularly for white women), performance evaluations are under-predicted for black women, and promotion probability is

Table 6.1: Characteristics of Employees in the Evaluation Data Set

| | All Workers (n = 2,338) | White Men (n = 795) | Black Men (n = 342) | White Women (n = 843) | Black Women (n = 358) |
|---|---|---|---|---|---|
| Occupational Category | | | | | |
| Officials & Admin. | 1.50[1] | 2.47 | 0.76 | 1.19 | 0.66 |
| Professional | 30.72 | 39.04 | 22.27 | 31.58 | 17.63 |
| Technicians | 17.60 | 15.24 | 21.16 | 16.30 | 22.54 |
| Protective Serv. | 3.20 | 4.18 | 6.68 | 0.71 | 3.39 |
| Paraprofessionals | 0.78 | 0.76 | 1.23 | 0.46 | 1.13 |
| Office & Clerical | 23.41 | 6.94 | 10.32 | 42.68 | 29.89 |
| Skilled Craft | 13.34 | 26.95 | 20.63 | 2.42 | 0.47 |
| Service & Maint. | 9.46 | 4.42 | 16.94 | 4.67 | 24.28 |
| Educational Level | | | | | |
| < High School | 4.89 | 4.84 | 8.44 | 1.35 | 9.48 |
| High School | 30.16 | 27.40 | 39.98 | 28.04 | 32.63 |
| > High School | 26.52 | 22.81 | 22.39 | 27.79 | 35.31 |
| College | 27.41 | 31.87 | 23.74 | 28.36 | 18.72 |
| Graduate Degree | 11.02 | 13.09 | 5.45 | 14.46 | 3.87 |
| Part-Time | 1.92 | 0.65 | 0.35 | 4.26 | 1.08 |
| Age at Hire | 36.58 | 37.02 | 36.74 | 36.65 | 35.25 |
| Starting Salary Grade | 61.23 | 63.13 | 57.54 | 62.21 | 58.23 |
| Earnings | 28,611 | 32,485 | 25,224 | 28,227 | 23,702 |
| Performance Evaluation | 4.20 | 4.22 | 3.90 | 4.35 | 4.10 |
| 1-2 | 0.75 | 0.50 | 1.96 | 0.51 | 0.82 |
| 3 | 14.54 | 12.34 | 26.71 | 10.85 | 17.20 |
| 4 | 48.63 | 52.05 | 50.27 | 41.97 | 53.60 |
| 5 | 36.07 | 35.11 | 21.06 | 46.67 | 28.39 |

Note
1) With the exception of age, salary grade, and earnings, all numbers in this table represent the percentage of the demographic group within a particular category (occupational, performance, evaluation, etc).

substantially over-predicted for white women. As the following is an exercise in simulation changes within the model, these discrepancies will be taken into account and hypothetical outcomes will be compared against the numbers presented in this table.

Table 6.2: Updating With No Interventions

| | White Men | | Black Men | | White Women | | Black Women | |
|---|---|---|---|---|---|---|---|---|
| | Observed | Evaluation | Observed | Evaluation | Observed | Evaluation | Observed | Evaluation |
| Salary Grade | 65.96 | 64.97 | 60.16 | 59.62 | 62.82 | 63.90 | 58.91 | 59.54 |
| | | (0.298) | | (0.374) | | (0.353) | | (0.146) |
| Earnings | 32,797 | 33,132 | 25,423 | 25,421 | 28,313 | 31,366 | 23,553 | 25,737 |
| | | (797.998) | | (927.918) | | (917.926) | | (296.483) |
| Ever Promoted | 30.69 | 24.78 | 23.10 | 14.04 | 23.72 | 23.72 | 29.89 | 20.95 |
| | | (0.019) | | (0.019) | | (0.014) | | (0.015) |
| Evaluation | 3.23 | 3.25 | 2.91 | 2.96 | 3.35 | 3.39 | 3.10 | 2.87 |
| | | (0.023) | | (0.025) | | (0.024) | | (0.020) |
| 1-2 | 0.48 | 0.30 | 1.95 | 1.16 | 0.55 | 0.51 | 0.71 | 10.27 |
| 3 | 11.81 | 10.80 | 26.68 | 21.98 | 10.62 | 8.80 | 16.94 | 14.89 |
| 4 | 52.23 | 52.87 | 50.22 | 56.10 | 42.09 | 41.62 | 53.50 | 52.75 |
| 5 | 35.49 | 36.03 | 21.15 | 20.76 | 46.75 | 49.07 | 28.85 | 22.10 |
| Spell Length | 5.54 | 6.23 | 4.65 | 5.30 | 4.78 | 5.82 | 5.54 | 5.39 |
| | | (0.021) | | (0.025) | | (0.017) | | (0.025) |
| 1 Year | 20.13 | 19.62 | 23.98 | 27.49 | 25.74 | 25.03 | 20.11 | 24.86 |
| 2 Years | 14.21 | 11.45 | 18.13 | 14.91 | 14.95 | 8.90 | 11.45 | 14.25 |
| 3 Years | 9.43 | 4.91 | 14.04 | 6.14 | 9.25 | 6.64 | 10.61 | 5.87 |
| 4 Years | 4.91 | 5.53 | 3.80 | 4.39 | 5.58 | 5.22 | 8.10 | 6.98 |
| 5 Years | 5.03 | 2.89 | 5.85 | 4.68 | 7.35 | 3.56 | 3.91 | 2.51 |
| 6 Years | 3.40 | 3.40 | 1.46 | 1.17 | 3.80 | 3.44 | 3.91 | 3.91 |
| 7 Years | 3.65 | 2.77 | 4.68 | 1.75 | 4.74 | 2.37 | 3.35 | 3.63 |
| 8 Years | 2.39 | 1.89 | 1.75 | 0.29 | 1.90 | 1.54 | 1.96 | 0.28 |
| 9 Years | 1.26 | 1.26 | 0.88 | 0.58 | 2.25 | 1.66 | 1.40 | 1.12 |
| 10 Years | 35.60 | 46.29 | 25.44 | 38.60 | 24.44 | 41.64 | 35.20 | 36.59 |

Seven interventions are conducted using the evaluation data set to determine which factors most significantly influence the employment outcomes predicted by the model: treat all workers as white; treat all workers as male; treat all workers as white males; assign education levels according to the empirical distribution observed for white men; assign occupational categories according to the white male distribution; promote all workers in their third employment year, and; assign starting salary grades according to the white male distribution. In all cases, the observed data str used in the first period of employment (rather than predicting the first period outcome). Thus, all results should be interpreted as the outcomes workers enjoy under the restriction, conditional on having been hired at the salary and salary actually observed in the data.

## 6.1 Intervention: All White Workers

One of the primary questions this research seeks to address is the impact being black has on wage and promotion differentials after controlling for a measure of worker productivity. Thus, the first intervention considered involves assigning race as white to all employees. If the state of NC discriminates against its black workforce, removing that factor should substantially improve the outcomes of workers who are black. Therefore, to examine that possibility, race is set to white for the first period stay/leave equation. In subsequent periods, the same assignment is made, and all interactions involving race are also set to zero. No changes should be observed for white men and white women, so only results for black men and women are presented in Table 6.3.

Table 6.3: Simulated Outcomes for All White Workers

| | All Blacks | | Black Men | | Black Women | |
|---|---|---|---|---|---|---|
| | Baseline | Intervention | Baseline | Intervention | Baseline | Intervention |
| Salary Grade | 59.58 | 59.81 | 59.62 | 59.80 | 59.54 | 59.82 |
| Earnings | 25,584 | 25,994 | 25,421 | 26,159 | 25,737 | 25,803 |
| Ever Promoted | 17.57 | 18.57 | 14.04 | 18.42 | 20.95 | 18.72 |
| Performance Evaluation | 2.91 | 3.14 | 2.96 | 3.09 | 2.87 | 3.20 |
| 1-2 | 5.86 | 0.49 | 1.16 | 0.39 | 10.27 | 0.62 |
| 3 | 18.32 | 15.51 | 21.98 | 16.43 | 14.89 | 14.45 |
| 4 | 54.37 | 53.41 | 56.10 | 56.69 | 52.75 | 49.61 |
| 5 | 21.45 | 30.58 | 20.76 | 26.49 | 22.10 | 35.33 |
| Spell Length | 5.34 | 5.51 | 5.30 | 6.05 | 5.39 | 4.99 |
| 1 Year | 26.14 | 24.71 | 27.49 | 21.64 | 24.86 | 27.65 |
| 2 Years | 14.57 | 13.71 | 14.91 | 11.40 | 14.25 | 15.92 |
| 3 Years | 6.00 | 6.29 | 6.14 | 6.14 | 5.87 | 6.42 |
| 4 Years | 5.71 | 6.29 | 4.39 | 5.26 | 6.98 | 7.26 |
| 5 Years | 3.57 | 3.14 | 4.68 | 4.39 | 2.51 | 1.96 |
| 6 Years | 2.57 | 2.86 | 1.17 | 1.46 | 3.91 | 4.19 |
| 7 Years | 2.71 | 2.14 | 1.75 | 1.75 | 3.63 | 2.51 |
| 8 Years | 0.29 | 0.43 | 0.29 | 0.29 | 0.28 | 0.56 |
| 9 Years | 0.86 | 1.00 | 0.58 | 0.88 | 1.12 | 1.12 |
| 10 Years | 37.57 | 39.43 | 38.60 | 46.78 | 36.59 | 32.40 |

The most noticeable differences in actual and simulated outcomes occur in promotion rates, performance evaluations, and spell lengths. First of all, black men are substantially more likely to be promoted when their race is changed to white. For black women, the reverse is true. It is worth noting that black men are unconditionally least likely to be promoted,

which leaves room for improvement in this outcome when their characteristics are altered. Similarly, black women are only slightly less likely to be unconditionally promoted than white men and more likely, by over four percentage points, than white women. Therefore, it is not surprising that they are are less likely to enjoy a promotion during their employment spell with the state when simulated to be white.

Both black men and black women enjoy an increase in overall performance evaluations when all workers are assigned a race of white. As evaluations are also tied to better salary grades and earnings in the next period, this intervention reveals a slight increase in both outcomes for both groups.

Finally, as proposed previously, if employers draw conclusions about a new hire based on what has been observed about that worker's group in the past, it would seem that a firm's expectation about a new worker's commitment to remain on the job would be of particular interest. In other words, how long the state has observed other blacks or women to remain in their current position ought to influence the hiring, wage, etc. decisions the state makes. In the absence of an intervention, black men have the shortest average spell length, and black women stay for a period of time between that of white men and black men. When all workers are assumed to be white, the biggest change occurs for black men. They are predicted to continue working for the state nearly one full year longer. This type of change would reflect favorably on an employer's prediction of whether or not black men are committed to their job.

## 6.2 Intervention: All Male Workers

The next simulation, like the first, involves changing the demographic characteristics of half of the sample. Much of the promotion literature focuses on the gender differential, where women are often times found to be either less likely to be promoted or to enjoy smaller wage gains when a promotion occurs. In the case of this intervention, all workers are simulated as men to explore how the labor market outcomes of women would change. The female dummy variable, and all interactions including it, are set to zero. The workers whose simulated outcomes should change, then, are women. Summary statistics for the predicted outcomes of interest are displayed in Table 6.4.

Table 6.4: Simulated Outcomes for All Male Workers

| | All Women | | White Women | | Black Women | |
|---|---|---|---|---|---|---|
| | Baseline | Intervention | Baseline | Intervention | Baseline | Intervention |
| Salary Grade | 62.67 | 63.08 | 63.90 | 64.19 | 59.54 | 59.66 |
| Earnings | 29,779 | 30,286 | 31,366 | 31,869 | 25,737 | 25,407 |
| Ever Promoted | 22.90 | 23.15 | 23.72 | 25.50 | 20.95 | 17.60 |
| Performance Evaluation | 3.24 | 3.27 | 3.39 | 3.34 | 2.87 | 3.05 |
| 1-2 | 3.26 | 0.56 | 0.51 | 0.43 | 10.27 | 0.98 |
| 3 | 10.52 | 12.08 | 8.80 | 9.71 | 14.89 | 19.40 |
| 4 | 44.76 | 47.47 | 41.62 | 45.53 | 52.75 | 53.44 |
| 5 | 41.47 | 39.89 | 49.07 | 44.34 | 22.10 | 26.18 |
| Spell Length | 5.69 | 5.92 | 5.82 | 6.37 | 5.39 | 4.87 |
| 1 Year | 24.98 | 23.40 | 25.03 | 20.88 | 24.86 | 29.33 |
| 2 Years | 10.49 | 10.91 | 8.90 | 8.78 | 14.25 | 15.92 |
| 3 Years | 6.41 | 5.91 | 6.64 | 5.34 | 5.87 | 7.26 |
| 4 Years | 5.75 | 5.16 | 5.22 | 4.74 | 6.98 | 6.15 |
| 5 Years | 3.25 | 3.25 | 3.56 | 3.56 | 2.51 | 2.51 |
| 6 Years | 3.58 | 2.83 | 3.44 | 2.61 | 3.91 | 3.35 |
| 7 Years | 2.75 | 2.33 | 2.37 | 2.37 | 3.63 | 2.23 |
| 8 Years | 1.17 | 1.17 | 1.54 | 1.42 | 0.28 | 0.56 |
| 9 Years | 1.50 | 0.92 | 1.66 | 1.07 | 1.12 | 0.56 |
| 10 Years | 40.13 | 44.13 | 41.64 | 49.23 | 36.59 | 32.12 |

As with the race intervention, assigning all workers to be male most significantly influences promotion probabilities, performance evaluations, and the length of employment spells. Black women are predicted to be less likely to be promoted during the tenure with the state, though white women enjoy a greater likelihood of promotion. The reverse is true for performance evaluations; black women are predicted to far better, and white women would earn slightly lower evalatuions.[21] Unconditionally, white women earn the highest ratings; thus, when restricted to an all-male population, it is not surprising that white women are expected to be evaluated less favorably.

Finally, as white women in the evaluation sample have the one of the shortest average spell lengths (second only to black men), when their stay/leave decision is predicted as if they were men, the duration of the average spell length with the state increases by roughly half of a year. Black women, who unconditionally spend the same amount of time as state employees as white men, and nearly one year longer than black men, are expected to terminate their employment sooner if they are assigned a gender of male.

## 6.3 Intervention: All White Male Workers

The first two interventions, restricting the entire sample to first be white, then male, reflect the marginal differences in the outcomes of interest for black men and white women compared to white men. However, imposing both restrictions on the evaluation sample is the only way to determine the difference in outcomes for black women. Thus, the third intervention involves setting both race and gender, as well as all interactions including these variables, to zero. Results are found in Table 6.5.

The wages of black women are not predicted to change substantially when only race, or only gender, changes. However, when black women are simulated to be white men, their annual earnings are shown to increase by nearly $1000. All other variables remain relatively constant (with the exception of the originally under-predicted performance evaluations), which is likely due to the fact that some of the unconditional black female outcomes compare

[21] The sizeable increase in performance evaluations for black women is likely due to the substantial under-prediction in the absence of an intervention.

Table 6.5: Simulated Outcomes for All White Male Workers

| | Black Women | |
|---|---|---|
| | Baseline | Intervention |
| Salary Grade | 59.54 | 60.06 |
| Earnings | 25,737 | 26,417 |
| Ever Promoted | 20.95 | 22.07 |
| Performance Evaluation | 2.87 | 3.17 |
| 1-2 | 10.27 | 0.55 |
| 3 | 14.89 | 13.89 |
| 4 | 52.75 | 53.15 |
| 5 | 22.10 | 32.41 |
| Spell Length | 5.39 | 5.55 |
| 1 Year | 24.86 | 23.74 |
| 2 Years | 14.25 | 13.69 |
| 3 Years | 5.87 | 5.59 |
| 4 Years | 6.98 | 7.82 |
| 5 Years | 2.51 | 2.51 |
| 6 Years | 3.91 | 3.35 |
| 7 Years | 3.63 | 2.51 |
| 8 Years | 0.28 | 0.84 |
| 9 Years | 1.12 | 0.56 |
| 10 Years | 36.59 | 39.39 |

to those of white men (spell length, promotion probability). promotion probability) offset the potential improvement from being male (white).

## 6.4 Intervention: White Male Education

Turning from basic, unchangable demographic characteristics to variables that could potentially be the focus of policy interventions, consider how blacks and women may fare differently if they brought to the labor market the same human capital as white men. There is a great deal of disparity between the education levels of blacks and whites in the population of NC state employees. Specifically, 45-50% of blacks begin their employment with the state with a high school education or less, compared to 25-30% of whites. On the other hand, nearly 40% of all white employees have a college or graduate level education, whereas only 25% of blacks have acquired that level of education by the time they begin working for the state (see Table C.3). Thus, one testable implication of the model is that those workers with more education, or better pre-market skills, are more likely to enjoy favorable employment outcomes. An intervention whereby all workers enjoy an educational distribution equal to that of white men, is considered. Table 6.6 contains the results of this simulation.

Table 6.6: Simulated Outcomes Under the Assumption of the White Male Educational Distribution

| | Black Men | | White Women | | Black Women | |
|---|---|---|---|---|---|---|
| | Baseline | Intervention | Baseline | Intervention | Baseline | Intervention |
| Salary Grade | 59.62 | 59.96 | 63.90 | 64.31 | 59.54 | 59.96 |
| Earnings | 25,421 | 25,662 | 31,366 | 31,926 | 25,737 | 26,454 |
| Ever Promoted | 14.04 | 14.04 | 23.72 | 24.20 | 20.96 | 20.11 |
| Performance Evaluation | 2.96 | 2.95 | 3.39 | 3.39 | 2.87 | 2.87 |
| 1-2 | 1.16 | 0.83 | 0.51 | 0.61 | 10.27 | 10.33 |
| 3 | 21.98 | 22.53 | 8.80 | 8.83 | 14.89 | 14.79 |
| 4 | 56.10 | 57.02 | 41.62 | 41.50 | 52.75 | 52.18 |
| 5 | 20.76 | 19.62 | 49.07 | 49.07 | 22.10 | 22.70 |
| Spell Length | 5.30 | 4.92 | 5.82 | 5.86 | 5.39 | 5.19 |
| 1 Year | 27.49 | 32.16 | 25.03 | 24.91 | 24.86 | 25.98 |
| 2 Years | 14.91 | 14.91 | 8.90 | 9.02 | 14.25 | 15.08 |
| 3 Years | 6.14 | 6.73 | 6.64 | 6.41 | 5.87 | 6.42 |
| 4 Years | 4.39 | 4.09 | 5.22 | 5.22 | 6.98 | 6.98 |
| 5 Years | 4.68 | 3.51 | 3.56 | 3.80 | 2.51 | 1.68 |
| 6 Years | 1.17 | 1.17 | 3.44 | 2.61 | 3.91 | 4.19 |
| 7 Years | 1.75 | 1.46 | 2.37 | 2.37 | 3.63 | 3.63 |
| 8 Years | 0.29 | 0.00 | 1.54 | 1.78 | 0.28 | 0.84 |
| 9 Years | 0.58 | 1.17 | 1.66 | 1.42 | 1.12 | 1.68 |
| 10 Years | 38.60 | 34.80 | 41.64 | 42.47 | 36.59 | 33.52 |

Across the board, there is an increase in earnings, by at most $700. Salary grades, promotion rates, and performance evaluations remain almost unchanged across the demographic groups due to the education intervention. Given that very few of the education variables are significant in these equations, this result is not surprising. Even in the salary grade equation, where all four education dummy variables are positive and significantly different from zero, the largest suggests that an employee with more than a high school education should enjoy an increase in salary grade of 0.13.

Tenure with the state is the only other outcome that changes by any noticeable amount, and the results for blacks are consistent with the empirical result that more educated workers are likely to attract better outside wage offers, which creates an incentive to terminate their current employment situation.

## 6.5 Intervention: White Male Occupations

Appendix Tables G.1 and G.3 contain information on promotion and salary grade differentials by EEO category. Additionally, Table C.3 describes the differences in race and gender by occupational assignment. Officials and administrators, professionals, and technicians are observed to have salary grades as low as 50 and as high as 85-90. Individuals employed in these occupations have much more room for upward mobility, given the high grade that may be achieved, than those working as paraprofessionals and in service and maintenance, for instance. This hypothesis is supported by the realized promotion probabilities in Table G.1. Further, if blacks or women are more likely to be employed in occupational categories with a more restrictive range of observed salary grades, promotion will be more difficult, if not impossible. An examination of Table C.3 reveals that whites are nearly twice as likely to be employed as professionals, and blacks are more often employed as technicians than are white workers. Black men and women are also much more likely to be employed in service and maintenance, an occupational category with very low promotion rates.

Therefore, to determine the impact occupational category has on the outcomes of interest, all workers in the sample are assigned the observed occupational distribution of white men. The results of this intervention are found in Table 6.7.

Table 6.7: Simulated Outcomes Under the Assumption of the White Male Occupational Distribution

| | Black Men | | White Women | | Black Women | |
|---|---|---|---|---|---|---|
| | Baseline | Intervention | Baseline | Intervention | Baseline | Intervention |
| Salary Grade | 59.62 | 59.71 | 63.90 | 64.09 | 59.54 | 59.87 |
| Earnings | 25,421 | 25,279 | 31,366 | 31,483 | 25,737 | 25,787 |
| Ever Promoted | 14.04 | 14.04 | 23.72 | 21.59 | 20.95 | 20.67 |
| Performance Evaluation | 2.96 | 2.97 | 3.39 | 3.34 | 2.87 | 2.83 |
| 1-2 | 1.16 | 0.90 | 0.51 | 0.40 | 10.27 | 9.85 |
| 3 | 21.98 | 21.57 | 8.80 | 9.65 | 14.89 | 15.95 |
| 4 | 56.10 | 56.69 | 41.62 | 44.99 | 52.75 | 55.09 |
| 5 | 20.76 | 20.84 | 49.07 | 44.95 | 22.10 | 19.11 |
| Spell Length | 5.30 | 5.20 | 5.82 | 5.63 | 5.39 | 5.13 |
| 1 Year | 27.49 | 28.95 | 25.03 | 26.57 | 24.86 | 25.42 |
| 2 Years | 14.91 | 14.33 | 8.90 | 9.61 | 14.25 | 15.92 |
| 3 Years | 6.14 | 7.31 | 6.64 | 6.76 | 5.87 | 6.70 |
| 4 Years | 4.39 | 3.80 | 5.22 | 5.34 | 6.98 | 7.26 |
| 5 Years | 4.68 | 3.80 | 3.56 | 3.68 | 2.51 | 2.23 |
| 6 Years | 1.17 | 1.17 | 3.44 | 2.85 | 3.91 | 4.19 |
| 7 Years | 1.75 | 1.75 | 2.37 | 2.49 | 3.63 | 3.07 |
| 8 Years | 0.29 | 0.58 | 1.54 | 1.54 | 0.28 | 0.56 |
| 9 Years | 0.58 | 0.29 | 1.66 | 1.42 | 1.12 | 1.96 |
| 10 Years | 38.60 | 38.01 | 41.64 | 39.74 | 36.59 | 32.68 |

Despite the apparent differences in promotability across occupations, and the way in which demographic groups sort themselves into the various occupational classifications, there are almost no changes in the predicted outcomes when all workers are assigned occupations according to the white male distribution. As Table F.1 reveals, the equations that contain significant coefficients on the occupational dummy variables are salary grade, earnings, promotion, and stay/leave. However, the first two equations include very small coefficients, despite their significance. For instance, all else constant, service and maintenance employees will be assigned a salary grade that is, at most, 0.88 levels lower than an otherwise observationally equivalent officials and administrators employee. Significant coefficients that are larger in magnitude, but still not among the most important determinants, are found in the promotion equation and stay/leave equations. Technicians, office and clerical, skilled craft, and service and maintenance workers are all noticeably more likely to be promoted than an individual employed as an administrator. Thus, an intervention that would involve training

disadvantaged workers to be able to market their skills in white male occupations would not seem to influence the labor market outcomes of these workers.

## 6.6 Intervention: Promotion in Employment Year 3

The occurrence of a promotion positively influences future salary grade, earnings, performance evaluations, the probability of being promoted, and the probability of continuing to work for the state. Therefore, evaluating the way outcomes are affected by a forced promotion may suggest the ways promotion differentials affect other outcomes of interest. Table 6.8 describes the results of a simulation whereby all workers are promoted in their third employment year, assuming they are predicted to work at least three years. As shown, the percentage of ever promoted workers increases dramatically. The 25-30% of workers who are never promoted are those who leave the state during the first or second year of employment.

Promoting all workers in their third year of employment makes them unambiguously worse off in terms of earnings, but by very small amounts. Likewise, changes in the other outcomes of interest are small or non-existent. This may be driven by the fact that the coefficients on promotion or lagged promotion are generally small and/or insignificant. Therefore, it seems forcing a promotion does little to influence the outcomes of any group. Perhaps this is due to the fact that there is little variation by demographic group in the unconditional percentage of workers ever promoted. Roughly 25-30% of all workers are promoted during their first employment spell with the state, the most frequently promoted group being white men, followed by black women, white women, and lastly, black men.

## 6.7 Intervention: White Male Starting Salary Grade

Finally, Table 6.9 contains summary statistics for a simulation that involves assigning a worker's initial grade according to the distribution of white male initial grades. One potential reason blacks and women earn less than men, particularly at the onset of their employment with the state, is because of statistical discrimination. Specifically, if the employer underestimates the ability of certain workers, or anticipates that they may terminate their employment due to a weaker attachment to the labor force, the worker may be assigned to a starting

Table 6.8: Simulated Outcomes for Automatic Period 3 Promotion

| | White Men | | Black Men | | White Women | | Black Women | |
|---|---|---|---|---|---|---|---|---|
| | Baseline | Intervention | Baseline | Intervention | Baseline | Intervention | Baseline | Intervention |
| Salary Grade | 64.97 | 65.13 | 59.62 | 59.78 | 63.90 | 64.08 | 59.54 | 59.67 |
| Earnings | 33,132 | 32,443 | 25,421 | 24,859 | 31,366 | 30,729 | 25,737 | 25,205 |
| Ever Promoted | 24.78 | 69.56 | 14.04 | 58.48 | 23.72 | 67.02 | 20.95 | 61.45 |
| Performance Evaluation | 3.25 | 3.24 | 2.96 | 2.96 | 3.39 | 3.40 | 2.87 | 2.87 |
| 1-2 | 0.30 | 0.36 | 1.16 | 0.94 | 0.51 | 0.49 | 10.27 | 9.61 |
| 3 | 10.80 | 11.52 | 21.98 | 22.79 | 8.80 | 9.15 | 14.89 | 15.76 |
| 4 | 52.87 | 52.34 | 56.10 | 55.74 | 41.62 | 40.72 | 52.75 | 52.82 |
| 5 | 36.03 | 35.78 | 20.76 | 20.53 | 49.07 | 49.63 | 22.10 | 21.81 |
| Spell Length | 6.23 | 6.24 | 5.30 | 5.30 | 5.82 | 5.83 | 5.39 | 5.41 |
| 1 Year | 19.62 | 19.62 | 27.49 | 27.49 | 25.03 | 25.03 | 24.86 | 24.86 |
| 2 Years | 11.45 | 11.45 | 14.91 | 14.91 | 8.90 | 8.90 | 14.25 | 14.25 |
| 3 Years | 4.91 | 4.91 | 6.14 | 5.85 | 6.64 | 6.17 | 5.87 | 5.59 |
| 4 Years | 5.53 | 5.66 | 4.39 | 4.68 | 5.22 | 5.58 | 6.98 | 6.98 |
| 5 Years | 2.89 | 2.89 | 4.68 | 4.68 | 3.56 | 3.56 | 2.51 | 2.51 |
| 6 Years | 3.40 | 3.52 | 1.17 | 1.17 | 3.44 | 3.56 | 3.91 | 3.91 |
| 7 Years | 2.77 | 2.26 | 1.75 | 1.75 | 2.37 | 2.37 | 3.63 | 3.63 |
| 8 Years | 1.89 | 1.76 | 0.29 | 0.29 | 1.54 | 1.54 | 0.28 | 0.28 |
| 9 Years | 1.26 | 1.01 | 0.58 | 0.58 | 1.66 | 1.54 | 1.12 | 1.12 |
| 10 Years | 46.29 | 46.92 | 38.60 | 38.60 | 41.64 | 41.76 | 36.59 | 36.87 |

position which is lower than that of a white male, for instance. Observed starting salary grades support this hypothesis. Unconditionally, white men have an average starting salary grade of 63.13, black men start at 57.54, white women start at 62.21, and black women have an average initial salary grade of 58.23.

In this particular simulation, the initial salary grade of white men remains unchanged. Black men, white women, and black women, however, are assigned starting salary grades according to the white male distribution. The results of each of the five outcomes of interest are presented below.

Table 6.9: Simulated Outcomes Under the Assumption of the White Male Initial Salary Grade Distribution

| | Black Men | | White Women | | Black Women | |
|---|---|---|---|---|---|---|
| | Baseline | Intervention | Baseline | Intervention | Baseline | Intervention |
| Salary Grade | 59.62 | 65.71 | 63.90 | 65.82 | 59.54 | 65.24 |
| Earnings | 25,421 | 28,806 | 31,366 | 32,056 | 25,737 | 28,790 |
| Ever Promoted | 14.04 | 13.45 | 23.72 | 24.08 | 20.95 | 16.48 |
| Performance Evaluation | 2.96 | 3.00 | 3.39 | 3.40 | 2.87 | 2.89 |
| 1-2 | 1.16 | 0.90 | 0.51 | 0.44 | 10.27 | 9.88 |
| 3 | 21.98 | 20.62 | 8.80 | 8.65 | 14.89 | 14.32 |
| 4 | 56.10 | 56.27 | 41.62 | 41.68 | 52.75 | 53.14 |
| 5 | 20.76 | 22.22 | 49.07 | 49.23 | 22.10 | 22.65 |
| Spell Length | 5.30 | 5.86 | 5.82 | 5.98 | 5.39 | 5.60 |
| 1 Year | 27.49 | 23.98 | 25.03 | 23.72 | 24.86 | 24.58 |
| 2 Years | 14.91 | 13.16 | 8.90 | 8.54 | 14.25 | 12.57 |
| 3 Years | 6.14 | 6.14 | 6.64 | 6.17 | 5.87 | 5.31 |
| 4 Years | 4.39 | 3.51 | 5.22 | 5.58 | 6.98 | 6.98 |
| 5 Years | 4.68 | 3.80 | 3.56 | 3.80 | 2.51 | 2.79 |
| 6 Years | 1.17 | 1.17 | 3.44 | 3.20 | 3.91 | 3.63 |
| 7 Years | 1.75 | 1.46 | 2.37 | 2.49 | 3.63 | 3.07 |
| 8 Years | 0.29 | 0.29 | 1.54 | 1.42 | 0.28 | 0.56 |
| 9 Years | 0.58 | 0.58 | 1.66 | 1.78 | 1.12 | 0.56 |
| 10 Years | 38.60 | 45.91 | 41.64 | 43.30 | 36.59 | 39.94 |

Both average salary grade and salary increase for all three groups when the white male initial salary grade distribution is imposed. Blacks benefit the most, enjoying as much as a $3300 increase in salary (black men). Blacks are less likely to be promoted, given the new distribution of initial salary grades, and white women experience only a small increase in promotability. Consistent with the notion of statistical discrimination, if parity is achieved in

terms of initial placement, there is less need for "catch up" for groups that would otherwise be evaluated based on group characteristics at the time of hire. Performance evaluations increase by a negligible amount. Average tenure with the state increases for all three groups.

In summary, seven interventions have been considered: treat all workers as white, treat all workers as male, treat all workers as white male, assign all workers an educational level which is derived from the empirical distribution of white male education, assign all workers an occupational category which is derived from the empirical distribution of white male occupations, promote all workers in their third period of employment, and assign all workers an initial salary grade derived from the distribution of white male starting salary grade.

When demographic characteristics are altered, the only noticeable changes in the outcomes of interest occur in promotion probabilities, performance evaluations, and tenure with the state. The exception to that is when both race and gender are altered such that black women, when treated as white men, experience a $1000 increase in annual earnings. When the educational or occupational distribution of white men is used to assign new, hypothetical education levels and occupational categories to all state employees, few changes are observed. The same is true when all workers are promoted in the third period of employment.

The only intervention that induces any sizeable changes in earnings is when the distribution of white male starting salary grades is used to assign initial grades to all workers, ceteris paribus. In that case, the average wages of white women increase by nearly $700, and the gain is as much as $3300 for black men. Likewise, there is a marked increase in salary grades and tenure for all three groups. These facts, coupled with there being fewer promotions when simulated to start at a higher salary grade, are consistent with the notion that the state under-places workers at the onset of employment. In the absence of this intervention, the more frequent promotions for black, in particular, seem to reflect the fact that the state is "catching up" workers who were originally assigned too-low starting salary grades. A more informed signal at the time initial salary grade decisions are made, should the result be a higher initial placement, would likely benefit the employer at the same time all workers would clearly fare much better in terms of all outcomes of interest.

The following graphs highlight the differences in the way the seven interventions affect four of the variables of interest: salary grade, earnings, performance evaluations, and the

probability of being promoted. The differences in predicated salary grades across demographic groups is consistent regardless of the intervention, with the exception of the last. When all workers begin with roughly the same average salary as white men, black salary grades are shown to grow at a slower rate than that of whites.

In terms of salary, it appears as if the smallest variation in wages is also seen in the last intervention. By the time workers are observed to work ten years, the difference between the highest average salary (white men) and the lowest (black men) is under $5,000, which is less than each of the other inventions.

The most noticeable changes in performance evaluation are observed when all workers are simulated to be white, or white and male. Specifically, in both of these interventions, the performance evaluations of black women are predicted to exceed that of white men by the tenth employment year, and the average evaluations among black men is almost the same as that of white men. It is in these two interventions where performance evaluation convergence among men is closest to being realized.

Predicted promotion rates vary only slightly depending upon the intervention. There is not a great deal of dispersion around the mean during a worker's tenure with the state. Black women tend to be the only workers whose promotion probability seems to increase over time. Not surprisingly, in the promotion intervention, whereby all workers enjoy a promotion in period three, promotion rates are shown to decline considerably over time.

## 6.8 Source of Changes in Interventions: Unobserved Heterogeneity or Performance Evaluations?

This research improves upon past earnings studies by controlling for a worker's ability on the job by utilizing a uniform measure of performance evaluation. Additionally, endogeneity of some of the explanatory variables in the earnings equation is addressed by jointly estimating five outcomes and modeling correlation across the error terms by controlling for both time-varying and permanent individual heterogeneity.

Simulations reveal that substantial improvements in the socioeconomic outcomes of blacks and women are possible, particularly if they begin their tenure with the state at a

Figure 1: Predicted Salary Grade from Interventions

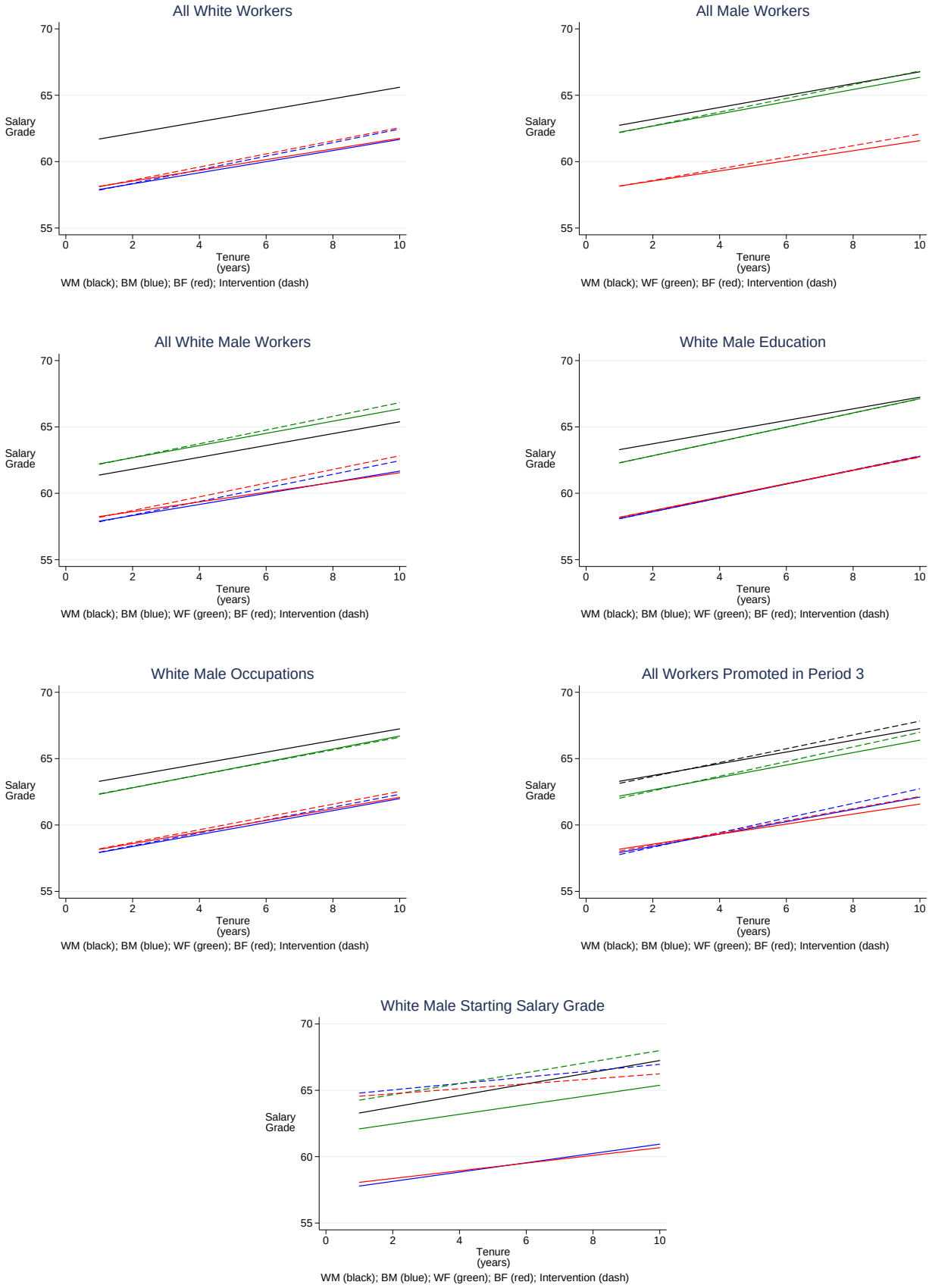


Figure 2: Predicted Earnings from Interventions

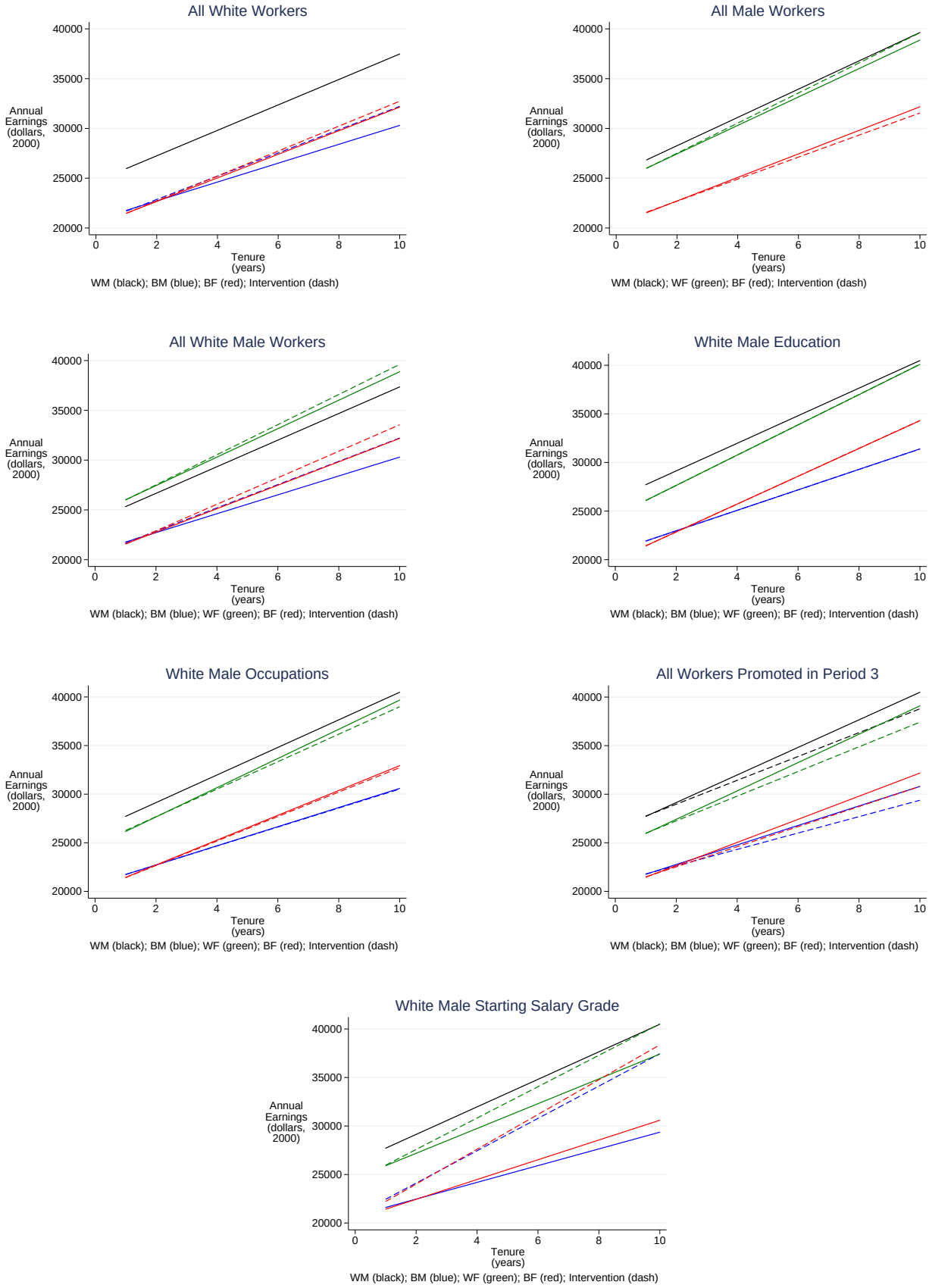
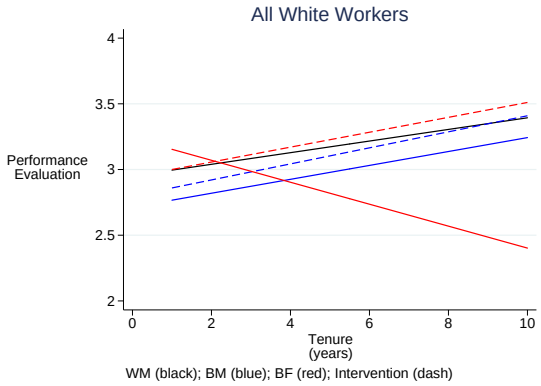
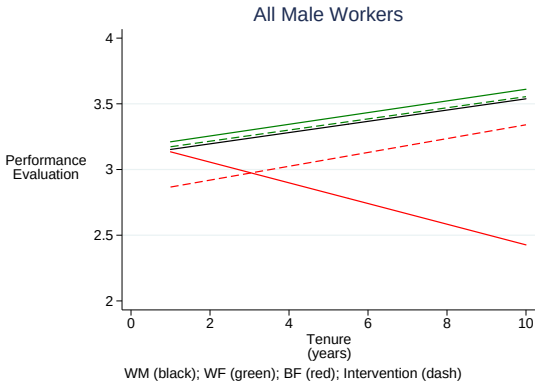
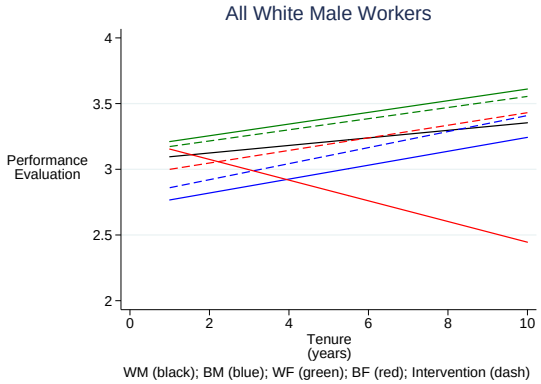
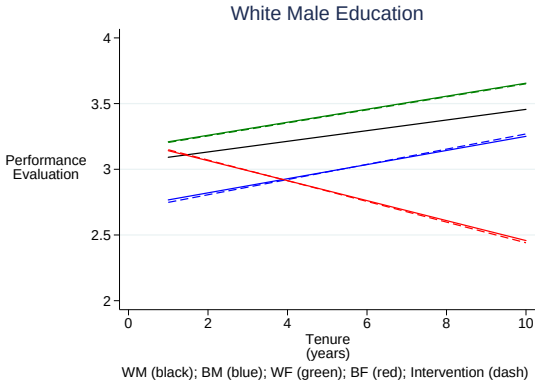


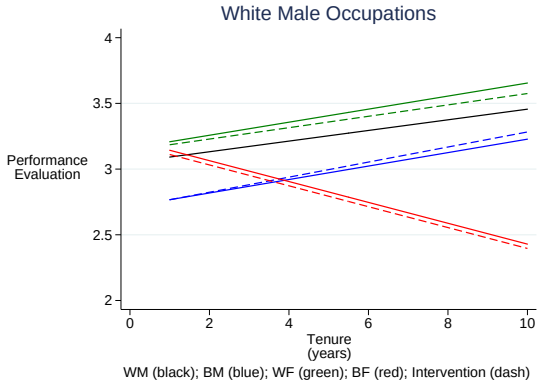
Figure 3: Predicted Performance Evaluations from Interventions



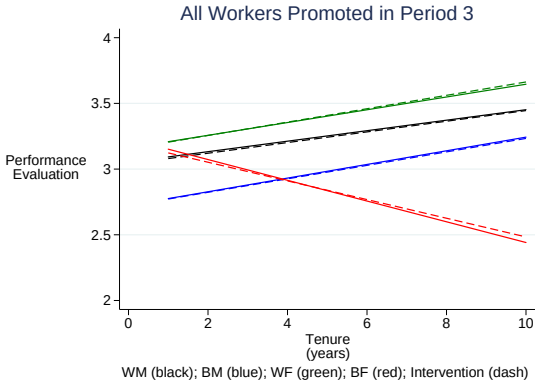
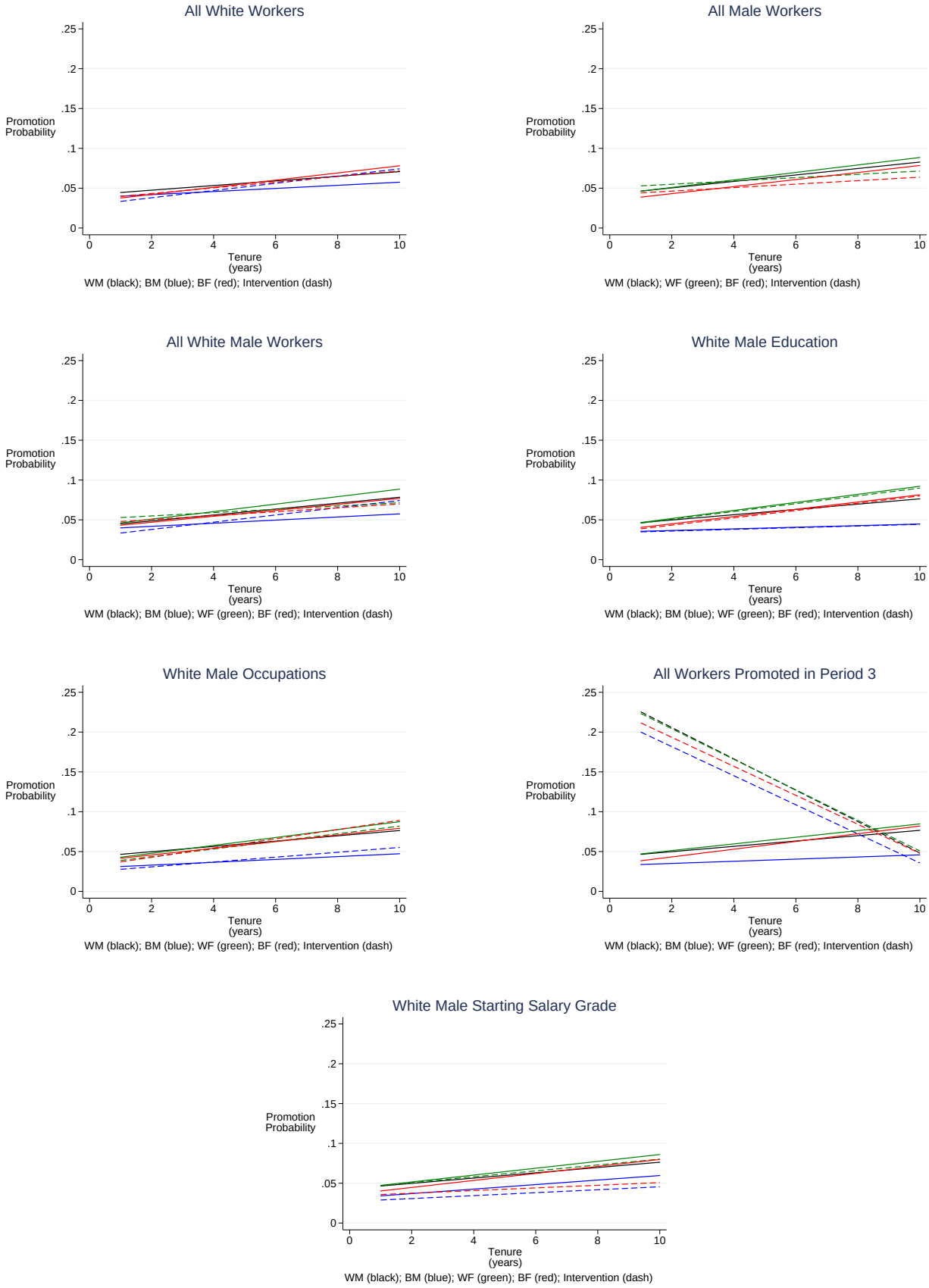




Figure 4: Predicted Promotion Probabilities from Interventions



better position in the salary grade hierarchy. Because of the introduction of performance evaluations and unobserved heterogeneity in this model, it is not obvious which is causing these important improvements. To disentangle these simultaneous sources of change, all interventions are run with a model that does not control for unobserved heterogeneity, but is otherwise identical to the preferred model, namely in its inclusion of the performance evaluation measure. These results are found in Appendix Tables F.7-F.9.

These interventions without controls for heterogeneity suggest that the source of the changes comes both performance evaluations and controls for unobserved heterogeneity. Specifically focusing on the last intervention, starting salary grade, where most notable changes occurred, it is clear that the inclusion of performance evaluations alone is responsible for a significant portion of the total change, but certainly not all. For instance, black men and women enjoy a roughly seven point increase in their overall salary grades, roughly four of which come from a model not controlling for unobserved heterogeneity. Earnings for the two groups increase by approximately $3000-4000, one-fourth of which comes from the inclusion of performance evaluations. These types of patterns are generally consistent across the interventions and demographic groups: blacks and woman have much to gain with these interventions, even in the absence of heterogeneity controls, but the full improvements come when the equations are jointly estimated.

# 7 Conclusions

This study makes use of a rich data set provided by the state of North Carolina that has never been released for external empirical research. Included in the data are two variables that do not typically exist in standard nationally-representative economic data sets. Specifically, the state of North Carolina defines a promotion as a change in position (personnel number) accompanied by an increase in salary grade. Both of these measures exist in the data, which makes identifying a promotion unambiguous and does not require reliance on an arbitrary characterization such as a change in tasks or unusually large wage increase. Additionally, the state of North Carolina annually evaluates the performance of all of its workers on a standard 1-5 scale. Because all employees in the data are employed by the same firm and evaluated using the same rubric, comparison of ability on the job of different workers is permissible.

These unique features create the opportunity to perform empirical tests and develop theoretical models that are either not possible or lack important components when estimated with other data. The existence of performance evaluation allows for a simple test of statistical discrimination. Specifically, the expected value of a worker's performance on the job, conditional on the receipt of an imperfect signal of ability, yields an equation that is estimable by OLS, whereby performance evaluation is regressed on individual and group characteristics. While an exact test of statistical discrimination cannot be performed due to the relevant measures being imbedded in a ratio containing two parameters, the equality of signal reliability across groups can be tested. In the first period, there does not appear to be a difference in signal qualities between men and women, but there is between blacks and whites. To further explore the possibility that statistical discrimination is present, this same test is conducted for all employment years. Across race, evidence of a difference in the reliability of signals persists throughout the first five employment years but disappears thereafter. These results are robust to several specifications, suggesting that the existence

of statistical discrimination, imbedded in, but not defined by differences in, signal quality, cannot necessarily be rejected.

If the state does, in fact, statistically discriminate against blacks, but later refines its beliefs according to the rules of Bayesian updating, the employer is predicted to anticipate greater ability, on average, the noisier is the initial signal. Therefore, as concluded in other studies of statistical discrimination, blacks would seem to benefit by extending their employment spell with the state so as to have the opportunity to be observed for a longer period of time. Throughout their tenure with the state, then, race should matter less in employment outcomes, and performance evaluations should be more influential in the determination processes.

In order to test these hypotheses, a five-equation model of performance evaluation, promotion, earnings, salary grade, and employment decisions, is estimated simultaneously, allowing for permanent and time-varying heterogeneity. While mirroring the results of many other wage and promotion studies, one less common finding is that the estimated coefficients suggest that, after controlling for productivity, blacks are not expected to earn less, or operate at a significantly lower salary grade, than whites. The coefficients on black and female are either small and negative or not significantly different from zero. Furthermore, in most equations, race and gender interacted with tenure is not significantly different from zero, further supporting the notion that as the state observes a worker and evaluates his or her performance, race by itself is not a significant determinant of the outcomes of interest. Where the interactions are significant, they are very small in magnitude.

Interventions considered include treating all workers as white and/or male, assigning all workers an education or occupation according to the respective white male distributions, promoting all workers during their third employment year, and assigning all workers a starting salary grade defined by the empirical distribution for white males. The intervention that produced the most notable results, particularly in terms of earnings, is the starting salary grade restriction. This also serves as evidence that if all workers were assigned a higher starting salary grade, that would benefit them more than simply being treated as a white male worker.

# Appendix A: Variable Construction

## A.1 Promotion/Demotion

According to the NC OSP, a promotion (demotion) is defined as an increase (decrease) in salary grade, accompanied by a change in the worker's position-specific personnel number. The "last action taken" variable also contains a code for "promotion (demotion) from." Since salary grade is not available for every employment-year observation, and some salary grades are recoded as missing (detailed below), a promotion (demotion) is also said to have occurred if "last action taken" is coded as such. In cases where it appears a promotion and demotion occurred simultaneously (possible if "last action taken" indicates a promotion (demotion) occurred at the same time personnel number changes and salary grade decreases (increases)), if salary and salary grade change in the same direction, it is assumed "last action take" is miscoded. If salary and salary grade movement conflict, those individuals are dropped from the sample.

action taken" indicates a promotion (demotion) occurred at the same time personnel number changes and salary grade decreases (increases). Upon inspection of "last action taken," salary, and grade, 20 of the 36 had incorrect "last action taken" codes (for instance, salary and grade may both decrease, but "last action taken" indicates a promotion occurred). The remaining 16 cases involved conflicting changes in grade and salary and are eliminated from the sample.

## A.2 Age

The data include a measure of age, as well as the individual's birth date. A second measure of age is calculated as the number of years between June 30 of a particular year and the worker's birth date. employment with the state. If reported age and calculated age differ in any of the ten years, the calculated measure of age is used as long as the two are the same in at least one year (in these cases, the years in which they differ typically report the worker as being between 80 and 100 years old). If reported age and calculated age are never equal, age is reported as missing. Similarly, if a worker's birth date is never available, coded invalidly (such as 236305 or 64610), or coded 10101, age is reported as missing.

## A.3 Race

The remaining 260 workers report variation in their race and are dropped from the sample. Race is coded as "White," "Black," "Hispanic," "Asian-American," "American-Indian or Alaskan Native," and "other." If no information on race is available, or if race appears to change during the employee's years of employment, it is coded as missing, and those individuals are dropped from the sample. In the end, only workers who are consistently reported as "White" or "Black" are used in the final sample.

It is worth nothing that according to the NC OSP, "The state employs only United States citizens or aliens who can provide proof of identity and work authorization with three working days of employment."

## A.4 Gender

A study of this nature necessitates that no worker have gender coded as missing. Therefore, if reported gender varies during the worker's tenure with the state, the most commonly-occurring report of gender is used all years during which the individual is employed. If gender is never reported, the individual is dropped from the sample.

## A.5 Tenure

The data include a measure of aggregate service months each year, as well as the original date the employee began working for the state of North Carolina. If neither is ever reported, or if the worker's entry date changes throughout the sample, experience is coded as missing. Note that when hire date changes, this does not necessarily reflect that the worker left the state and returned. Workers who left and returned most often have a constant entry date, and most individuals with changing entry dates had only one employment spell. Experience is also coded as missing if there exists no valid entry date and reported aggregate service never changes during the worker's employment. case for 57 workers.

Based on entry date, tenure is manually calculated each year. If calculated tenure exceeds reported aggregate service, it is assumed the individual left the state and returned at some point. Therefore, aggregate service is used as the tenure measure. If the worker's

hire date is unavailable and reported aggregate service changes during the sample period, reported service is used. If aggregate service is unavailable or reported service is constant during the sample period (always missing, zero, or some unchanging positive value), and hire data is available and unchanging, calculated tenure is used.

Of the workers who have constant hire dates and varying reports of aggregate service, but whose reported aggregate service exceeds calculated tenure by more than six months in every employment year, there appears to have been a coding error. Though the reported service values appear too large, they are used as the measure of tenure.

After coding tenure as detailed above, if an individual has zero months of tenure in multiple years (reported aggregate service months are constant during a portion of the sample period, though not in every period), the first nonzero observation is used to calculate tenure for all previous periods. If calculated tenure is positive in each employment year, tenure is recoded in this manner. However, for workers with tenure less than zero in at least one of the previous employment years, tenure is considered missing.

For all workers whose tenure is still missing, a random draw is taken from the uniform distribution for the first employment year and observed tenure is assigned according to this draw within the actual observed tenure distribution. The final sample contains only workers who have 0-12 months of reported service at the start of the first observation.

## A.6 Education

Both "employee education level" and "education level required" are reported in the data and are supposed to be equal to one another. In some cases (73 occurrences in the 967,473 total observations), "employee education level" is missing or listed as "other" or "miscellaneous." When that occurs, "education level required" is used as the employee's education level. Categorical education levels include less than high school (workers with education reported as "less than 9th grade" or "high school, not graduated"), high school, more than high school but no degree (workers with education reported as "high school + 1 year," "high school + 2 years," or "high school + 3 years"), college graduate, and graduate degree (workers with education reported as "masters," "phd.," "assoc. degree," "dentist," "attorney," or "physician").

Education is considered missing if reported as "miscell.," "other," or "miscellaneous, doctors, lawyers, medical profession." Excluding one-year spells, reported education does not change while employed with the state for most workers. If education is missing during any of their years with the state, it is imputed as the level reported in other years.

If education is missing during any of the years employed with the state, it is assumed to be the previous reported level (or next, in the case of a worker whose education is not reported in the first year he or she is employed with the state). For instance, a worker whose education is first reported to increase from "high school" to "more than high school, no degree" in 1997 is assumed to be a high school graduate in all years prior to 1997 and a high school graduate with additional years of schooling in all years after and including 1997.

The remaining workers report a decrease and/or multi-level categorical increase (for instance, directly from "high school graduate" to "graduate degree") in their education level during their employment with the state. Like the workers with no report of education, education is coded as missing for these individuals. The final sample contains only individuals whose education is not considered missing throughout the sample period and whose missing education levels could be imputed from other years of data for that worker.

## A.7 Salary/Wage

A record of salary is present for all workers for each year they worked with the state. There exist no missing observations. However, an annual salary is indistinguishable from hourly and monthly earnings as reported. The only way to identify how earnings are reported is to examine the integer of earnings. If the integer of earnings ("wage") differs from reported earnings, it appears that the worker earns an hourly wage.

Earnings are considered hourly if salary and its integer do not differ and annual otherwise. There exist 1020 observations where salary and its integer do not differ, but salary is less than or equal to \$85. In these cases, it appears as if the individual's hourly wage is an even dollar amount (e.g., \$14.00), so earnings are coded as hourly. For one worker who is employed in each of the ten sample years, he reportedly earns \$195.00 in every period. This individual's record indicates that his hours per year vary from 3 months to 12 months. As these data do not seem reliable, this salary of \$195 is also coded as hourly, and thus,

not used in estimation. The next smallest salary is $750 (followed by $855, $1000, $1350, $1500, $2000, $2500, $3000, $3500, $3510, etc.), which seems less likely to be a (pattern of) hourly wages, particularly if these individuals began working with the state near the end of a sample period and earned only a partial annual salary.

annual salaries and are thus used in estimation.

## A.8 Salary Grade

The North Carolina salary schedule includes grades 50-96. However, in addition to 50-96, the data contain salary grades 0, 00, 03, 04, 07, 32, 33, 37, A1, A2, A3, A4, A5, B, B1, B2, B3, B4, C, C1, C2, C3, C4, D, D2, D3, D4, E, G, FR (flat rate), and NG (no grade, used for trainees). In estimation, salary grade will be used a measure of ranking, and as such, FR and NG have no meaning and will be coded as missing. According to the NC OSP, 0, 03, 04, and 07 should be considered NG, and 00 is treated as bad data on temporary workers. 32, 33, and 37 are likely teachers (in hospitals, for instance, whose salary grades were later consolidated to FR) whose salary grades are invalid and should be considered NG. Finally, there appears to be a hierarchical structure to grades A1 through G, though it is not clear how they compare to grades 50-96. Therefore, all grades that do not fall within the 50-96 will be treated as missing.

# Appendix B: Sample Selection

Of the 1,081,533 employment positions offered by the state over a ten year period (1994-2003), 114,060 were vacant positions, leaving 967,473 valid filled positions (in some cases, a worker may hold multiple jobs in a single year). Of those, 190,784 were unique individuals. The sample used in estimation contains 23,123 unique black or white individuals, each with a valid set of dependent variables and with the following summary statistics. The following sections detail the selection of the sample, as well as the racial and gender characteristics of the employees dropped from the final sample.

## B.1 One Job with the State at a Time

857 workers (6,925 observations) were dropped from the sample because they held multiple jobs with the state in at least one of the ten sample years.

Table B.1: Description of Individuals Dropped from Estimation Sample Due to Multiple Jobs in a Given Year

| | White | Black | Spanish American | Asian American | American Indian | Total |
|---|---|---|---|---|---|---|
| | 118 | 49 | 3 | 0 | 2 | 172 |
| Male | 68.60 | 28.49 | 1.74 | 0 | 1.16 | 100% |
| | 19.28 | 21.49 | 42.86 | 0 | 28.57 | 20% |
| | 494 | 179 | 4 | 6 | 5 | 688 |
| Female | 71.80 | 26.02 | 0.58 | 0.87 | 0.73 | 100% |
| | 90.72 | 78.51 | 57.14 | 100 | 71.43 | 80% |
| | 612 | 228 | 7 | 6 | 7 | 860 |
| Total | 71.16 | 26.51 | 0.81 | 0.70 | 0.81 | 100% |
| | 100 | 100 | 100 | 100 | 100 | 100% |

Note
Three individuals have an equal number of each of two race reports; thus, 860 races are reported for 857 individuals.

## B.2 Age 25 or Older at the Time of Hire

25,079 individuals were dropped because they were less than 25 when first observed. An additional 22 were eliminated because no age was available. 30 individuals had a reported birthday of January 1, 01, and were dropped as a result. Finally, 291 workers had changing birthdates, which made the determination of age impossible. A total of 25,422 individuals were dropped due to age limitations.

Table B.2: Description of Individuals Dropped from Estimation Sample Due to Age

| | White | Black | Spanish American | Asian American | American Indian | Other | Total |
|---|---|---|---|---|---|---|---|
| | 8,813 | 2,813 | 123 | 113 | 178 | 0 | 12,039 |
| Male | 73.20 | 23.36 | 1.02 | 0.94 | 1.48 | 0 | 100% |
| | 50.62 | 39.24 | 42.71 | 38.70 | 55.11 | 0 | 47.25% |
| | 8,589 | 4,352 | 165 | 179 | 145 | 1 | 13,431 |
| Female | 63.95 | 32.40 | 1.23 | 1.33 | 1.08 | 0.01 | 100% |
| | 49.34 | 60.73 | 57.29 | 61.30 | 44.89 | 25 | 52.71% |
| | 7 | 2 | 0 | 0 | 0 | 3 | 12 |
| Missing | 58.33 | 16.67 | 0 | 0 | 0 | 25 | 100% |
| | 0.04 | 0.03 | 0 | 0 | 0 | 75 | 0.05% |
| | 17,409 | 7,166 | 288 | 292 | 323 | 4 | 25,482 |
| Total | 68.32 | 28.12 | 1.13 | 1.15 | 1.27 | 0.02 | 100% |
| | 100 | 100 | 100 | 100 | 100 | 100 | 100% |

Note
53 individuals have two race reports, one worker has three race reports, and five have equal reports of female and male; thus, 25,482 races and genders are reported for 25,422 individuals.

## B.3 Race Reported as Black or White

283 workers are excluded from the sample due to inconsistent reports of race, as well as the small sample (5,410 total) of the workers whose race is listed as "other" (American-Indian, Asian-American, Spanish-American, or "other").

Table B.3: Description of Individuals Dropped from Estimation Sample Due to Race

| | | White | Black | Spanish American | Asian American | American Indian | Other | Total |
|---|---|---|---|---|---|---|---|---|
| "Other" Race | Male | | | 739 | 807 | 1,121 | 0 | 2,667 |
| | | | | 27.71 | 30.26 | 42.03 | 0 | 100% |
| | | | | 48.88 | 41.99 | 56.79 | 0 | 49.30% |
| | Female | | | 773 | 1,115 | 853 | 2 | 2,743 |
| | | | | 28.18 | 40.65 | 31.10 | 0.07 | 100% |
| | | | | 51.12 | 58.01 | 43.21 | 100 | 50.70% |
| | Total | | | 1,512 | 1,922 | 1,974 | 2 | 5,410 |
| | | | | 27.95 | 35.53 | 36.49 | 0.04 | 100% |
| | | | | 100 | 100 | 100 | 100 | 100% |
| Varying Race | Male | 91 | 46 | 32 | 23 | 57 | 0 | 249 |
| | | 36.55 | 18.47 | 12.85 | 9.24 | 22.89 | 0 | 100% |
| | | 44.61 | 30.87 | 40 | 54.76 | 60.64 | | 43.76% |
| | Female | 113 | 103 | 48 | 19 | 37 | 0 | 320 |
| | | 35.31 | 32.19 | 15 | 5.94 | 11.56 | 0 | 100% |
| | | 55.39 | 69.13 | 60 | 45.24 | 39.36 | 0 | 56.24% |
| | Total | 204 | 149 | 80 | 42 | 94 | 0 | 569 |
| | | 35.85 | 26.19 | 14.06 | 7.38 | 16.52 | 0 | 100% |
| | | 100 | 100 | 100 | 100 | 100 | 0 | 100% |

Note

281 individuals have two reports of race, one has three reports of race, and one has four reports. Thus, there are 569 reports of race for 283 workers.

## B.4 Inconsistent Reports of Gender

22 workers are have equal reports of being male and female. Race characteristics are reported below. Note that when gender varied as reported, but one gender was documented more frequently than the other, the more commonly-reported gender was used. Furthermore, in the age exclusion section, 12 workers had no report of gender and have thus already been excluded from the sample.

Table B.4: Composition of Individuals Dropped: Gender

| | N | Percent |
|---|---|---|
| White | 16 | 72.73% |
| Black | 6 | 27.27% |

## B.5 Education

Workers were dropped from the sample if no report of education was available (831 individuals), education decreases during the individual's tenure with the state (374 workers), or if education jumps more than one level during an unreaslistic number of years, such as an increase from less than a high school diploma to a college degree in three years (144 workers).

## B.6 First Year with the State in 1994 or Later

In order to model unobserved heterogeneity, only workers who are new employees of the state when first observed are used in estimation. A total of 83,820 individuals are dropped because of tenure information. Of those, 192 did not have months of service or a valid entry date from which tenure could be calculated. The remaining 83,628 are eliminated because number of months of service was more than 12 when first observed. The demographic characteristics of these workers follows.

Table B.5: Description of Individuals Dropped from Estimation Sample Due to Education

| | White | Black | Total |
|---|---|---|---|
| Male | 711 | 221 | 932 |
| | 76.29 | 23.71 | 100% |
| | 75.72 | 53.90 | 69.09% |
| Female | 228 | 189 | 417 |
| | 54.68 | 45.32 | 100% |
| | 24.28 | 46.10 | 30.91% |
| Total | 939 | 410 | 1,349 |
| | 69.61 | 30.39 | 100% |
| | 100 | 100 | 100% |

Table B.6: Description of Individuals Dropped from Estimation Sample Due to Tenure

| | White | Black | Total |
|---|---|---|---|
| Male | 31,196 | 9,742 | 40,938 |
| | 76.20 | 23.80 | 100% |
| | 50.38 | 44.48 | 48.84% |
| Female | 30,724 | 12,158 | 42,882 |
| | 71.65 | 28.35 | 100% |
| | 49.62 | 55.52 | 51.16% |
| Total | 61,920 | 21,900 | 83,820 |
| | 73.87 | 26.13 | 100% |
| | 100 | 100 | 100% |

## B.7 Invalid Independent Variables

In addition to the demographic variables described above (age, gender, race), some individuals have independent variables that are missing or otherwise coded in such a way that the observations must be eliminated from the final sample. Specifically, 7,162 workers have one or more earnings observation that is an hourly wage, rather than an annual salary, in their first employment spell. 57 workers are missing information about the EEO category in which their job is classified, and eight workers are dropped because they hold a position located somewhere other than the state of North Carolina (Atlanta, Washington, DC, or Chicago). Therefore, 7,227 workers are dropped from the sample due to missing or invalid independent variables other than demographic characteristics described above.

Table B.7: Description of Individuals Dropped from Estimation Sample Due to Independent Variables

| | White | Black | Total |
|---|---|---|---|
| Male | 2,034<br>69.90<br>44.46 | 876<br>30.10<br>33.03 | 2,910<br>100%<br>40.27% |
| Female | 2,541<br>58.86<br>55.54 | 1,776<br>41.14<br>66.97 | 4,317<br>100%<br>59.73% |
| Total | 4,575<br>63.30<br>100 | 2,652<br>36.70<br>100 | 7,227<br>100%<br>100% |

## B.8 Missing Dependent Variables

Finally, 43,271 individuals were eliminated due to missing dependent variables. Among them, 3,706 are dropped due to missing salary grade, 25,263 are missing performance evaluation, and the remaining 14,302 are missing both salary grade and performance evalauation. A

total of 58,804 employment-year observations have invalid (outside the "unsatisfactory" to "outstanding" range) or missing performance evaluations. Of those, 28,827 (49.02%) are coded as "not enough time in job to evaluate."

Table B.8: Description of Individuals Dropped from Estimation Sample Due to Missing Dependent Variables

| | White | Black | Total |
|---|---|---|---|
| Male | 14,734 | 6,491 | 21,225 |
| | 69.42 | 30.58 | 100% |
| | 51.14 | 44.89 | 49.05% |
| Female | 14,077 | 7,969 | 22,046 |
| | 63.85 | 36.15 | 100% |
| | 48.86 | 55.11 | 50.95% |
| Total | 28,811 | 14,460 | 43,271 |
| | 66.58 | 33.42 | 100% |
| | 100 | 100 | 100% |

# Appendix C: Descriptive Statistics

Table C.1: Descriptive Statistics

| | Number of Observations | Mean/Percent | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| Non-Time-Varying Demographic Variables | | | | | |
| Age at EOD[1] | 23,123 | 37.12 | 9.47 | 25 | 77 |
| Sex (Female = 1) | 23,123 | 0.57 | 0.50 | 0 | 1 |
| Race (Black = 1) | 23,123 | 0.31 | 0.46 | 0 | 1 |
| Handicap Status (Yes = 1) at EOD | 23,123 | 1.47 | 0.12 | 0 | 1 |
| Veteran Status (Yes = 1) at EOD | 23,123 | 11.33 | 0.32 | 0 | 1 |
| Time-Varying Variables | | | | | |
| Evaluation | 85,180 | 4.13 | 0.70 | 1 | 5 |
| Unsatisfactory (1) | | 0.06 | | | |
| Below Good (2) | | 0.56 | | | |
| Good (3) | | 17.35 | | | |
| Very Good (4) | | 50.85 | | | |
| Outstanding (5) | | 31.19 | | | |
| Education Level | 85,180 | 3.11 | 1.09 | 1 | 5 |
| Less than High School | | 3.45 | | | |
| High School | | 32.94 | | | |
| More than High School | | 24.41 | | | |
| Four Year Degree | | 27.54 | | | |
| Graduate Degree | | 11.66 | | | |
| Annual Earnings | 85,180 | 27,881.97 | 10,713.21 | 4,492.17 | 111,785.30 |
| Spell Length (in months) | 85,180 | 34.77 | 26.37 | 0 | 120 |
| Federal EEO Category | 85,180 | | | | |
| Officials and Administrators | | 1.10 | | | |
| Professionals | | 28.33 | | | |
| Technicians | | 17.40 | | | |
| Protective Service | | 6.73 | | | |
| Paraprofessionals | | 1.19 | | | |
| Office and Clerical | | 25.66 | | | |
| Skilled Craft | | 9.65 | | | |
| Service and Maintenance | | 9.93 | | | |

Note
1) This is the worker's age at the time of Entry on Duty.

Table C.2: Time-Varying Descriptive Statistics by Race and Gender

| | Number of Observations | Mean/Percent | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Annual Earnings | | | | | |
| White Men | 28,377 | 31,914.31 | 11,913.77 | 7,233.76 | 111,785.30 |
| Black Men | 9,382 | 24,270.11 | 8,605.11 | 6,396.31 | 78,431.18 |
| White Women | 31,157 | 27,759.98 | 10,166.65 | 5,634.23 | 96,069.32 |
| Black Women | 16,264 | 23,163.69 | 7,386.57 | 4,492.17 | 84,218.53 |
| Evaluation | | | | | |
| White Men | 28,377 | 4.14 | 0.67 | 1 | 5 |
| Black Men | 9,382 | 3.82 | 0.69 | 1 | 5 |
| White Women | 31,157 | 4.29 | 0.68 | 1 | 5 |
| Black Women | 16,264 | 3.96 | 0.71 | 1 | 5 |
| Ever Promoted (Yes = 1) | | | | | |
| White Men | 7,287 | 0.18 | 0.39 | 0 | 1 |
| Black Men | 2,645 | 0.16 | 0.37 | 0 | 1 |
| White Women | 8,754 | 0.17 | 0.38 | 0 | 1 |
| Black Women | 4,437 | 0.16 | 0.37 | 0 | 1 |
| Ever Demoted (Yes = 1) | | | | | |
| White Men | 7,287 | 0.01 | 0.11 | 0 | 1 |
| Black Men | 2,645 | 0.02 | 0.13 | 0 | 1 |
| White Women | 8,754 | 0.02 | 0.13 | 0 | 1 |
| Black Women | 4,437 | 0.02 | 0.14 | 0 | 1 |

Table C.3: Descriptive Statistics (Non-time Varying or at EOD) by Race and Gender

| | White Men (7,287) | Black Men (2,645) | White Women (8,754) | Black Women (4,437) |
|---|---|---|---|---|
| Education at EOD | | | | |
| Less than High School | 3.29[1] | 7.11 | 1.45 | 5.05 |
| High School | 28.50 | 45.26 | 24.81 | 39.24 |
| More than High School | 20.74 | 21.21 | 24.34 | 29.10 |
| 4-year Degree | 32.81 | 21.44 | 33.48 | 20.80 |
| Graduate Degree | 14.66 | 4.99 | 15.91 | 5.81 |
| Federal EEO Category at EOD | | | | |
| Officials and Administrators | 1.32 | 0.42 | 0.65 | 0.47 |
| Professionals | 32.07 | 16.22 | 31.03 | 15.39 |
| Technicians | 15.89 | 19.81 | 14.90 | 23.94 |
| Protective Service | 10.48 | 12.44 | 1.52 | 4.98 |
| Paraprofessionals | 0.85 | 0.76 | 0.89 | 0.70 |
| Office and Clerical | 10.99 | 10.25 | 43.36 | 36.83 |
| Skilled Craft | 21.89 | 13.76 | 1.61 | 0.54 |
| Service and Maintenance | 6.50 | 26.35 | 6.04 | 17.15 |
| Number of Promotions | | | | |
| 0 | 79.26 | 81.81 | 80.13 | 80.96 |
| 1 | 16.11 | 15.05 | 15.95 | 15.66 |
| 2 | 3.73 | 2.87 | 3.39 | 2.75 |
| 3 | 0.78 | 0.26 | 0.48 | 0.56 |
| 4 | 0.11 | . | 0.03 | 0.07 |
| 5 | . | . | 0.01 | . |
| Yrs Tenure at First Promotion | 3.42 | 3.30 | 3.35 | 3.40 |
| Grade Change\|Promotion | 3.24 | 3.31 | 3.04 | 2.87 |
| 1 | 13.15 | 11.76 | 10.04 | 7.98 |
| 2 | 38.86 | 35.47 | 47.14 | 56.83 |
| 3 | 14.84 | 18.18 | 12.25 | 9.67 |
| 4 | 12.72 | 14.97 | 15.14 | 12.86 |
| 5 | 7.50 | 6.60 | 4.52 | 3.29 |
| 6 | 3.75 | 3.03 | 4.66 | 3.79 |
| 7 | 2.80 | 3.21 | 2.55 | 1.79 |
| 8 | 2.75 | 4.10 | 1.83 | 2.39 |
| 9 | 1.74 | 1.43 | 0.86 | 0.60 |
| 10+ | 1.89 | 1.25 | 1.01 | 0.80 |

Note
1) This number represents the percentage of white men with less than a high school education, the percent with a high school diploma, etc.

Table C.4: Salary Grade and Occupation at the Time of Hire

| | White Men | Black Men | White Women | Black Women |
|---|---|---|---|---|
| Salary Grade at Hire | 64.27 | 58.75 | 62.11 | 58.80 |
| | (6.77) | (6.50) | (6.25) | (5.57) |
| Officials & Administrators | 74.75 | 74.44 | 72.08 | 73.57 |
| | (5.92) | (4.78) | (7.17) | (7.39) |
| Professionals | 70.26 | 67.27 | 68.47 | 66.58 |
| | (5.08) | (5.71) | (4.91) | (5.32) |
| Technicians | 63.08 | 59.01 | 61.09 | 58.05 |
| | (3.95) | (3.40) | (4.16) | (2.58) |
| Protective Service | 62.96 | 61.78 | 61.92 | 61.71 |
| | (2.99) | (2.55) | (3.11) | (2.00) |
| Paraprofessionals | 62.39 | 62.25 | 62.64 | 61.80 |
| | (2.68) | (3.45) | (2.86) | (3.05) |
| Office & Clerical | 59.05 | 57.91 | 58.16 | 57.87 |
| | (3.85) | (3.51) | (1.94) | (1.85) |
| Skilled Craft | 60.81 | 57.37 | 58.12 | 55.90 |
| | (4.44) | (5.00) | (5.40) | (5.41) |
| Service & Maintenance | 54.43 | 51.69 | 52.67 | 51.29 |
| | (3.98) | (2.80) | (3.50) | (2.61) |

Table C.5: Tenure (in Months) at the Time of Promotion

| | White Men | Black Men | White Women | Black Women |
|---|---|---|---|---|
| Employment Year (First Promotion) | | | | |
| Second | 38.44 | 41.89 | 39.24 | 37.85 |
| Third | 25.98 | 22.74 | 26.59 | 25.89 |
| Fourth | 14.79 | 18.74 | 14.82 | 16.97 |
| Fifth | 9.73 | 7.16 | 9.35 | 9.52 |
| Sixth | 5.80 | 4.00 | 4.76 | 5.25 |
| Seventh | 2.40 | 3.16 | 2.47 | 1.83 |
| Eighth | 1.47 | 1.68 | 1.59 | 1.95 |
| Ninth | 0.67 | 0.63 | 1.06 | 0.24 |
| Tenth | 0.73 | - | 0.12 | 0.49 |
| Employment Year (All Promotions) | | | | |
| Second | 30.07 | 35.04 | 31.90 | 30.97 |
| Third | 23.61 | 21.30 | 24.01 | 23.38 |
| Fourth | 15.74 | 18.49 | 16.88 | 17.98 |
| Fifth | 12.14 | 9.51 | 11.24 | 11.59 |
| Sixth | 8.39 | 6.69 | 6.55 | 6.79 |
| Seventh | 4.64 | 5.11 | 4.21 | 4.10 |
| Eighth | 3.23 | 1.94 | 2.92 | 2.80 |
| Ninth | 1.09 | 1.76 | 1.96 | 1.30 |
| Tenth | 1.09 | 0.18 | 0.33 | 1.10 |

Table C.6: Employment Spells in Sample

| | White Men | Black Men | White Women | Black Women |
|---|---|---|---|---|
| Number of Employment Spells | | | | |
| One | 96.97 | 95.16 | 95.42 | 94.57 |
| Two | 2.94 | 4.65 | 4.34 | 5.27 |
| Three | 0.10 | 0.15 | 0.23 | 0.16 |
| Four | . | 0.04 | 0.01 | . |
| Length of First Observed Spell | | | | |
| One Year | 22.96 | 28.17 | 26.89 | 24.99 |
| Two Years | 16.74 | 18.26 | 18.39 | 16.41 |
| Three Years | 14.11 | 12.93 | 13.88 | 14.33 |
| Four Years | 10.50 | 9.98 | 9.55 | 12.19 |
| Five Years | 9.44 | 9.04 | 9.42 | 9.62 |
| Six Years | 7.30 | 5.48 | 6.44 | 6.49 |
| Seven Years | 5.60 | 5.29 | 4.99 | 6.20 |
| Eight Years | 5.60 | 4.76 | 4.54 | 4.15 |
| Nine Years | 3.87 | 2.80 | 3.54 | 2.77 |
| Ten Years | 3.88 | 3.29 | 2.35 | 2.84 |

Table C.7: Entry into Employment

| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | Cumulative |
|---|---|---|---|---|---|---|---|---|---|---|---|
| New | 2,338 | 2,204 | 2,683 | 2,501 | 2,547 | 2,752 | 2,413 | 2,286 | 1,717 | 1,682 | 23,123 |
| Entrants | 10.11% | 9.53% | 11.60% | 10.82% | 11.02% | 11.90% | 10.44% | 9.89% | 7.43% | 7.27% | 100% |
| Number of | 2,338 | 4,011 | 5,896 | 7,322 | 8,650 | 10,053 | 10,908 | 11,562 | 11,985 | 12,455 | |
| Employees | 2.74% | 4.71% | 6.92% | 8.60% | 10.15% | 11.80% | 12.81% | 13.57% | 14.07% | 14.62% | |

# Appendix D: Data Limitations

## D.1 Employment Alternatives

When a worker's employment at the state is terminated (either voluntarily or involuntary), neither the reason for leaving nor the new destination is clear. The data contain the date and description of the "Last Personnel Action on Employee," which in theory, should allow the researcher to determine the exact reason for departure. However, if the employee notifies the state that he is quitting in favor of alternative employment, but a subsequent personnel action is taken during the same time period, the new destination will be replaced with the most recent action taken. Furthermore, while there exist 157 detailed action codes, only 69 actually appear in the data.[22] If an employee works for the state in one time period but not the next, all that is clear is that his tenure was terminated.

## D.2 Involuntary Termination

Related to the lack of information about the worker's destination after leaving the state, none of the action codes appearing in the data suggest that a worker was fired. In much the same way a future destination may be masked by a subsequent personnel code, if an action is taken after the worker is fired, the econometrician is unable to detect an involuntary termination. It is not clear why such separations do not appear in the data, but there does

[22]The action codes which appear include: Fill by Temporary, Position Transferred To, Position Title Change, Range Revision on Position, Remarks Only, EOD (Entry on Duty) - New Hire, Salary Adjustment, Performance Increase, Range Revision, Reallocation - Employee, Promotion From, Demotion From, Re-Statement, Appointment Change From, Increment Cancelation, Reassignment From, Performance Bonus, Did Not Report, Temporary Assignment Terminated, Other Employment, Separation - Other, Legislative Increase (Automated Update), Accelerated Pay Plan Salary Adjustment, Initial Employee Entry, Broad Banded Area Change, Broad Banded Level Change, Grade-Band Transfer, Broad Banded Job Change, Broad Banded Salary Adjustment, Cancel COLA and/or CGRA, Cancel Legislative Increase, Judicial Automatic Salary Adjustment, Promotional Increase Granted After Effective Date, Reallocation Increase Granted After Effective Date, Range Revision Increase Granted After Effective Date, Special Entry Rate Increase, Geographic Differential, Geographic Differential Increase After Effective Date, Special Salary Adjustment - Retention, Special Salary Adjustment - Equity, Accelerated Pay Plan Salary Adjustment, Salary Adjustment - Trainee, Acting Capacity Promotion, Return From Acting Capacity, Salary Adjustment - Lead Worker, Cancel Salary Adjustment - Lead Worker, Reallocation - Trainee, In-Range - Higher Level, In-Range - Increased Variety and Scope, In-Range - Equity, In-Range - Retention, In-Range Turnover, In-Range - Other Labor Market, In-Range - Skill Based, Cancel In-Range, Demotion (Personal Conduct), Demotion (Unsatisfactory Performance), Demotion (Grossly Ineffective Job Performance), Reallocation Down (Personal Conduct), Reallocation Down (Unsatisfactory Job Performance), Reallocation Down (Grossly Ineffective Job Performance), Legislative Increase - CGRA Bonus, Legislative Increase - Performance Bonus, Legislative Increase - Comp Bonus, as well as five additional codes without descriptions.

not seem to be a way to identify when a worker has been fired by the state. As such, if a promotion (demotion) is conditional on having not been fired in the previous period, there does not exist a way to identify employees for whom the condition is not met.

## D.3 Potential Hires

Like most employment data sets, only applicants to a particular position who receive and accept a job offer from the state are included in the data. Nothing is known about the state's decision to hire the individuals for whom data are available relative to other applicants. Therefore, only workers who begin their tenure with the state during the sample period will be used in estimation and analysis. In other words, all individuals have 0-12 months of tenure when first observed, and in the case of multiple employments spells between 1994 and 2003, only the first is used.

## D.4 Outside Wages

The empirical concern with wages in this study is not unique to the NC OSP data. An employee's wage is not observed after he leaves the state. Therefore, it is not possible for the econometrician to compare the monetary benefits of an outside employment option with the employee's current salary offered by the state. One alternative is to use the average earnings within the state of North Carolina for the occupational category in which the employee was last observed. This approach is used, as it seems reasonable for the individual to consider the option of joining the private sector when making his next-period employment decision.

## D.5 Supervisor Demographic Information

One explanatory variable that might prove important in many of the outcomes is information about a particular worker's supervisor. Specifically, if one argument supporting the theory of statistical discrimination is that workers belonging to particular groups communicate differently than workers in the same group, it would be useful to know information about the supervisor making performance evaluation, promotion, etc. decisions. If the majority of managerial positions are filled by white employees, black workers may have difficulty

demonstrating their true productivity to a white supervisor. Therefore, of particular use to this study is the supervisor's race and gender. Codes in the data that would contain this information are no longer maintained, so the best attempt at obtaining these demographic characteristics would be to identify the worker with the highest salary grade in a particular department. A series of approximately eight budget codes exist which might allow for disaggregation of all positions into smaller departmental units, from which a supervisor could be isolated.

## D.6 Nature of the Data

Finally, the nature of the data may preclude generalization of the results of this study to other industries or the private sector. All individuals in the sample are employed by the (public sector) state of North Carolina. Furthermore, only employees of the state who are covered by the State Personnel Act (SPA) are included in the data.[23]

[23]Those employees exempt from the SPA and who are excluded from the data fall into one of the following four categories: Exempt from the Personnel Act (EPA) Professional, Faculty, Senior Academic Administrative Officer Tier-I (SAAO Tier-I), or Senior Academic Administrative Officer Tier-II.

# Appendix E: Derivation of Conditional (on original signal *and* evaluation) Expectation and Variance

In the basic statistical discrimination model, ability ($\alpha$) is conditioned on just the worker's signal ($s$) at the time of hire:

$$\begin{aligned} s &= \alpha + v \\ \alpha &\sim N(m, \sigma_\alpha^2) \\ v &\sim N(0, \sigma_v^2) \end{aligned}$$

$$\begin{aligned} E(s) = E(\alpha + v) &= E(\alpha) + E(v) = m \\ var(s) = var(\alpha + v) &= var(\alpha) + var(v) + 2\underbrace{cov(\alpha, v)}_{=0} = \sigma_\alpha^2 + \sigma_v^2, \text{ so that} \\ s &\sim N(m, \sigma_\alpha^2 + \sigma_v^2) \end{aligned}$$

The employer forms an expectation of a worker's ability, given the received signal. Using the joint density of $\alpha$ and $s$, as well as the marginal density of $\alpha$, the conditional expectation and variance is extracted.

$$f(\alpha|s) = \frac{f(\alpha, s)}{f(s)}, \text{ where}$$

$$f(s) = \frac{1}{\sqrt{2\lambda}\sigma_s} exp\Big[\frac{-(s-m)^2}{2\sigma_s^2}\Big] \text{ and}$$

$$f(\alpha, s) = \frac{1}{2\lambda\sigma_\alpha\sigma_s\sqrt{1-\lambda^2}} exp\Big[\frac{-\frac{(\alpha-m)^2}{\sigma_\alpha^2} + \frac{2\lambda(\alpha-m)(s-m)}{\sigma_\alpha\sigma_s} - \frac{(s-m)^2}{\sigma_s^2}}{2(1-\lambda^2)}\Big], \text{ where}$$

$$
\begin{aligned}
\lambda &= corr(\alpha, s) = \frac{E\Big[(\alpha - m)(s - m)\Big]}{\sigma_\alpha \sigma_s} \\
&= \frac{E\Big(\alpha s - \alpha m - ms + m^2\Big)}{\sigma_\alpha \sigma_s} \\
&= \frac{E(\alpha s) - mE(\alpha) - mE(s) + m^2}{\sigma_\alpha \sigma_s} \\
&= \frac{E\Big(\alpha(\alpha + v)\Big) - m^2}{\sigma_\alpha \sigma_s} \\
&= \frac{E\Big(\alpha^2 + \alpha v\Big) - m^2}{\sigma_\alpha \sigma_s} \\
&= \frac{E(\alpha^2) - m^2}{\sigma_\alpha \sigma_s} = \frac{\sigma_\alpha^2}{\sigma_\alpha \sigma_s} = \frac{\sigma_\alpha}{\sigma_s}
\end{aligned}
$$

Focusing on just the terms preceeding in $exp(\cdot)$ in $f(s|\alpha)$ and $f(\alpha)$, will reveal var$(\alpha|s)$.

$$
\begin{aligned}
\frac{\frac{1}{2\lambda\sigma_\alpha\sigma_s\sqrt{1-\lambda^2}}}{\frac{1}{\sqrt{2\lambda}\sigma_s}} &= \frac{\sqrt{2\lambda}\sigma_s}{2\lambda\sigma_\alpha\sigma_s\sqrt{1-\lambda^2}} \\
&= \frac{1}{\sqrt{2\lambda}\underbrace{\sigma_\alpha\sqrt{1-\lambda^2}}_{\text{statistical discrimination}}}
\end{aligned}
$$

Therefore, var$(\alpha|s) = \sigma_\alpha^2(1 - \lambda^2)$. To solve for the conditional expectation, E$(\alpha|s)$, simplify the ratio of $exp(\cdot)$ expressions and extract var$(\alpha|s) = \sigma_\alpha^2(1 - \lambda^2)$:

$$
\begin{aligned}
&\frac{exp\Big[\frac{-\frac{(\alpha-m)^2}{\sigma_\alpha^2} + \frac{2\lambda(\alpha-m)(s-m)}{\sigma_\alpha\sigma_s} - \frac{(s-m)^2}{\sigma_s^2}}{2(1-\lambda^2)}\Big]}{exp\Big[\frac{-(s-m)^2}{2\sigma_s^2}\Big]} \\
&= exp\Big[ - \frac{\frac{(\alpha-m)^2}{\sigma_\alpha^2} + \frac{2\lambda(\alpha-m)(s-m)}{\sigma_\alpha\sigma_s} - \frac{(s-m)^2}{\sigma_s^2}}{2(1-\lambda^2)} + \frac{(s-m)^2}{2\sigma_s^2}\Big] \\
&= exp\Big[ - \frac{\frac{(\alpha-m)^2}{\sigma_\alpha^2} + \frac{2\lambda(\alpha-m)(s-m)}{\sigma_\alpha\sigma_s} - \frac{(s-m)^2}{\sigma_s^2}}{2(1-\lambda^2)} + \frac{(s-m)^2}{2\sigma_s^2}\Big] \\
&= exp\Big[\frac{-(\alpha-m)^2\sigma_s^2 + 2\lambda\sigma_\alpha\sigma_s(\alpha-m)(s-m) - (s-m)^2\sigma_\alpha^2}{2(1-\lambda^2)\sigma_\alpha^2\sigma_s^2} + \frac{(s-m)^2}{2\sigma_s^2}\Big]
\end{aligned}
$$

$$
\begin{aligned}
&= exp\Big[\frac{-(\alpha-m)^2\sigma_s^2 + 2\lambda\sigma_\alpha\sigma_s(\alpha-m)(s-m) - (s-m)^2\sigma_\alpha^2}{2(1-\lambda^2)\sigma_\alpha^2\sigma_s^2} \\
&\qquad\qquad + \frac{(s-m)^2(1-\lambda^2)\sigma_\alpha^2}{2(1-\lambda^2)\sigma_\alpha^2\sigma_s^2}\Big] \\
&= exp\Big[\frac{-1}{2(1-\lambda^2)\sigma_\alpha^2}\Big[(\alpha-m)^2 - \frac{2\lambda\sigma_\alpha\sigma_s(\alpha-m)(s-m)}{\sigma_s^2} \\
&\qquad\qquad + \frac{(s-m)^2\sigma_\alpha^2}{\sigma_s^2} - \frac{(s-m)^2(1-\lambda^2)\sigma_\alpha^2}{\sigma_s^2}\Big]\Big] \\
&= exp\Big[\frac{-1}{2(1-\lambda^2)\sigma_\alpha^2}\Big[(\alpha-m)^2 - 2\lambda^2(\alpha-m)(s-m) + (s-m)^2\lambda^2 \\
&\qquad\qquad - (s-m)^2(1-\lambda^2)\lambda^2\Big]\Big] \\
&= exp\Big[\frac{-1}{2(1-\lambda^2)\sigma_\alpha^2}\Big[(\alpha-m)^2 - 2\lambda^2(\alpha-m)(s-m) + (s-m)^2\lambda^4\Big]\Big] \\
&= exp\Big[\frac{-1}{2(1-\lambda^2)\sigma_\alpha^2}\Big[(\alpha - \underbrace{m) - \lambda^2(s-m)}_{\text{mean}}\Big]^2\Big]
\end{aligned}
$$

Therefore, $\alpha|s \sim N\Big(m + \lambda^2(s-m), \sigma_\alpha^2(1-\lambda^2)\Big)$. Given the availability of performance evaluations, the firm is able to condition its expectation about a worker's ability on both her signal and her performance evaluation ($p$), i.e. $\alpha|s,h$. The same approach is used to solve for the conditional expectation and variance of $\alpha$, given $s$ and $h$, this time in matrix notation for simplicity.

As before,

$$\begin{aligned}
s &= \alpha + v \\
\alpha &\sim N(m, \sigma_\alpha^2) \\
v &\sim N(0, \sigma_v^2) \\
s &\sim N(m, \sigma_v^2 + \sigma_m u^2) \\
s|\alpha &\sim N(\alpha, \sigma_v^2) \\
\alpha|s &\sim N(m(1-\lambda^2) + \lambda^2 s, \sigma_\alpha^2(1-\lambda^2)), \text{ where } \lambda = \frac{\sigma_\alpha^2}{\sigma_s^2} \\
corr(s, \alpha) &= \frac{\sigma_\alpha}{\sigma_s} \text{ (see } \lambda \text{ from } \alpha|s)
\end{aligned}$$

Similarly,

$$\begin{aligned}
p &= \alpha + \kappa \\
\kappa &\sim N(0, \sigma_\kappa^2) \\
p &\sim N(m, \sigma_\kappa^2 + \sigma_\alpha^2) \\
p|\alpha &\sim N(\alpha, \sigma_\kappa^2) \\
\alpha|p &\sim N(m(1-\theta^2) + \theta^2 p, \sigma_\alpha^2(1-\theta^2)), \text{ where } \theta = \frac{\sigma_\alpha^2}{\sigma_p^2} \\
corr(p, \alpha) &= \frac{\sigma_\alpha}{\sigma_p} \text{ (see } \lambda \text{ from } \alpha|s)
\end{aligned}$$

Finally,

$$\begin{aligned} corr(p,s) &= \frac{E\Big[(p-E(p))(s-E(s))\Big]}{\sigma_p\sigma_s} \\ &= \frac{E\Big[(p-m)(s-m)\Big]}{\sigma_p\sigma_s} \\ &= \frac{E\Big(ps-pm-ms+m^2\Big)}{\sigma_p\sigma_s} \\ &= \frac{E(ps)-mE(p)-mE(s)+m^2}{\sigma_p\sigma_s} \\ &= \frac{E\Big[(\alpha+\kappa)(\alpha+v)\Big]-m^2}{\sigma_p\sigma_s} \\ &= \frac{E(\alpha^2+v\alpha+\kappa\alpha+\kappa v)-m^2}{\sigma_p\sigma_s} \\ &= \frac{E(\alpha^2)-m^2}{\sigma_p\sigma_s} = \frac{\sigma_\alpha^2}{\sigma_p\sigma_s} \end{aligned}$$

Bayes' Theorem, $f(A|B) = \frac{f(A)f(B|A)}{f(B)}$, is applied in this situation to find the expectation and variance of $\alpha$, conditioned on both $s$ and $h$. In other words,

$$f(\alpha|s,p) = \frac{f(\alpha)f(s,p|\alpha)}{f(s,p)} = \frac{f(\alpha,s,p)}{f(s,p)} \text{ since } f(s,p|\alpha) = \frac{f(\alpha,s,p)}{f(s,p)},$$

where, generally,

$$f(x_1,x_2,...x_n) = \frac{1}{(2\lambda)^{\frac{n}{2}}det(\Sigma)^{\frac{1}{2}}}exp\Big[\frac{1}{2}(x-\overline{x})^\top\Sigma^{-1}(x-\overline{x})\Big], \text{ where}$$

$$\overline{x} = \begin{bmatrix} \overline{x}_1 \\ \overline{x}_2 \\ \vdots \\ \overline{x}_n \end{bmatrix} = \begin{bmatrix} E(x_1) \\ E(x_2) \\ \vdots \\ E(x_n) \end{bmatrix} \text{ and } \Sigma = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \cdots & \sigma_{1n} \\ \sigma_{21} & \sigma_{22} & & \sigma_{2n} \\ \vdots & & \ddots & \vdots \\ \sigma_{n1} & \sigma_{n2} & \cdots & \sigma_{nn} \end{bmatrix}.$$

Define the following for $f(\alpha sh)$:

$$A = \begin{bmatrix} \alpha \\ s \\ p \end{bmatrix} \text{ with mean vector } B = \begin{bmatrix} m \\ m \\ m \end{bmatrix} \text{ and var-cov matrix, } C = \begin{bmatrix} \sigma_\alpha^2 & \sigma_\alpha^2 & \sigma_\alpha^2 \\ \sigma_\alpha^2 & \sigma_s^2 & \sigma_\alpha^2 \\ \sigma_\alpha^2 & \sigma_\alpha^2 & \sigma_p^2 \end{bmatrix}.$$

Similarly, for $f(sp)$:

$$D = \begin{bmatrix} s \\ p \end{bmatrix} \text{ with mean vector } E = \begin{bmatrix} m \\ m \end{bmatrix} \text{ and var-cov matrix, } F = \begin{bmatrix} \sigma_s^2 & \sigma_\alpha^2 \\ \sigma_\alpha^2 & \sigma_p^2 \end{bmatrix}.$$

Therefore,

$$\begin{aligned} \frac{f(\alpha sp)}{f(sp)} &= \frac{\frac{1}{(2\lambda)^{\frac{3}{2}} det(C)^{\frac{1}{2}}} exp\Big[ -\frac{1}{2}(A-B)^\top C^{-1}(A-B)\Big]}{\frac{1}{(2\lambda)^{\frac{2}{2}} det(F)^{\frac{1}{2}}} exp\Big[ -\frac{1}{2}(D-E)^\top F^{-1}(D-E)\Big]} \\ &= \frac{1}{(2\lambda)^{\frac{1}{2}}\sqrt{\frac{det(C)}{det(F)}}} exp\Big\{ -\frac{1}{2}\big[(A-B)^\top C^{-1}(A-B) - (D-E)^\top F^{-1}(D-E)\big]\Big\} \end{aligned}$$

In this setup, $\sqrt{\frac{det(C)}{det(F)}}$ is the standard deviation of $\alpha$, conditional on both the worker's signal and performance evaluation. Specifically, the standard deviation simplifies to $\sqrt{\frac{det(C)}{det(F)}} = \sqrt{\frac{\sigma_\alpha^2(\sigma_\alpha^2-\sigma_s^2)(\sigma_\alpha^2-\sigma_p^2)}{\sigma_s^2\sigma_p^2-\sigma_\alpha^4}}$, so $\text{var}(\alpha|s,p) = \frac{\sigma_\alpha^2(\sigma_\alpha^2-\sigma_s^2)(\sigma_\alpha^2-\sigma_p^2)}{\sigma_s^2\sigma_p^2-\sigma_\alpha^4} = \frac{\sigma_\alpha^2\sigma_v^2\sigma_\kappa^2}{\sigma_s^2\sigma_p^2-\sigma_\alpha^4}$.

Now, the $\text{var}(\alpha|s,p)$ can be extracted from the $exp(\cdot)$ term to determine $E(\alpha|s,p)$.

Here,

$$exp(\cdot) = exp\left\{ -\frac{1}{2}\frac{\big[s\sigma_\alpha^2(\sigma_p^2-\sigma_\alpha^2) - (\sigma_\alpha^2-\sigma_s^2)(p\sigma_\alpha^2 - m\sigma_\alpha^2 + m\sigma_p^2) + \alpha(\sigma_s^2\sigma_p^2-\sigma_\alpha^4)\big]^2}{2\sigma_\alpha^2(\sigma_\alpha^2-\sigma_s^2)(\sigma_\alpha^2-\sigma_p^2)(\sigma_s^2\sigma_p^2-\sigma_\alpha^4)} \right\}$$

Multiplying numerator and denominator by $(\sigma_s^2\sigma_p^2 - \sigma_\alpha^2)$ yields

$$exp\left\{ -\frac{\sigma_s^2\sigma_p^2-\sigma_\alpha^4}{2\sigma_\alpha^2(\sigma_\alpha^2-\sigma_s^2)(\sigma_\alpha^2-\sigma_p^2)} \left[\frac{s\sigma_\alpha^2(\sigma_p^2-\sigma_\alpha^2)}{(\sigma_s^2\sigma_p^2-\sigma_\alpha^4)} - \frac{(\sigma_\alpha^2-\sigma_s^2)(p\sigma_\alpha^2 - m\sigma_\alpha^2 + m\sigma_p^2)}{(\sigma_s^2\sigma_p^2-\sigma_\alpha^4)} + \alpha\right]^2 \right\}$$

$$= exp\left\{-\frac{\sigma_s^2\sigma_p^2-\sigma_\alpha^4}{2\sigma_\alpha^2\sigma_v^2\sigma_\kappa^2}\left[\alpha-\left(\frac{(\sigma_\alpha^2-\sigma_s^2)(p\sigma_\alpha^2-m\sigma_\alpha^2+m\sigma_p^2)}{(\sigma_s^2\sigma_p^2-\sigma_\alpha^4)}-\frac{s\sigma_\alpha^2(\sigma_p^2-\sigma_\alpha^2)}{(\sigma_s^2\sigma_p^2-\sigma_\alpha^4)}\right)\right]^2\right\}$$

$$= exp\left\{-\frac{\sigma_s^2\sigma_p^2-\sigma_\alpha^4}{2\sigma_\alpha^2\sigma_v^2\sigma_\kappa^2}\left[\alpha-\underbrace{\left(\frac{p\sigma_\alpha^2\sigma_v^2+m\sigma_\kappa^2\sigma_v^2+s\sigma_\alpha^2\sigma_\kappa^2}{\sigma_s^2\sigma_p^2-\sigma_\alpha^4}\right)}_{\mathrm{E}(\alpha|s,p)}\right]^2\right\}$$

Therefore, $(\alpha|s,p) \sim N\left(\frac{p\sigma_\alpha^2\sigma_v^2+m\sigma_\kappa^2\sigma_v^2+s\sigma_\alpha^2\sigma_\kappa^2}{\sigma_s^2\sigma_p^2-\sigma_\alpha^4}, \frac{\sigma_\alpha^2\sigma_v^2\sigma_\kappa^2}{\sigma_s^2\sigma_p^2-\sigma_\alpha^4}\right)$.

# Appendix F: Additional Results

Table F.1: Jointly-Estimated Equations with Unobserved Heterogeneity

| | Grade n = 62,057 | | Earnings n = 62,057 | | Evaluation (Eval = 5 Excl.) n = 62,057 Eval = 4 | | Eval = 3 | | Eval = 1-2 | | Promotion n = 62,057 | | Pr(Leave) n = 72,725 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Endogenous Variables | | | | | | | | | | | | | | |
| Salary Grade | | | 0.020 | * | 0.026 | * | 0.059 | * | -0.033 | | 0.727 | * | -0.056 | * |
| | | | (0.0002) | | (0.008) | | (0.013) | | (0.045) | | (0.012) | | (0.012) | |
| ln(Annual Earnings) | | | | | -0.396 | * | -1.253 | * | -0.709 | | 0.264 | | -0.470 | * |
| | | | | | (0.092) | | (0.133) | | (0.488) | | (0.135) | | (0.093) | |
| Performance Evaluation | | | | | | | | | | | -0.121 | * | -0.307 | * |
| | | | | | | | | | | | (0.026) | | (0.017) | |
| Current Promotion | | | | | | | | | | | | | -0.056 | |
| | | | | | | | | | | | | | (0.107) | |
| Lagged $t-1$ Endogenous Variables | | | | | | | | | | | | | | |
| Salary Grade$_{t-1}$ | 0.941 | * | | | | | | | | | | | | |
| | (0.004) | | | | | | | | | | | | | |
| Salary$_{t-1}$ | 0.328 | * | 0.764 | * | | | | | | | | | | |
| | (0.033) | | (0.002) | | | | | | | | | | | |
| Evaluation$_{t-1}$ | 0.050 | * | 0.004 | * | -2.188 | * | -3.844 | * | -4.340 | * | | | | |
| | (0.012) | | (0.001) | | (0.038) | | (0.060) | | (0.205) | | | | | |
| Promoted$_{t-1}$ | 0.085 | * | 0.031 | * | 0.200 | * | 0.333 | * | 0.071 | | 2.260 | * | | |
| | (0.041) | | (0.002) | | (0.099) | | (0.163) | | (0.532) | | (0.143) | | | |
| Demographic Characteristics | | | | | | | | | | | | | | |
| Female | 0.071 | | -0.005 | | -0.771 | * | -2.068 | * | -0.342 | | -0.115 | | 0.258 | * |
| | (0.081) | | (0.005) | | (0.235) | | (0.372) | | (1.191) | | (0.204) | | (0.082) | |
| Black | -0.013 | | -0.003 | | -0.061 | | 0.121 | | 2.544 | * | -0.082 | | 0.394 | * |
| | (0.111) | | (0.007) | | (0.380) | | (0.483) | | (1.234) | | (0.308) | | (0.113) | |
| Female*Black | -0.112 | | 0.006 | | -0.355 | | 0.212 | | -1.738 | | -0.266 | | -0.580 | * |
| | (0.144) | | (0.009) | | (0.470) | | (0.626) | | (1.703) | | (0.394) | | (0.146) | |
| Age | -0.005 | * | 0.001 | * | -0.0004 | | 0.004 | * | -0.002 | | -0.016 | * | -0.135 | * |
| | (0.000) | | (0.0002) | | (0.001) | | (0.002) | | (0.005) | | (0.002) | | (0.009) | |
| Age$^2$ | | | -0.001 | * | | | | | | | | | 0.130 | * |
| | | | (0.0003) | | | | | | | | | | (0.011) | |
| High School | 0.071 | * | -0.004 | * | -0.083 | | -0.186 | * | -0.304 | | 0.118 | | -0.042 | |
| | (0.026) | | (0.002) | | (0.072) | | (0.092) | | (0.272) | | (0.124) | | (0.064) | |
| > High School | 0.133 | * | -0.003 | | -0.094 | | -0.160 | | -0.175 | | 0.154 | | 0.157 | * |
| | (0.027) | | (0.002) | | (0.075) | | (0.098) | | (0.295) | | (0.128) | | (0.068) | |
| College | 0.095 | * | -0.004 | * | -0.203 | * | -0.240 | * | -0.057 | | -0.072 | | 0.392 | * |
| | (0.029) | | (0.002) | | (0.078) | | (0.103) | | (0.310) | | (0.132) | | (0.070) | |
| Graduate Degree | 0.062 | * | -0.004 | * | -0.330 | * | -0.483 | * | -0.184 | | -0.018 | | 0.743 | * |
| | (0.031) | | (0.002) | | (0.083) | | (0.119) | | (0.364) | | (0.141) | | (0.077) | |
| Occupational Controls | | | | | | | | | | | | | | |
| Professionals | -0.271 | * | -0.018 | * | 0.016 | | -0.104 | | -0.230 | | 0.195 | | -0.332 | * |
| | (0.043) | | (0.002) | | (0.095) | | (0.205) | | (0.700) | | (0.139) | | (0.123) | |
| Technicians | -0.501 | * | -0.011 | * | 0.084 | | -0.013 | | -0.495 | | 0.666 | * | -0.456 | * |
| | (0.047) | | (0.003) | | (0.104) | | (0.214) | | (0.729) | | (0.151) | | (0.130) | |
| Protective Service | -0.591 | * | -0.001 | | 0.889 | * | 1.084 | * | -0.882 | | 0.323 | | -0.470 | * |
| | (0.049) | | (0.003) | | (0.120) | | (0.223) | | (0.785) | | (0.170) | | (0.134) | |
| Paraprofessional | -0.122 | * | -0.013 | * | 0.236 | | 0.381 | | 0.0001 | | 0.296 | | -0.283 | |
| | (0.059) | | (0.003) | | (0.141) | | (0.248) | | (0.805) | | (0.200) | | (0.162) | |
| Office & Clerical | -0.651 | * | 0.004 | | -0.175 | | -0.264 | | -0.535 | | 1.054 | * | -0.566 | * |
| | (0.048) | | (0.003) | | (0.106) | | (0.217) | | (0.734) | | (0.155) | | (0.131) | |
| Skilled Craft | -0.590 | * | -0.005 | | 0.273 | * | 0.246 | | -0.286 | | 0.428 | * | -0.293 | * |
| | (0.049) | | (0.003) | | (0.109) | | (0.219) | | (0.745) | | (0.161) | | (0.134) | |
| Service & Maintenance | -0.876 | * | 0.019 | * | 0.059 | | 0.217 | | -0.811 | | 0.605 | * | -0.594 | * |
| | (0.052) | | (0.003) | | (0.119) | | (0.230) | | (0.775) | | (0.178) | | (0.141) | |

Continued on the next page

Table F.1: Results with Unobserved Heterogeneity, cont.

| | Grade | Earnings | Evaluation (Relative to 5) Eval = 4 | Eval = 3 | Eval = 1-2 | Promoted | Pr(Leave) |
|---|---|---|---|---|---|---|---|
| Tenure Controls | | | | | | | |
| Tenure | 0.049 * | 0.003 | 0.092 | 0.038 | 0.618 | -0.293 * | 0.024 |
| | (0.026) | (0.002) | (0.067) | (0.111) | (0.413) | (0.090) | (0.042) |
| $\text{Tenure}^2$ | -0.057 * | -0.004 * | -0.065 | -0.017 | -0.444 | -0.155 | -0.071 |
| | (0.022) | (0.001) | (0.057) | (0.097) | (0.363) | (0.085) | (0.055) |
| Female*Tenure | -0.051 | -0.003 | 0.031 | 0.270 | -1.110 * | 0.015 | -0.033 |
| | (0.034) | (0.002) | (0.089) | (0.161) | (0.540) | (0.099) | (0.054) |
| Female*$\text{Tenure}^2$ | 0.039 | 0.003 | -0.021 | -0.213 | 0.893 | 0.074 | 0.070 |
| | (0.030) | (0.002) | (0.077) | (0.142) | (0.473) | (0.102) | (0.070) |
| Black*Tenure | -0.030 | -0.003 | -0.236 | -0.254 | -0.852 | 0.091 | -0.082 |
| | (0.048) | (0.003) | (0.140) | (0.196) | (0.543) | (0.151) | (0.077) |
| Black*$\text{Tenure}^2$ | 0.018 | 0.003 | 0.160 | 0.159 | 0.719 | -0.108 | 0.024 |
| | (0.041) | (0.003) | (0.120) | (0.171) | (0.470) | (0.157) | (0.101) |
| Female*Black* Tenure | 0.003 | 0.003 | 0.231 | 0.013 | 1.189 | 0.080 | 0.099 |
| | (0.062) | (0.004) | (0.177) | (0.262) | (0.760) | (0.192) | (0.100) |
| Female*Black* $\text{Tenure}^2$ | 0.006 | -0.003 | -0.196 | -0.023 | -1.006 | 0.004 | -0.097 |
| | (0.054) | (0.003) | (0.153) | (0.231) | (0.658) | (0.200) | (0.132) |
| Promotion Controls | | | | | | | |
| Promoted Yet | -0.236 * | -0.041 * | -0.151 | -0.024 | 0.435 | -2.365 * | 0.040 |
| | (0.037) | (0.002) | (0.087) | (0.144) | (0.518) | (0.076) | (0.086) |
| Time Since Promotion | 0.111 * | 0.004 * | 0.012 | -0.003 | -0.206 | | -0.031 |
| | (0.011) | (0.001) | (0.025) | (0.043) | (0.166) | | (0.036) |
| Grade Change \| $\text{Promotion}_{t-1}$ | | | | | | | -0.040 |
| | | | | | | | (0.041) |
| Female*Grade $\triangle$\| $\text{Promotion}_{t-1}$ | | | | | | | 0.028 |
| | | | | | | | (0.031) |
| Black*Grade $\triangle$\| $\text{Promotion}_{t-1}$ | | | | | | | -0.003 |
| | | | | | | | (0.044) |
| Female*Black*Grade $\triangle$\| $\text{Promotion}_{t-1}$ | | | | | | | 0.026 |
| | | | | | | | (0.059) |
| Grade Change \| $\text{Promotion}_t$ | 0.022 * | -0.010 * | -0.026 | -0.072 | -0.087 | -0.726 * | |
| | (0.010) | (0.001) | (0.025) | (0.042) | (0.159) | (0.041) | |
| Female*Grade $\triangle$\| $\text{Promotion}_t$ | -0.036 * | 0.0005 | -0.010 | -0.084 | 0.126 | -0.049 | |
| | (0.010) | (0.001) | (0.026) | (0.051) | (0.157) | (0.045) | |
| Black*Grade $\triangle$\| $\text{Promotion}_t$ | -0.008 | 0.00001 | -0.005 | -0.011 | -0.134 | -0.094 | |
| | (0.015) | (0.001) | (0.041) | (0.059) | (0.236) | (0.072) | |
| Female*Black*Grade $\triangle$\| $\text{Promotion}_t$ | 0.027 | -0.001 | -0.022 | 0.028 | 0.106 | -0.044 | |
| | (0.021) | (0.001) | (0.054) | (0.083) | (0.274) | (0.099) | |
| Evaluation Controls | | | | | | | |
| Female* $\text{Evaluation}_{t-1}$ | 0.002 | 0.002 * | 0.148 * | 0.407 * | 0.725 * | | |
| | (0.012) | (0.001) | (0.051) | (0.084) | (0.274) | | |
| Black* $\text{Evaluation}_{t-1}$ | 0.017 | 0.001 | 0.292 * | 0.437 * | -0.088 | | |
| | (0.023) | (0.001) | (0.083) | (0.111) | (0.302) | | |
| Female*Black* $\text{Evaluation}_{t-1}$ | 0.020 | -0.002 | -0.043 | -0.113 | -0.114 | | |
| | (0.029) | (0.002) | (0.102) | (0.143) | (0.400) | | |
| Previous Evaluations | -0.003 | 0.004 * | -0.827 * | -1.392 * | -1.346 * | | |
| | (0.012) | (0.001) | (0.033) | (0.055) | (0.201) | | |
| Female*Previous Evaluations | 0.001 | 0.001 | -0.002 | 0.012 | 0.443 * | | |
| | (0.013) | (0.001) | (0.031) | (0.060) | (0.215) | | |
| Black*Previous Evaluations | -0.012 | -0.0004 | 0.006 | -0.030 | 0.173 | | |
| | (0.020) | (0.001) | (0.053) | (0.076) | (0.237) | | |
| Female*Black*Previous Evaluations | 0.010 | -0.001 | 0.005 | 0.034 | -0.511 | | |
| | (0.025) | (0.002) | (0.065) | (0.100) | (0.311) | | |
| Job Characteristics | | | | | | | |
| Period 2 | -0.036 | 0.013 * | -2.732 * | -4.233 * | -3.948 * | -0.244 * | 0.107 * |
| | (0.034) | (0.002) | (0.094) | (0.132) | (0.395) | (0.072) | (0.027) |
| Initial Grade | 0.017 * | -0.008 * | -0.018 * | -0.030 * | 0.015 | -0.701 * | 0.027 * |
| | (0.003) | (0.0002) | (0.007) | (0.011) | (0.040) | (0.010) | (0.011) |
| Part-Time | -0.033 | -0.136 * | -0.346 * | -0.887 * | -0.122 | -1.039 * | 0.199 * |
| | (0.037) | (0.002) | (0.095) | (0.160) | (0.476) | (0.237) | (0.081) |

Continued on the next page

Table F.1: Results with Unobserved Heterogeneity, cont.

| | Grade | Earnings | Evaluation (Relative to 5) Eval = 4 | Eval = 3 | Eval = 1-2 | Promoted | Pr(Leave) |
|---|---|---|---|---|---|---|---|
| Year 2 | | | | | | | -0.067 (0.069) |
| Year 3 | -0.009 (0.033) | -0.020 * (0.002) | -0.038 (0.081) | 0.057 (0.115) | 0.406 (0.396) | -0.038 (0.113) | -0.129 * (0.066) |
| Year 4 | 0.156 * (0.032) | 0.011 * (0.002) | 0.032 (0.077) | 0.201 (0.109) | 0.252 (0.391) | -0.025 (0.105) | -0.190 * (0.066) |
| Year 5 | 0.016 (0.031) | 0.015 * (0.002) | 0.033 (0.076) | 0.293 * (0.107) | 0.299 (0.386) | -0.091 (0.105) | -0.197 * (0.066) |
| Year 6 | 0.033 (0.031) | 0.005 * (0.002) | 0.124 (0.074) | -0.054 (0.107) | 0.050 (0.387) | 0.108 (0.102) | -0.154 * (0.066) |
| Year 7 | 0.066 * (0.031) | -0.008 * (0.002) | 0.034 (0.073) | -0.069 (0.105) | -0.088 (0.388) | 0.088 (0.101) | -0.129 (0.066) |
| Year 8 | 0.091 * (0.031) | 0.010 * (0.002) | -0.020 (0.073) | -0.050 (0.105) | -0.022 (0.384) | -0.081 (0.102) | -0.350 * (0.069) |
| Year 9 | -0.032 (0.032) | 0.0002 (0.002) | 0.043 (0.073) | 0.088 (0.105) | 0.114 (0.381) | -0.591 * (0.106) | -0.360 * (0.073) |
| Year 10 | -0.012 (0.032) | -0.024 * (0.002) | 0.069 (0.073) | 0.152 (0.106) | 0.487 (0.376) | -0.224 (0.105) | |
| Constant | 0.113 (0.379) | 1.688 * (0.024) | 13.831 * (0.700) | 25.410 * (1.006) | 19.299 * (3.843) | -6.479 * (0.987) | 7.215 * (0.996) |
| Exogenous Variables | | | | | | | |
| Unemployment Rate | -0.007 * (0.003) | -0.001 * (0.0002) | | | | | -0.041 * (0.009) |
| Vacancies | 0.042 * (0.004) | 0.003 * (0.0002) | -0.007 (0.007) | 0.034 * (0.010) | 0.110 * (0.037) | 0.113 * (0.011) | 0.002 (0.010) |
| ln(Private Wages) | -0.030 (0.028) | -0.003 * (0.002) | | | | | 0.204 * (0.071) |
| Heterogeneity Coefficients | | | | | | | |
| $\rho$ | 10.000 (10.000) | 0.540 * (0.031) | 0.234 (1.208) | 1.199 (1.471) | -124.204 (772.610) | -1.653 (1.460) | 6.538 * (0.509) |
| $\omega$ | 10.000 (10.000) | 0.098 * (0.003) | 0.177 (0.118) | 0.467 * (0.183) | -23.769 (10111.460) | 0.233 (0.145) | 0.038 (0.217) |

Table F.2: Initial Conditions with Unobserved Heterogeneity

| | Grade n = 23,123 | | Earnings n = 23,123 | | Evaluation (Eval = 5 Excl.) n = 23,123 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Eval = 4 | | Eval = 3 | | Eval = 1-2 | |
| Female | -2.497 | * | -0.127 | * | -0.383 | * | -0.573 | * | -0.877 | * |
| | (0.080) | | (0.004) | | (0.040) | | (0.047) | | (0.223) | |
| Black | -3.490 | * | -0.155 | * | 0.510 | * | 1.104 | * | 1.345 | * |
| | (0.117) | | (0.006) | | (0.078) | | (0.080) | | (0.242)) | |
| Female*Black | 2.169 | * | 0.098 | * | -0.005 | | -0.021 | | 0.204 | |
| | (0.148) | | (0.008) | | (0.094) | | (0.098) | | (0.331) | |
| Age | 0.022 | * | 0.003 | * | -0.002 | | -0.009 | * | 0.007 | |
| | (0.004) | | (0.0002) | | (0.002) | | (0.002) | | (0.009) | |
| $< 9^{th}$ Grade | -6.658 | * | -0.241 | * | -0.060 | | 0.046 | | 0.793 | |
| | (0.636) | | (0.035) | | (0.399) | | (0.411) | | (0.983) | |
| < High School | -4.220 | * | -0.144 | * | 0.313 | * | 0.153 | | -0.083 | |
| | (0.198) | | (0.011) | | (0.135) | | (0.141) | | (0.538) | |
| High School + 1 Year | 1.611 | * | 0.086 | * | -0.171 | * | -0.366 | * | 0.283 | |
| | (0.142) | | (0.008) | | (0.080) | | (0.086) | | (0.307) | |
| High School + 2 Years | 2.386 | * | 0.115 | * | -0.289 | * | -0.508 | * | -0.439 | |
| | (0.156) | | (0.008) | | (0.085) | | (0.093) | | (0.414) | |
| High School + 3 Years | 3.088 | * | 0.151 | * | -0.469 | * | -0.927 | * | -0.986 | |
| | (0.197) | | (0.011) | | (0.101) | | (0.116) | | (0.603) | |
| Associate's Degree | 4.196 | * | 0.205 | * | -0.174 | * | -0.426 | * | 0.330 | |
| | (0.129) | | (0.007) | | (0.071) | | (0.078) | | (0.279) | |
| College | 6.418 | * | 0.293 | * | -0.545 | * | -1.018 | * | -0.374 | |
| | (0.088) | | (0.005) | | (0.048) | | (0.053) | | (0.218) | |
| Master's Degree | 9.610 | * | 0.448 | * | -0.695 | * | -1.459 | * | -0.471 | |
| | (0.121) | | (0.007) | | (0.059) | | (0.074) | | (0.300) | |
| > Master's Degree | 14.403 | * | 0.670 | * | -0.769 | * | -1.705 | * | -0.965 | |
| | (0.259) | | (0.014) | | (0.116) | | (0.165) | | (0.724) | |
| Constant | 59.142 | * | 9.893 | * | 1.400 | * | 1.248 | * | -3.498 | * |
| | (0.162) | | (0.009) | | (0.087) | | (0.097) | | (0.401) | |
| $\rho$ | 8.878 | * | 0.478 | * | 0.288 | | 0.453 | * | 1.877 | * |
| | (0.295) | | (0.015) | | (0.160) | | (0.181) | | (0.388) | |

Table F.3: Independent Equations with No Unobserved Heterogeneity

| | Grade n = 62,057 | | Earnings n = 62,057 | | Evaluation (Eval = 5 Excl.) n = 62,057 Eval = 4 | | Eval = 3 | | Eval = 1-2 | | Promotion n = 62,057 | | Pr(Leave) n = 72,725 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Endogenous Variables | | | | | | | | | | | | | | |
| Salary Grade | | | 0.022 | * | 0.030 | * | 0.072 | * | -0.045 | | 0.732 | * | -0.058 | * |
| | | | (0.0002) | | (0.008) | | (0.013) | | (0.041) | | (0.012) | | (0.012) | |
| ln(Annual Earnings) | | | | | -0.402 | * | -1.261 | * | -0.713 | | 0.252 | | -0.260 | * |
| | | | | | (0.098) | | (0.141) | | (0.503) | | (0.138) | | (0.094) | |
| Performance Evaluation | | | | | | | | | | | -0.121 | * | -0.319 | * |
| | | | | | | | | | | | (0.029) | | (0.017) | |
| Current Promotion | | | | | | | | | | | | | -0.086 | |
| | | | | | | | | | | | | | (0.093) | |
| Lagged $t-1$ Endogenous Variables | | | | | | | | | | | | | | |
| Salary Grade$_{t-1}$ | 0.885 | * | | | | | | | | | | | | |
| | (0.004) | | | | | | | | | | | | | |
| Salary$_{t-1}$ | 0.560 | * | 0.753 | * | | | | | | | | | | |
| | (0.048) | | (0.002) | | | | | | | | | | | |
| Evaluation$_{t-1}$ | 0.098 | * | 0.004 | * | -2.188 | * | -3.842 | * | -4.341 | * | | | | |
| | (0.017) | | (0.001) | | (0.040) | | (0.063) | | (0.201) | | | | | |
| Promoted$_{t-1}$ | 0.232 | * | 0.038 | * | 0.214 | * | 0.374 | * | 0.032 | | 2.283 | * | | |
| | (0.047) | | (0.002) | | (0.100) | | (0.165) | | (0.634) | | (0.146) | | | |
| Demographic Characteristics | | | | | | | | | | | | | | |
| Female | 0.019 | | -0.005 | | -0.774 | * | -2.066 | * | -0.351 | | -0.118 | | 0.292 | * |
| | (0.092) | | (0.008) | | (0.249) | | (0.395) | | (0.932) | | (0.235) | | (0.082) | |
| Black | -0.128 | | -0.003 | | -0.063 | | 0.121 | | 2.543 | * | -0.083 | | 0.351 | * |
| | (0.128) | | (0.009) | | (0.393) | | (0.491) | | (0.959) | | (0.384) | | (0.113) | |
| Female*Black | -0.076 | | 0.005 | | -0.355 | | 0.206 | | -1.739 | | -0.270 | | -0.579 | * |
| | (0.168) | | (0.011) | | (0.487) | | (0.640) | | (1.137) | | (0.503) | | (0.147) | |
| Age | -0.008 | * | 0.001 | * | -0.0004 | | 0.004 | * | -0.002 | | -0.016 | * | -0.130 | * |
| | (0.001) | | (0.0002) | | (0.001) | | (0.002) | | (0.005) | | (0.002) | | (0.010) | |
| Age$^2$ | | | -0.001 | * | | | | | | | | | 0.124 | * |
| | | | (0.0003) | | | | | | | | | | (0.011) | |
| High School | 0.175 | * | -0.004 | * | -0.083 | | -0.186 | * | -0.306 | | 0.117 | | -0.063 | |
| | (0.032) | | (0.002) | | (0.074) | | (0.095) | | (0.317) | | (0.125) | | (0.067) | |
| > High School | 0.289 | * | -0.003 | | -0.094 | | -0.160 | | -0.176 | | 0.153 | | 0.123 | |
| | (0.033) | | (0.002) | | (0.077) | | (0.101) | | (0.348) | | (0.130) | | (0.070) | |
| College | 0.328 | * | -0.004 | * | -0.202 | * | -0.237 | * | -0.062 | | -0.072 | | 0.311 | * |
| | (0.035) | | (0.002) | | (0.079) | | (0.106) | | (0.371) | | (0.133) | | (0.072) | |
| Graduate Degree | 0.259 | * | -0.004 | | -0.329 | * | -0.478 | * | -0.190 | | -0.019 | | 0.577 | * |
| | (0.039) | | (0.002) | | (0.085) | | (0.123) | | (0.428) | | (0.142) | | (0.078) | |
| Occupational Controls | | | | | | | | | | | | | | |
| Professionals | -0.589 | * | -0.019 | * | 0.015 | | -0.104 | | -0.224 | | 0.193 | | -0.281 | * |
| | (0.046) | | (0.004) | | (0.108) | | (0.298) | | (0.533) | | (0.142) | | (0.120) | |
| Technicians | -1.233 | * | -0.013 | * | 0.082 | | -0.016 | | -0.487 | | 0.661 | * | -0.420 | * |
| | (0.050) | | (0.004) | | (0.119) | | (0.311) | | (0.555) | | (0.155) | | (0.129) | |
| Protective Service | -1.294 | * | -0.002 | | 0.888 | * | 1.084 | * | -0.876 | | 0.322 | | -0.460 | * |
| | (0.055) | | (0.004) | | (0.137) | | (0.321) | | (0.641) | | (0.171) | | (0.133) | |
| Parapro-fessional | -0.717 | * | -0.016 | * | 0.231 | | 0.368 | | 0.018 | | 0.288 | | -0.245 | |
| | (0.070) | | (0.005) | | (0.157) | | (0.346) | | (0.658) | | (0.207) | | (0.162) | |
| Office & Clerical | -1.585 | * | 0.002 | | -0.176 | | -0.266 | | -0.528 | | 1.051 | * | -0.523 | * |
| | (0.050) | | (0.004) | | (0.122) | | (0.316) | | (0.555) | | (0.159) | | (0.130) | |
| Skilled Craft | -1.309 | * | -0.006 | | 0.272 | * | 0.245 | | -0.278 | | 0.425 | * | -0.253 | |
| | (0.051) | | (0.004) | | (0.126) | | (0.319) | | (0.570) | | (0.164) | | (0.134) | |
| Service & Maintenance | -2.031 | * | 0.018 | * | 0.058 | | 0.214 | | -0.803 | | 0.601 | * | -0.509 | * |
| | (0.055) | | (0.004) | | (0.136) | | (0.334) | | (0.591) | | (0.179) | | (0.141) | |

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Table F.3: Results with No Unobserved Heterogeneity, cont.

| | Grade | Earnings | Evaluation | | | Promoted | Pr(Leave) |
|---|---|---|---|---|---|---|---|
| | | | Eval = 4 | Eval = 3 | Eval = 1-2 | | |
| Tenure Controls | | | | | | | |
| Tenure | 0.014 | 0.002 | 0.091 | 0.036 | 0.614 | -0.294 * | -0.052 |
| | (0.034) | (0.002) | (0.069) | (0.117) | (0.383) | (0.096) | (0.045) |
| Tenure$^2$ | -0.033 | -0.004 * | -0.065 | -0.018 | -0.439 | -0.156 | -0.008 |
| | (0.030) | (0.002) | (0.059) | (0.102) | (0.340) | (0.091) | (0.058) |
| Female*Tenure | -0.042 | -0.003 | 0.031 | 0.269 | -1.106 * | 0.016 | -0.035 |
| | (0.041) | (0.003) | (0.094) | (0.170) | (0.399) | (0.112) | (0.056) |
| Female*Tenure$^2$ | 0.036 | 0.003 | -0.021 | -0.211 | 0.889 * | 0.075 | 0.076 |
| | (0.036) | (0.003) | (0.082) | (0.150) | (0.367) | (0.115) | (0.073) |
| Black*Tenure | -0.002 | -0.003 | -0.236 | -0.255 | -0.851 * | 0.091 | -0.042 |
| | (0.056) | (0.004) | (0.144) | (0.203) | (0.430) | (0.184) | (0.078) |
| Black*Tenure$^2$ | -0.003 | 0.003 | 0.160 | 0.160 | 0.717 | -0.107 | -0.013 |
| | (0.049) | (0.003) | (0.124) | (0.178) | (0.386) | (0.185) | (0.103) |
| Female*Black* | -0.006 | 0.003 | 0.231 | 0.016 | 1.184 * | 0.084 | 0.089 |
| Tenure | (0.072) | (0.005) | (0.187) | (0.277) | (0.570) | (0.243) | (0.101) |
| Female*Black* | 0.005 | -0.003 | -0.197 | -0.028 | -1.001 | 0.001 | -0.088 |
| Tenure$^2$ | (0.063) | (0.004) | (0.162) | (0.243) | (0.537) | (0.247) | (0.133) |
| Promotion Controls | | | | | | | |
| Promoted Yet | -0.345 * | -0.049 * | -0.168 | -0.068 | 0.479 | -2.389 * | 0.038 |
| | (0.043) | (0.002) | (0.088) | (0.146) | (0.657) | (0.080) | (0.090) |
| Time Since | 0.156 * | 0.004 * | 0.013 | -0.002 | -0.207 | | -0.028 |
| Promotion | (0.012) | (0.001) | (0.026) | (0.044) | (0.206) | | (0.038) |
| Grade Change \| | | | | | | | -0.031 |
| Promotion$_{t-1}$ | | | | | | | (0.034) |
| Female*Grade $\triangle$\| | | | | | | | 0.029 |
| Promotion$_{t-1}$ | | | | | | | (0.033) |
| Black*Grade $\triangle$\| | | | | | | | -0.003 |
| Promotion$_{t-1}$ | | | | | | | (0.048) |
| Female*Black*Grade $\triangle$\| | | | | | | | 0.031 |
| Promotion$_{t-1}$ | | | | | | | (0.062) |
| Grade Change \| | -0.003 | -0.012 * | -0.030 | -0.085 | -0.075 | -0.732 * | |
| Promotion$_t$ | (0.014) | (0.001) | (0.025) | (0.043) | (0.157) | (0.042) | |
| Female*Grade $\triangle$\| | -0.031 * | 0.001 | -0.009 | -0.084 | 0.128 | -0.049 | |
| Promotion$_t$ | (0.015) | (0.001) | (0.026) | (0.050) | (0.155) | (0.042) | |
| Black*Grade $\triangle$\| | 0.016 | 0.0002 | -0.005 | -0.010 | -0.134 | -0.093 | |
| Promotion$_t$ | (0.023) | (0.001) | (0.043) | (0.060) | (0.221) | (0.069) | |
| Female*Black*Grade $\triangle$\| | 0.004 | -0.001 | -0.022 | 0.027 | 0.107 | -0.046 | |
| Promotion$_t$ | (0.034) | (0.001) | (0.055) | (0.084) | (0.256) | (0.101) | |
| Evaluation Controls | | | | | | | |
| Female* | -0.017 | 0.002 | 0.149 * | 0.406 * | 0.727 * | | |
| Evaluation$_{t-1}$ | (0.023) | (0.001) | (0.053) | (0.087) | (0.272) | | |
| Black* | 0.012 | 0.001 | 0.293 * | 0.436 * | -0.088 | | |
| Evaluation$_{t-1}$ | (0.029) | (0.002) | (0.088) | (0.118) | (0.304) | | |
| Female*Black* | 0.017 | -0.001 | -0.043 | -0.113 | -0.111 | | |
| Evaluation$_{t-1}$ | (0.035) | (0.002) | (0.107) | (0.148) | (0.396) | | |
| Previous | 0.012 | 0.004 * | -0.827 * | -1.393 * | -1.343 * | | |
| Evaluations | (0.018) | (0.001) | (0.033) | (0.057) | (0.191) | | |
| Female*Previous | -0.0001 | 0.0005 | -0.002 | 0.013 | 0.441 * | | |
| Evaluations | (0.016) | (0.001) | (0.032) | (0.063) | (0.194) | | |
| Black*Previous | -0.025 | -0.0004 | 0.006 | -0.030 | 0.172 | | |
| Evaluations | (0.027) | (0.001) | (0.054) | (0.080) | (0.205) | | |
| Female*Black*Previous | 0.032 | -0.001 | 0.005 | 0.034 | -0.509 * | | |
| Evaluations | (0.035) | (0.002) | (0.068) | (0.104) | (0.253) | | |
| Job Characteristics | | | | | | | |
| Period 2 | 0.012 | 0.013 * | -2.733 * | -4.236 * | 0.028 | -0.245 * | 0.060 * |
| | (0.050) | (0.002) | (0.097) | (0.134) | (0.034) | (0.074) | (0.030) |
| Initial Grade | 0.013 * | -0.011 * | -0.023 * | -0.043 * | -0.123 | -0.706 * | 0.034 * |
| | (0.004) | (0.0002) | (0.006) | (0.011) | (0.461) | (0.010) | (0.011) |
| Part-Time | -0.059 | -0.142 * | -0.349 * | -0.892 * | -3.945 * | -1.045 * | 0.299 * |
| | (0.056) | (0.002) | (0.099) | (0.166) | (0.397) | (0.174) | (0.083) |

Continued on the next page

Table F.3: Results with No Unobserved Heterogeneity, cont.

| | Grade | Earnings | Evaluation | | | Promoted | Pr(Leave) |
|---|---|---|---|---|---|---|---|
| | | | Eval = 4 | Eval = 3 | Eval = 1-2 | | |
| Year 2 | | | | | | | -0.101 (0.068) |
| Year 3 | -0.025 (0.041) | -0.020 * (0.002) | -0.038 (0.083) | 0.056 (0.118) | 0.409 (0.396) | -0.039 (0.111) | -0.167 * (0.065) |
| Year 4 | 0.192 * (0.038) | 0.011 * (0.002) | 0.032 (0.077) | 0.199 (0.110) | 0.255 (0.391) | -0.026 (0.108) | -0.219 * (0.065) |
| Year 5 | 0.055 (0.036) | 0.015 * (0.002) | 0.034 (0.076) | 0.293 * (0.108) | 0.301 (0.386) | -0.093 (0.107) | -0.237 * (0.066) |
| Year 6 | 0.108 * (0.037) | 0.005 * (0.002) | 0.125 (0.074) | -0.052 (0.107) | 0.049 (0.387) | 0.108 (0.105) | -0.189 * (0.066) |
| Year 7 | 0.116 * (0.035) | -0.008 * (0.002) | 0.035 (0.073) | -0.069 (0.106) | -0.084 (0.390) | 0.087 (0.105) | -0.163 * (0.067) |
| Year 8 | 0.150 * (0.033) | 0.010 * (0.002) | -0.020 (0.073) | -0.050 (0.106) | -0.019 (0.384) | -0.080 (0.105) | -0.385 * (0.070) |
| Year 9 | -0.011 (0.035) | 0.0002 (0.002) | 0.044 (0.073) | 0.088 (0.105) | 0.118 (0.382) | -0.590 * (0.107) | -0.393 * (0.074) |
| Year 10 | 0.007 (0.037) | -0.024 * (0.002) | 0.070 (0.073) | 0.153 (0.107) | 0.489 (0.377) | -0.224 * (0.107) | |
| Constant | 1.837 * (0.446) | 1.774 * (0.024) | 13.882 * (0.773) | 25.497 * (0.974) | 19.306 * (4.145) | -6.373 * (0.994) | 5.239 * (0.996) |
| Exogenous Variables | | | | | | | |
| Unemployment Rate | -0.008 (0.004) | -0.001 * (0.0002) | | | | | -0.040 * (0.009) |
| Vacancies | 0.053 * (0.005) | 0.003 * (0.0002) | -0.007 (0.008) | 0.033 * (0.012) | 0.110 * (0.036) | 0.112 * (0.014) | 0.003 (0.009) |
| ln(Private Wages) | -0.008 (0.037) | -0.003 (0.002) | | | | | 0.167 * (0.072) |

Table F.4: Initial Conditions with No Unobserved Heterogeneity

| | Grade n = 23,123 | | Earnings n = 23,123 | | Evaluation (Eval = 5 Excl.) n = 23,123 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Eval = 4 | | Eval = 3 | | Eval = 1-2 | |
| Female | -2.466 | * | -0.125 | * | -0.381 | * | -0.571 | * | -0.856 | * |
| | (0.084) | | (0.005) | | (0.041) | | (0.049) | | (0.195) | |
| Black | -3.506 | * | -0.156 | * | 0.509 | * | 1.102 | * | 1.331 | * |
| | (0.121) | | (0.007) | | (0.080) | | (0.083) | | (0.241) | |
| Female*Black | 2.128 | * | 0.096 | * | -0.006 | | -0.022 | | 0.186 | |
| | (0.154) | | (0.010) | | (0.096) | | (0.100) | | (0.313) | |
| Age | 0.027 | * | 0.004 | * | -0.002 | | -0.008 | * | 0.008 | |
| | (0.004) | | (0.0002) | | (0.002) | | (0.002) | | (0.008) | |
| $< 9^{th}$ Grade | -6.776 | * | -0.247 | * | -0.063 | | 0.040 | | 0.743 | |
| | (0.652) | | (0.036) | | (0.533) | | (0.552) | | (0.994) | |
| < High School | -4.247 | * | -0.146 | * | 0.312 | * | 0.152 | | -0.097 | |
| | (0.213) | | (0.011) | | (0.140) | | (0.145) | | (0.558) | |
| High School + 1 Year | 1.584 | * | 0.084 | * | -0.171 | * | -0.367 | * | 0.272 | |
| | (0.155) | | (0.010) | | (0.082) | | (0.089) | | (0.307) | |
| High School + 2 Years | 2.489 | * | 0.121 | * | -0.286 | * | -0.503 | * | -0.394 | |
| | (0.170) | | (0.011) | | (0.088) | | (0.096) | | (0.388) | |
| High School + 3 Years | 3.281 | * | 0.161 | * | -0.462 | * | -0.917 | * | -0.918 | |
| | (0.218) | | (0.012) | | (0.106) | | (0.122) | | (0.599) | |
| Associate's Degree | 4.366 | * | 0.214 | * | -0.168 | * | -0.417 | * | 0.387 | |
| | (0.139) | | (0.008) | | (0.074) | | (0.082) | | (0.285) | |
| College | 6.583 | * | 0.302 | * | -0.539 | * | -1.010 | * | -0.304 | |
| | (0.097) | | (0.006) | | (0.050) | | (0.055) | | (0.226) | |
| Master's Degree | 9.666 | * | 0.451 | * | -0.692 | * | -1.456 | * | -0.446 | |
| | (0.129) | | (0.008) | | (0.062) | | (0.077) | | (0.302) | |
| > Master's Degree | 14.518 | * | 0.677 | * | -0.765 | * | -1.698 | * | -0.909 | |
| | (0.336) | | (0.013) | | (0.121) | | (0.174) | | (0.693) | |
| Constant | 59.052 | * | 9.888 | * | 1.395 | * | 1.242 | * | -3.524 | * |
| | (0.179) | | (0.010) | | (0.090) | | (0.101) | | (0.396) | |

Table F.5: Jointly-Estimated Equations with Unobserved Heterogeneity

(Testing for Statistical Discrimination)

| | Grade n = 62,057 | | Earnings n = 62,057 | | Evaluation (Eval = 5 Excl.) n = 62,057 Eval = 4 | | Eval = 3 | | Eval = 1-2 | | Promotion n = 62,057 | | Pr(Leave) n = 72,725 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Endogenous Variables | | | | | | | | | | | | | | |
| Salary Grade | | | 0.006 | * | 0.022 | * | 0.077 | * | -0.007 | | 0.190 | * | -0.118 | * |
| | | | (0.0002) | | (0.010) | | (0.015) | | (0.051) | | (0.019) | | (0.013) | |
| ln(Annual Earnings) | | | | | -0.419 | * | -1.272 | * | -0.658 | | -1.317 | * | -0.151 | |
| | | | | | (0.092) | | (0.135) | | (0.515) | | (0.231) | | (0.095) | |
| Performance Evaluation | | | | | | | | | | | -0.236 | * | -0.335 | * |
| | | | | | | | | | | | (0.034) | | (0.017) | |
| Current Promotion | | | | | | | | | | | | | -0.018 | |
| | | | | | | | | | | | | | (0.096) | |
| Lagged $t-1$ Endogenous Variables | | | | | | | | | | | | | | |
| Salary Grade$_{t-1}$ | 0.845 | * | | | | | | | | | | | | |
| | (0.003) | | | | | | | | | | | | | |
| Salary$_{t-1}$ | 0.706 | * | 0.823 | * | | | | | | | | | | |
| | (0.024) | | (0.002) | | | | | | | | | | | |
| Evaluation$_{t-1}$ | 0.015 | | 0.002 | * | -2.188 | * | -3.842 | * | -4.338 | * | | | | |
| | (0.008) | | (0.001) | | (0.039) | | (0.061) | | (0.200) | | | | | |
| Promoted$_{t-1}$ | 0.297 | * | 0.006 | * | 0.151 | | 0.365 | * | 0.152 | | 0.983 | * | | |
| | (0.026) | | (0.002) | | (0.100) | | (0.166) | | (0.548) | | (0.193) | | | |
| Demographic Characteristics | | | | | | | | | | | | | | |
| Female | -0.130 | | 0.089 | | 0.113 | | -2.708 | * | -3.198 | | 0.880 | | -1.620 | |
| | (0.885) | | (0.071) | | (0.754) | | (1.059) | | (5.725) | | (1.436) | | (0.817) | |
| Black | -1.226 | | 0.054 | | 3.303 | * | 3.301 | * | 2.041 | | -0.539 | | -2.232 | * |
| | (1.075) | | (0.092) | | (1.114) | | (1.262) | | (5.597) | | (1.090) | | (0.994) | |
| Female*Black | 1.715 | | -0.035 | | -4.118 | * | -3.132 | * | 6.003 | | -1.019 | | 1.505 | |
| | (1.697) | | (0.149) | | (1.330) | | (1.580) | | (8.096) | | (1.655) | | (1.150) | |
| Age | -0.002 | * | 0.001 | * | -0.0003 | | 0.004 | * | -0.003 | | -0.009 | * | -0.133 | * |
| | (0.000) | | (0.0002) | | (0.001) | | (0.002) | | (0.006) | | (0.003) | | (0.010) | |
| Age$^2$ | | | -0.001 | * | | | | | | | | | 0.129 | * |
| | | | (0.0002) | | | | | | | | | | (0.011) | |
| High School | 0.029 | | -0.004 | | -0.016 | | -0.149 | | -0.220 | | 0.053 | | -0.252 | * |
| | (0.024) | | (0.002) | | (0.082) | | (0.111) | | (0.375) | | (0.187) | | (0.075) | |
| > High School | 0.022 | | -0.004 | | -0.013 | | -0.076 | | -0.034 | | 0.045 | | -0.182 | * |
| | (0.032) | | (0.003) | | (0.094) | | (0.129) | | (0.461) | | (0.210) | | (0.088) | |
| College | 0.012 | | -0.004 | | -0.109 | | -0.147 | | 0.091 | | -0.155 | | -0.078 | |
| | (0.036) | | (0.003) | | (0.100) | | (0.139) | | (0.505) | | (0.221) | | (0.095) | |
| Graduate Degree | -0.063 | | -0.006 | * | -0.270 | * | -0.366 | * | 0.027 | | -0.226 | | 0.167 | |
| | (0.036) | | (0.003) | | (0.101) | | (0.147) | | (0.505) | | (0.230) | | (0.097) | |
| Female*Education (in years)) | 0.020 | | -0.012 | | -0.127 | | 0.091 | | 0.405 | | -0.168 | | 0.244 | * |
| | (0.121) | | (0.010) | | (0.098) | | (0.143) | | (0.755) | | (0.190) | | (0.109) | |
| Female*Education$^2$ | -0.005 | | 0.004 | | 0.044 | | -0.031 | | -0.140 | | 0.066 | | -0.072 | |
| | (0.040) | | (0.003) | | (0.032) | | (0.048) | | (0.252) | | (0.063) | | (0.036) | |
| Black*Education | 0.183 | | -0.009 | | -0.484 | * | -0.431 | * | 0.112 | | -0.032 | | 0.399 | * |
| | (0.154) | | (0.013) | | (0.156) | | (0.176) | | (0.762) | | (0.151) | | (0.141) | |
| Black*Education$^2$ | -0.065 | | 0.003 | | 0.168 | * | 0.141 | * | -0.054 | | 0.036 | | -0.145 | * |
| | (0.054) | | (0.005) | | (0.054) | | (0.061) | | (0.263) | | (0.055) | | (0.050) | |
| Female*Black *Education | -0.275 | | 0.011 | | 0.556 | * | 0.499 | * | -1.098 | | 0.062 | | -0.322 | |
| | (0.239) | | (0.021) | | (0.187) | | (0.227) | | (1.099) | | (0.240) | | (0.162) | |
| Female*Black *Education$^2$ | 0.097 | | -0.006 | | -0.198 | * | -0.180 | * | 0.380 | | -0.019 | | 0.120 | * |
| | (0.083) | | (0.007) | | (0.065) | | (0.080) | | (0.378) | | (0.085) | | (0.057) | |
| Occupational Controls | | | | | | | | | | | | | | |
| Professionals | -0.211 | * | -0.017 | * | 0.009 | | -0.119 | | -0.189 | | 0.118 | | -0.265 | * |
| | (0.028) | | (0.002) | | (0.096) | | (0.205) | | (0.667) | | (0.207) | | (0.116) | |
| Technicians | -0.501 | * | -0.016 | * | 0.068 | | -0.035 | | -0.449 | | -0.115 | | -0.422 | * |
| | (0.031) | | (0.003) | | (0.104) | | (0.214) | | (0.698) | | (0.225) | | (0.124) | |
| Protective Service | -0.447 | * | -0.003 | | 0.879 | * | 1.076 | * | -0.840 | | 0.152 | | -0.483 | * |
| | (0.032) | | (0.003) | | (0.122) | | (0.224) | | (0.751) | | (0.248) | | (0.128) | |

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Table F.5: Results with Unobserved Heterogeneity, cont.

| | Grade | | Earnings | | Evaluation (Relative to 5) Eval = 4 | | Eval = 3 | | Eval = 1-2 | | Promoted | | Pr(Leave) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Paraprofessional | 0.055 | * | -0.003 | | 0.230 | | 0.351 | | 0.024 | | 0.884 | * | -0.177 | |
| | (0.039) | | (0.003) | | (0.142) | | (0.249) | | (0.776) | | (0.289) | | (0.158) | |
| Office & Clerical | -0.634 | * | -0.006 | * | -0.190 | | -0.273 | | -0.457 | | 0.220 | | -0.545 | * |
| | (0.032) | | (0.003) | | (0.107) | | (0.217) | | (0.700) | | (0.232) | | (0.126) | |
| Skilled Craft | -0.483 | * | -0.009 | * | 0.269 | * | 0.246 | | -0.215 | | 0.104 | | -0.302 | * |
| | (0.032) | | (0.003) | | (0.110) | | (0.219) | | (0.710) | | (0.240) | | (0.128) | |
| Service & Maintenance | -0.759 | * | 0.006 | * | 0.037 | | 0.193 | | -0.777 | | -0.054 | | -0.569 | * |
| | (0.035) | | (0.003) | | (0.120) | | (0.230) | | (0.740) | | (0.261) | | (0.136) | |
| Tenure Controls | | | | | | | | | | | | | | |
| Tenure | 0.073 | | -0.003 | | 0.091 | | 0.039 | | 0.614 | | -0.178 | | 0.050 | |
| | (0.127) | | (0.011) | | (0.068) | | (0.113) | | (0.400) | | (0.117) | | (0.044) | |
| Tenure$^2$ | -0.165 | | 0.001 | | -0.063 | | -0.022 | | -0.448 | | 0.097 | | -0.089 | |
| | (0.169) | | (0.015) | | (0.058) | | (0.099) | | (0.352) | | (0.107) | | (0.056) | |
| Female*Tenure | 0.151 | | -0.023 | | 0.032 | | 0.271 | | -1.101 | * | -0.048 | | -0.060 | |
| | (0.419) | | (0.034) | | (0.090) | | (0.160) | | (0.520) | | (0.128) | | (0.055) | |
| Female*Tenure$^2$ | -0.056 | | 0.012 | | -0.022 | | -0.212 | | 0.888 | | 0.079 | | 0.098 | |
| | (0.436) | | (0.036) | | (0.078) | | (0.141) | | (0.458) | | (0.128) | | (0.071) | |
| Black*Tenure | 0.610 | | -0.016 | | -0.234 | | -0.256 | | -0.847 | | 0.221 | | -0.076 | |
| | (0.514) | | (0.044) | | (0.142) | | (0.198) | | (0.529) | | (0.202) | | (0.078) | |
| Black*Tenure$^2$ | -0.741 | | 0.027 | | 0.159 | | 0.162 | | 0.718 | | -0.245 | | 0.017 | |
| | (0.555) | | (0.047) | | (0.122) | | (0.173) | | (0.457) | | (0.203) | | (0.103) | |
| Female*Black *Tenure | -0.857 | | 0.002 | | 0.224 | | 0.005 | | 1.162 | | 0.141 | | 0.100 | |
| | (0.797) | | (0.070) | | (0.179) | | (0.262) | | (0.718) | | (0.256) | | (0.101) | |
| Female*Black *Tenure$^2$ | 0.923 | | -0.006 | | -0.192 | | -0.019 | | -0.988 | | -0.027 | | -0.096 | |
| | (0.820) | | (0.071) | | (0.155) | | (0.231) | | (0.626) | | (0.259) | | (0.134) | |
| Tenure*Education Controls | | | | | | | | | | | | | | |
| Education* Tenure | -0.008 | | 0.001 | | | | | | | | | | | |
| | (0.017) | | (0.002) | | | | | | | | | | | |
| Education* Tenure$^2$ | 0.023 | | -0.0004 | | | | | | | | | | | |
| | (0.023) | | (0.002) | | | | | | | | | | | |
| Education$^2$* Tenure | 0.003 | | -0.0003 | | | | | | | | | | | |
| | (0.003) | | (0.001) | | | | | | | | | | | |
| Education$^2$* Tenure$^2$ | -0.008 | | 0.0002 | | | | | | | | | | | |
| | (0.008) | | (0.001) | | | | | | | | | | | |
| Female*Educ* Tenure | -0.024 | | 0.002 | | | | | | | | | | | |
| | (0.006) | | (0.057) | | | | | | | | | | | |
| Female*Educ* Tenure$^2$ | 0.010 | | -0.0004 | | | | | | | | | | | |
| | (0.060) | | (0.005) | | | | | | | | | | | |
| Female*Educ$^2$* Tenure | 0.007 | | -0.001 | | | | | | | | | | | |
| | (0.019) | | (0.002) | | | | | | | | | | | |
| Female*Educ$^2$* Tenure$^2$ | -0.002 | | -0.0001 | | | | | | | | | | | |
| | (0.020) | | (0.002) | | | | | | | | | | | |
| Black*Educ* Tenure | -0.087 | | 0.003 | | | | | | | | | | | |
| | (0.073) | | (0.006) | | | | | | | | | | | |
| Black*Educ* Tenure$^2$ | 0.102 | | -0.004 | | | | | | | | | | | |
| | (0.079) | | (0.007) | | | | | | | | | | | |
| Black*Educ$^2$* Tenure | 0.030 | | -0.001 | | | | | | | | | | | |
| | (0.026) | | (0.002) | | | | | | | | | | | |
| Black*Educ$^2$* Tenure$^2$ | -0.034 | | 0.002 | | | | | | | | | | | |
| | (0.028) | | (0.002) | | | | | | | | | | | |
| Female*Black* Educ*Tenure | 0.123 | | -0.002 | | | | | | | | | | | |
| | (0.112) | | (0.010) | | | | | | | | | | | |
| Female*Black* Educ*Tenure$^2$ | -0.127 | | 0.002 | | | | | | | | | | | |
| | (0.116) | | (0.010) | | | | | | | | | | | |
| Female*Black* Educ$^2$*Tenure | -0.041 | | 0.001 | | | | | | | | | | | |
| | (0.039) | | (0.003) | | | | | | | | | | | |
| Female*Black* Educ$^2$*Tenure$^2$ | 0.041 | | -0.001 | | | | | | | | | | | |
| | (0.040) | | (0.004) | | | | | | | | | | | |

Continued on the next page

Table F.5: Results with Unobserved Heterogeneity, cont.

| | Grade | Earnings | Evaluation (Relative to 5) Eval = 4 | Eval = 3 | Eval = 1-2 | Promoted | Pr(Leave) |
|---|---|---|---|---|---|---|---|
| Promotion Controls | | | | | | | |
| Promoted Yet | 0.157 * | -0.001 | -0.121 | -0.075 | 0.347 | 0.003 | 0.159 |
| | (0.023) | (0.002) | (0.089) | (0.148) | (0.531) | (0.093) | (0.089) |
| Time Since Promotion | -0.012 | -0.001 | 0.008 | -0.002 | -0.203 | | -0.030 |
| | (0.007) | (0.001) | (0.026) | (0.044) | (0.164) | | (0.037) |
| Grade Change \| $\text{Promotion}_{t-1}$ | | | | | | | -0.112 * |
| | | | | | | | (0.031) |
| Female*Grade $\triangle$\| $\text{Promotion}_{t-1}$ | | | | | | | 0.033 |
| | | | | | | | (0.032) |
| Black*Grade $\triangle$\| $\text{Promotion}_{t-1}$ | | | | | | | 0.006 |
| | | | | | | | (0.045) |
| Female*Black*Grade $\triangle$\| $\text{Promotion}_{t-1}$ | | | | | | | 0.017 |
| | | | | | | | (0.060) |
| Grade Change \| $\text{Promotion}_{t}$ | -0.097 * | -0.002 * | -0.009 | -0.080 | -0.107 | -0.271 * | |
| | (0.006) | (0.001) | (0.025) | (0.043) | (0.158) | (0.060) | |
| Female*Grade $\triangle$\| $\text{Promotion}_{t}$ | 0.005 | 0.001 | -0.011 | -0.089 | 0.113 | 0.002 | |
| | (0.007) | (0.001) | (0.027) | (0.054) | (0.151) | (0.062) | |
| Black*Grade $\triangle$\| $\text{Promotion}_{t}$ | 0.012 | -0.00001 | -0.003 | -0.006 | -0.129 | -0.351 * | |
| | (0.010) | (0.001) | (0.042) | (0.061) | (0.224) | (0.097) | |
| Female*Black*Grade $\triangle$\| $\text{Promotion}_{t}$ | -0.001 | -0.001 | -0.022 | 0.028 | 0.118 | 0.206 | |
| | (0.014) | (0.001) | (0.056) | (0.088) | (0.266) | (0.134) | |
| Evaluation Controls | | | | | | | |
| Female* $\text{Evaluation}_{t-1}$ | -0.003 | 0.001 | 0.146 * | 0.404 * | 0.722 * | | |
| | (0.011) | (0.001) | (0.051) | (0.085) | (0.270) | | |
| Black* $\text{Evaluation}_{t-1}$ | -0.003 | 0.0002 | 0.294 * | 0.441 * | -0.072 | | |
| | (0.015) | (0.001) | (0.085) | (0.114) | (0.308) | | |
| Female*Black* $\text{Evaluation}_{t-1}$ | 0.023 | -0.0002 | -0.042 | -0.113 | -0.113 | | |
| | (0.020) | (0.002) | (0.104) | (0.145) | (0.411) | | |
| Previous Evaluations | -0.015 | 0.003 * | -0.826 * | -1.395 * | -1.348 * | | |
| | (0.008) | (0.001) | (0.034) | (0.056) | (0.193) | | |
| Female*Previous Evaluations | 0.009 | 0.001 | -0.001 | 0.012 | 0.437 * | | |
| | (0.008) | (0.001) | (0.032) | (0.060) | (0.210) | | |
| Black*Previous Evaluations | 0.004 | 0.0001 | 0.005 | -0.032 | 0.165 | | |
| | (0.012) | (0.001) | (0.054) | (0.078) | (0.232) | | |
| Female*Black*Previous Evaluations | -0.0003 | -0.002 | 0.007 | 0.038 | -0.499 | | |
| | (0.016) | (0.001) | (0.066) | (0.100) | (0.304) | | |
| Job Characteristics | | | | | | | |
| Period 2 | -0.025 | 0.014 * | -2.728 * | -4.238 * | -3.960 * | -0.035 | 0.118 * |
| | (0.021) | (0.002) | (0.096) | (0.136) | (0.393) | (0.101) | (0.029) |
| Initial Grade | 0.104 * | 0.002 * | -0.015 | -0.048 * | -0.012 | -0.120 * | 0.097 * |
| | (0.003) | (0.0002) | (0.009) | (0.014) | (0.047) | (0.016) | (0.012) |
| Part-Time | 0.275 * | -0.105 * | -0.352 * | -0.897 * | -0.091 | -1.987 * | 0.152 |
| | (0.025) | (0.002) | (0.097) | (0.163) | (0.487) | (0.280) | (0.083) |
| Year 2 | | | | | | | -0.099 |
| | | | | | | | (0.068) |
| Year 3 | -0.036 * | -0.020 * | -0.038 | 0.057 | 0.421 | -0.189 | -0.166 * |
| | (0.019) | (0.002) | (0.082) | (0.116) | (0.394) | (0.179) | (0.065) |
| Year 4 | 0.050 | 0.010 * | 0.030 | 0.201 * | 0.282 | -0.411 * | -0.225 * |
| | (0.020) | (0.002) | (0.078) | (0.110) | (0.387) | (0.171) | (0.064) |
| Year 5 | -0.002 | 0.016 * | 0.036 | 0.295 | 0.318 | -0.049 | -0.244 * |
| | (0.018) | (0.002) | (0.076) | (0.107) | (0.383) | (0.167) | (0.064) |
| Year 6 | -0.013 | 0.003 * | 0.125 | -0.050 | 0.073 | -0.011 | -0.201 * |
| | (0.018) | (0.002) | (0.075) | (0.107) | (0.384) | (0.163) | (0.065) |
| Year 7 | 0.020 | -0.008 * | 0.037 | -0.068 | -0.064 | 0.168 | -0.171 * |
| | (0.018) | (0.002) | (0.074) | (0.106) | (0.383) | (0.163) | (0.065) |
| Year 8 | 0.021 | 0.009 * | -0.018 | -0.048 | -0.002 | -0.282 | -0.397 * |
| | (0.019) | (0.002) | (0.073) | (0.106) | (0.380) | (0.164) | (0.068) |
| Year 9 | -0.031 | 0.001 | 0.050 | 0.091 | 0.132 | -0.587 * | -0.402 * |
| | (0.019) | (0.002) | (0.073) | (0.105) | (0.381) | (0.167) | (0.071) |
| Year 10 | -0.045 * | -0.025 * | 0.074 | 0.157 | 0.509 | -0.315 | |
| | (0.019) | (0.002) | (0.074) | (0.106) | (0.378) | (0.166) | |

Continued on the next page

Table F.5: Results with Unobserved Heterogeneity, cont.

| | Grade | | Earnings | | Evaluation (Relative to 5) Eval = 4 | | Eval = 3 | | Eval = 1-2 | | Promoted | | Pr(Leave) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Constant | -11.094 | * | 0.979 | * | 13.674 | * | 25.504 | * | 19.551 | * | -7.745 | * | 3.184 | * |
| | (0.264) | | (0.024) | | (0.711) | | (1.026) | | (4.186) | | (1.749) | | (1.017) | |
| Exogenous Variables | | | | | | | | | | | | | | |
| Unemployment Rate | -0.002 | | -0.001 | * | | | | | | | | | -0.042 | * |
| | (0.002) | | (0.0002) | | | | | | | | | | (0.010) | |
| Vacancies | 0.001 | | 0.002 | * | -0.008 | | 0.031 | * | 0.107 | * | 0.123 | * | 0.001 | |
| | (0.003) | | (0.0002) | | (0.007) | | (0.011) | | (0.037) | | (0.015) | | (0.010) | |
| ln(Private) Wages | 0.045 | * | -0.001 | | | | | | | | | | 0.187 | * |
| | (0.019) | | (0.002) | | | | | | | | | | (0.071) | |
| Heterogeneity Coefficients | | | | | | | | | | | | | | |
| $\rho$ | 10.000 | | 0.279 | * | -0.168 | | -0.280 | | -0.783 | | 6.080 | * | 2.656 | * |
| | (10.00) | | (0.005) | | (0.201) | | (0.320) | | (1.250) | | (0.477) | | (0.139) | |
| $\omega$ | 10.000 | | 0.398 | * | 0.440 | * | 0.005 | | -1.135 | | 18.381 | * | 1.006 | * |
| | (10.00) | | (0.004) | | (0.134) | | (0.225) | | (0.817) | | (0.255) | | (0.215) | |

Table F.6: Independent Equations with No Unobserved Heterogeneity

(Testing for Statistical Discrimination)

| | Grade n = 62,057 | | Earnings n = 62,057 | | Evaluation (Eval = 5 Excl.) n = 62,057 Eval = 4 | | Eval = 3 | | Eval = 1-2 | | Promotion n = 62,057 | | Pr(Leave) n = 72,725 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Endogenous Variables | | | | | | | | | | | | | | |
| Salary Grade | | | 0.022 | * | 0.030 | * | 0.073 | * | -0.046 | | 0.733 | * | -0.057 | * |
| | | | (0.0002) | | (0.008) | | (0.012) | | (0.037) | | (0.011) | | (0.011) | |
| ln(Annual Earnings) | | | | | -0.406 | * | -1.272 | * | -0.700 | | 0.253 | | -0.274 | * |
| | | | | | (0.102) | | (0.134) | | (0.508) | | (0.139) | | (0.093) | |
| Performance Evaluation | | | | | | | | | | | -0.122 | * | -0.321 | * |
| | | | | | | | | | | | (0.027) | | (0.016) | |
| Current Promotion | | | | | | | | | | | | | -0.084 | |
| | | | | | | | | | | | | | (0.092) | |
| Lagged $t-1$ Endogenous Variables | | | | | | | | | | | | | | |
| Salary Grade$_{t-1}$ | 0.885 | * | | | | | | | | | | | | |
| | (0.004) | | | | | | | | | | | | | |
| Salary$_{t-1}$ | 0.561 | * | 0.753 | * | | | | | | | | | | |
| | (0.042) | | (0.002) | | | | | | | | | | | |
| Evaluation$_{t-1}$ | 0.099 | * | 0.004 | * | -2.187 | * | -3.844 | * | -4.343 | | | | | |
| | (0.014) | | (0.001) | | (0.038) | | (0.058) | | (0.200) | | | | | |
| Promoted$_{t-1}$ | 0.232 | * | 0.039 | * | 0.214 | * | 0.374 | * | 0.026 | * | 2.284 | * | | |
| | (0.048) | | (0.002) | | (0.100) | | (0.164) | | (0.547) | | (0.141) | | | |
| Demographic Characteristics | | | | | | | | | | | | | | |
| Female | -0.247 | | 0.051 | | 0.130 | | -2.719 | * | -3.206 | | 1.560 | | -1.735 | * |
| | (1.373) | | (0.081) | | (0.766) | | (1.051) | | (5.839) | | (0.987) | | (0.832) | |
| Black | 1.622 | | 0.194 | | 3.281 | * | 3.255 | * | 1.974 | | 0.886 | | -2.168 | * |
| | (1.945) | | (0.104) | | (1.135) | | (1.301) | | (5.920) | | (0.972) | | (0.912) | |
| Female*Black | -0.798 | | -0.166 | | -4.105 | * | -3.069 | | 6.123 | | -4.970 | * | 1.458 | |
| | (2.916) | | (0.167) | | (1.407) | | (1.716) | | (8.277) | | (0.990) | | (0.928) | |
| Age | -0.008 | * | 0.001 | * | -0.0003 | | 0.004 | * | -0.003 | | -0.016 | * | -0.128 | * |
| | (0.001) | | (0.0002) | | (0.001) | | (0.002) | | (0.006) | | (0.002) | | (0.009) | |
| Age$^2$ | | | -0.001 | * | | | | | | | | | 0.123 | * |
| | | | (0.0003) | | | | | | | | | | (0.011) | |
| High School | 0.181 | * | -0.002 | | -0.015 | | -0.150 | | -0.221 | | 0.082 | | -0.194 | * |
| | (0.040) | | (0.002) | | (0.083) | | (0.112) | | (0.354) | | (0.138) | | (0.075) | |
| > High School | 0.242 | * | -0.001 | | -0.014 | | -0.078 | | -0.033 | | 0.068 | | -0.090 | |
| | (0.054) | | (0.003) | | (0.095) | | (0.130) | | (0.437) | | (0.155) | | (0.087) | |
| College | 0.282 | * | -0.002 | | -0.113 | | -0.152 | | 0.088 | | -0.156 | | 0.071 | |
| | (0.060) | | (0.004) | | (0.101) | | (0.141) | | (0.474) | | (0.163) | | (0.093) | |
| Graduate Degree | 0.146 | * | -0.003 | | -0.275 | * | -0.374 | * | 0.019 | | -0.135 | | 0.345 | * |
| | (0.059) | | (0.003) | | (0.103) | | (0.150) | | (0.487) | | (0.167) | | (0.095) | |
| Female*Education (in years)) | 0.026 | | -0.008 | | -0.130 | | 0.091 | | 0.404 | | -0.219 | | 0.239 | * |
| | (0.187) | | (0.011) | | (0.100) | | (0.143) | | (0.771) | | (0.132) | | (0.111) | |
| Female*Education$^2$ | -0.005 | | 0.003 | | 0.045 | | -0.031 | | -0.140 | | 0.070 | | -0.069 | |
| | (0.062) | | (0.004) | | (0.033) | | (0.048) | | (0.258) | | (0.044) | | (0.037) | |
| Black*Education | -0.204 | | -0.027 | | -0.482 | * | -0.426 | * | 0.120 | | -0.239 | | 0.370 | * |
| | (0.277) | | (0.015) | | (0.160) | | (0.182) | | (0.812) | | (0.131) | | (0.129) | |
| Black*Education$^2$ | 0.053 | | 0.009 | | 0.168 | * | 0.139 | * | -0.057 | | 0.116 | * | -0.133 | * |
| | (0.097) | | (0.005) | | (0.055) | | (0.063) | | (0.282) | | (0.046) | | (0.045) | |
| Female*Black* Education | 0.083 | | 0.029 | | 0.555 | * | 0.492 | * | -1.110 | | 0.688 | * | -0.300 | * |
| | (0.411) | | (0.023) | | (0.197) | | (0.245) | | (1.125) | | (0.150) | | (0.132) | |
| Female*Black* Education$^2$ | -0.020 | | -0.012 | | -0.198 | * | -0.177 | * | 0.384 | | -0.245 | * | 0.110 | * |
| | (0.142) | | (0.008) | | (0.068) | | (0.085) | | (0.386) | | (0.054) | | (0.046) | |
| Occupational Controls | | | | | | | | | | | | | | |
| Professionals | -0.581 | * | -0.019 | * | 0.010 | | -0.122 | | -0.208 | | 0.188 | | -0.282 | * |
| | (0.044) | | (0.002) | | (0.099) | | (0.212) | | (0.517) | | (0.143) | | (0.119) | |
| Technicians | -1.224 | * | -0.013 | * | 0.074 | | -0.039 | | -0.480 | | 0.664 | * | -0.411 | * |
| | (0.047) | | (0.003) | | (0.108) | | (0.221) | | (0.542) | | (0.155) | | (0.126) | |
| Protective Service | -1.286 | * | -0.002 | | 0.883 | * | 1.074 | * | -0.861 | | 0.321 | | -0.479 | * |
| | (0.050) | | (0.003) | | (0.124) | | (0.229) | | (0.594) | | (0.168) | | (0.131) | |

Continued on the next page

Table F.6: Results with No Unobserved Heterogeneity, cont.

| | Grade | | Earnings | | Evaluation | | | Promoted | | Pr(Leave) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Eval = 4 | Eval = 3 | Eval = 1-2 | | | | |
| Parapro-fessional | -0.708 | * | -0.017 | * | 0.229 | 0.356 | 0.043 | 0.273 | | -0.248 | |
| | (0.063) | | (0.003) | | (0.144) | (0.255) | (0.642) | (0.203) | | (0.159) | |
| Office & Clerical | -1.578 | * | 0.002 | | -0.181 | -0.277 | -0.491 | 1.025 | * | -0.517 | * |
| | (0.048) | | (0.003) | | (0.112) | (0.225) | (0.536) | (0.159) | | (0.128) | |
| Skilled Craft | -1.300 | * | -0.006 | * | 0.272 | * 0.242 | -0.239 | 0.409 | * | -0.299 | * |
| | (0.049) | | (0.003) | | (0.114) | (0.226) | (0.554) | (0.165) | | (0.131) | |
| Service & Maintenance | -2.027 | * | 0.018 | * | 0.043 | 0.190 | -0.801 | 0.628 | * | -0.502 | * |
| | (0.053) | | (0.003) | | (0.124) | (0.237) | (0.578) | (0.182) | | (0.138) | |
| Tenure Controls | | | | | | | | | | | |
| Tenure (in months) | 0.001 | | -0.012 | | 0.091 | 0.039 | 0.619 | -0.296 | * | -0.053 | |
| | (0.217) | | (0.011) | | (0.068) | (0.112) | (0.396) | (0.093) | | (0.042) | |
| Tenure$^2$ | -0.032 | | 0.022 | | -0.065 | -0.021 | -0.444 | -0.155 | | -0.007 | |
| | (0.289) | | (0.014) | | (0.056) | (0.097) | (0.352) | (0.088) | | (0.055) | |
| Female*Tenure | 0.147 | | -0.016 | | 0.032 | 0.272 | -1.101 | * 0.011 | | -0.033 | |
| | (0.643) | | (0.038) | | (0.090) | (0.160) | (0.525) | (0.102) | | (0.054) | |
| Female*Tenure$^2$ | 0.064 | | 0.010 | | -0.021 | -0.213 | 0.886 | 0.080 | | 0.074 | |
| | (0.677) | | (0.039) | | (0.079) | (0.142) | (0.461) | (0.105) | | (0.071) | |
| Black*Tenure | -0.436 | | -0.080 | | -0.234 | -0.256 | -0.845 | 0.103 | | -0.043 | |
| | (0.929) | | (0.050) | | (0.147) | (0.203) | (0.514) | (0.155) | | (0.077) | |
| Black*Tenure$^2$ | 0.261 | | 0.097 | | 0.159 | 0.162 | 0.714 | -0.119 | | -0.012 | |
| | (0.995) | | (0.052) | | (0.127) | (0.177) | (0.447) | (0.159) | | (0.102) | |
| Female*Black *Tenure | -0.048 | | 0.067 | | 0.225 | 0.005 | 1.155 | 0.083 | | 0.092 | |
| | (1.350) | | (0.078) | | (0.185) | (0.272) | (0.676) | (0.196) | | (0.099) | |
| Female*Black* Tenure$^2$ | -0.010 | | -0.091 | | -0.193 | -0.019 | -0.981 | 0.001 | | -0.091 | |
| | (1.384) | | (0.078) | | (0.160) | (0.239) | (0.586) | (0.203) | | (0.131) | |
| Tenure*Education Controls | | | | | | | | | | | |
| Education* Tenure | -0.008 | | 0.002 | | | | | | | | |
| | (0.029) | | (0.002) | | | | | | | | |
| Education* Tenure$^2$ | 0.008 | | -0.004 | | | | | | | | |
| | (0.039) | | (0.002) | | | | | | | | |
| Education$^2$* Tenure | 0.005 | | -0.001 | | | | | | | | |
| | (0.009) | | (0.001) | | | | | | | | |
| Education$^2$* Tenure$^2$ | -0.005 | | 0.001 | | | | | | | | |
| | (0.013) | | (0.001) | | | | | | | | |
| Female*Educ* Tenure | -0.019 | | 0.002 | | | | | | | | |
| | (0.088) | | (0.005) | | | | | | | | |
| Female*Educ* Tenure$^2$ | -0.013 | | -0.0002 | | | | | | | | |
| | (0.093) | | (0.005) | | | | | | | | |
| Female*Educ$^2$* Tenure | 0.004 | | -0.0004 | | | | | | | | |
| | (0.029) | | (0.002) | | | | | | | | |
| Female*Educ$^2$* Tenure$^2$ | 0.008 | | -0.0002 | | | | | | | | |
| | (0.031) | | (0.002) | | | | | | | | |
| Black*Educ* Tenure | 0.043 | | 0.010 | | | | | | | | |
| | (0.132) | | (0.007) | | | | | | | | |
| Black*Educ* Tenure$^2$ | -0.024 | | -0.013 | | | | | | | | |
| | (0.142) | | (0.008) | | | | | | | | |
| Black*Educ$^2$* Tenure | -0.007 | | -0.003 | | | | | | | | |
| | (0.046) | | (0.003) | | | | | | | | |
| Black*Educ$^2$* Tenure$^2$ | 0.003 | | 0.004 | | | | | | | | |
| | (0.050) | | (0.003) | | | | | | | | |
| Female*Black* Educ*Tenure | 0.007 | | -0.010 | | | | | | | | |
| | (0.190) | | (0.011) | | | | | | | | |
| Female*Black* Educ*Tenure$^2$ | 0.008 | | 0.013 | | | | | | | | |
| | (0.196) | | (0.011) | | | | | | | | |
| Female*Black* Educ$^2$*Tenure | -0.003 | | 0.004 | | | | | | | | |
| | (0.066) | | (0.004) | | | | | | | | |
| Female*Black* Educ$^2$*Tenure$^2$ | -0.005 | | -0.005 | | | | | | | | |
| | (0.068) | | (0.004) | | | | | | | | |

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Table F.6: Results with No Unobserved Heterogeneity, cont.

| | Grade | | Earnings | | Evaluation | | | Promoted | | Pr(Leave) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Eval = 4 | Eval = 3 | Eval = 1-2 | | | | |
| Promotion Controls | | | | | | | | | | | |
| Promoted Yet | -0.348 | * | -0.049 | * | -0.167 | -0.066 | 0.489 | -2.396 | * | 0.039 | |
| | (0.043) | | (0.002) | | (0.087) | (0.146) | (0.532) | (0.075) | | (0.086) | |
| Time Since Promotion | 0.156 | * | 0.004 | * | 0.013 | -0.002 | -0.211 | | | -0.028 | |
| | (0.012) | | (0.001) | | (0.026) | (0.044) | (0.165) | | | (0.037) | |
| Grade Change \| $\text{Promotion}_{t-1}$ | -0.003 | | -0.012 | * | -0.031 | -0.086 | * -0.075 | -0.732 | * | | |
| | (0.012) | | (0.001) | | (0.026) | (0.042) | (0.147) | (0.039) | | | |
| Female*Grade $\triangle$\| $\text{Promotion}_{t-1}$ | -0.030 | * | 0.001 | | -0.009 | -0.086 | 0.124 | -0.047 | | | |
| | (0.013) | | (0.001) | | (0.027) | (0.049) | (0.149) | (0.044) | | | |
| Black*Grade $\triangle$\| $\text{Promotion}_{t-1}$ | 0.015 | | 0.0002 | | -0.001 | -0.005 | -0.128 | -0.106 | | | |
| | (0.019) | | (0.001) | | (0.042) | (0.061) | (0.214) | (0.069) | | | |
| Female*Black*Grade $\triangle$\| $\text{Promotion}_{t-1}$ | 0.003 | | -0.001 | | -0.024 | 0.028 | 0.115 | -0.045 | | | |
| | (0.026) | | (0.001) | | (0.055) | (0.084) | (0.254) | (0.095) | | | |
| Grade Change \| $\text{Promotion}_{t}$ | | | | | | | | | | -0.029 | |
| | | | | | | | | | | (0.033) | |
| Female*Grade $\triangle$\| $\text{Promotion}_{t}$ | | | | | | | | | | 0.025 | |
| | | | | | | | | | | (0.032) | |
| Black*Grade $\triangle$\| $\text{Promotion}_{t}$ | | | | | | | | | | -0.001 | |
| | | | | | | | | | | (0.045) | |
| Female*Black*Grade $\triangle$\| $\text{Promotion}_{t}$ | | | | | | | | | | 0.026 | |
| | | | | | | | | | | (0.059) | |
| Evaluation Controls | | | | | | | | | | | |
| Female* $\text{Evaluation}_{t-1}$ | -0.016 | | 0.002 | * | 0.148 | * 0.407 | * 0.727 | * | | | |
| | (0.020) | | (0.001) | | (0.051) | (0.080) | (0.260) | | | | |
| Black* $\text{Evaluation}_{t-1}$ | 0.013 | | 0.001 | | 0.297 | * 0.442 | * -0.069 | | | | |
| | (0.028) | | (0.001) | | (0.083) | (0.111) | (0.275) | | | | |
| Female*Black* $\text{Evaluation}_{t-1}$ | 0.013 | | -0.001 | | -0.045 | -0.115 | -0.124 | | | | |
| | (0.036) | | (0.002) | | (0.102) | (0.141) | (0.346) | | | | |
| Previous Evaluations | 0.011 | | 0.004 | * | -0.826 | * -1.394 | * -1.344 | * | | | |
| | (0.015) | | (0.001) | | (0.033) | (0.054) | (0.199) | | | | |
| Female*Previous Evaluations | -0.0002 | | 0.0005 | | -0.002 | 0.013 | 0.440 | * | | | |
| | (0.015) | | (0.001) | | (0.032) | (0.059) | (0.218) | | | | |
| Black*Previous Evaluations | -0.025 | | -0.0003 | | 0.004 | -0.031 | 0.166 | | | | |
| | (0.023) | | (0.001) | | (0.055) | (0.078) | (0.232) | | | | |
| Female*Black*Previous Evaluations | 0.030 | | -0.001 | | 0.008 | 0.037 | -0.500 | | | | |
| | (0.030) | | (0.002) | | (0.068) | (0.103) | (0.299) | | | | |
| Job Characteristics | | | | | | | | | | | |
| Period 2 | 0.009 | | 0.013 | * | -2.732 | * -4.238 | * -3.944 | * -0.248 | * | 0.060 | * |
| | (0.040) | | (0.002) | | (0.095) | (0.133) | (0.383) | (0.073) | | (0.028) | |
| Initial Grade | 0.013 | * | -0.011 | * | -0.023 | * -0.043 | * 0.029 | -0.708 | * | 0.034 | * |
| | (0.004) | | (0.0001) | | (0.006) | (0.010) | (0.029) | (0.008) | | (0.011) | |
| Part-Time | -0.061 | | -0.142 | * | -0.354 | * -0.899 | * -0.099 | -1.037 | * | 0.289 | * |
| | (0.045) | | (0.002) | | (0.098) | (0.162) | (0.462) | (0.234) | | (0.081) | |
| Year 2 | | | | | | | | | | -0.101 | |
| | | | | | | | | | | (0.068) | |
| Year 3 | -0.024 | | -0.020 | * | -0.038 | 0.055 | 0.414 | -0.034 | | -0.169 | * |
| | (0.033) | | (0.002) | | (0.082) | (0.118) | (0.409) | (0.113) | | (0.063) | |
| Year 4 | 0.192 | * | 0.011 | * | 0.031 | 0.198 | 0.264 | -0.024 | | -0.218 | * |
| | (0.031) | | (0.002) | | (0.078) | (0.112) | (0.386) | (0.107) | | (0.063) | |
| Year 5 | 0.055 | | 0.015 | * | 0.034 | 0.293 | * 0.310 | -0.089 | | -0.238 | * |
| | (0.030) | | (0.002) | | (0.077) | (0.111) | (0.387) | (0.106) | | (0.063) | |
| Year 6 | 0.108 | * | 0.005 | * | 0.125 | -0.052 | 0.059 | 0.111 | | -0.190 | * |
| | (0.030) | | (0.002) | | (0.075) | (0.109) | (0.372) | (0.104) | | (0.063) | |
| Year 7 | 0.116 | * | -0.008 | * | 0.035 | -0.070 | -0.075 | 0.088 | | -0.165 | * |
| | (0.030) | | (0.002) | | (0.075) | (0.108) | (0.382) | (0.102) | | (0.064) | |
| Year 8 | 0.149 | * | 0.010 | * | -0.019 | -0.050 | -0.010 | -0.078 | | -0.388 | * |
| | (0.030) | | (0.002) | | (0.075) | (0.109) | (0.376) | (0.103) | | (0.067) | |
| Year 9 | -0.011 | | 0.0002 | | 0.044 | 0.087 | 0.126 | -0.588 | * | -0.397 | * |
| | (0.031) | | (0.002) | | (0.074) | (0.108) | (0.361) | (0.107) | | (0.071) | |
| Year 10 | 0.007 | | -0.024 | * | 0.069 | 0.152 | 0.499 | -0.224 | * | | |
| | (0.032) | | (0.002) | | (0.075) | (0.109) | (0.365) | (0.105) | | | |

Continued on the next page

Table F.6: Results with No Unobserved Heterogeneity, cont.

| | Grade | | Earnings | | Evaluation | | | Promoted | | Pr(Leave) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Eval = 4 | Eval = 3 | Eval = 1-2 | | | | |
| Constant | 1.908 | * | 1.771 | * | 13.869 | * 25.490 | * 19.036 | * -6.217 | * | 5.450 | * |
| | (0.437) | | (0.021) | | (0.787) | (1.005) | (4.185) | (1.012) | | (0.993) | |
| Exogenous Variables | | | | | | | | | | | |
| Unemployment Rate | -0.008 | * | -0.001 | * | | | | | | -0.040 | * |
| | (0.004) | | (0.0002) | | | | | | | (0.009) | |
| Vacancies | 0.054 | * | 0.003 | * | -0.007 | 0.032 | * 0.107 | * 0.114 | * | 0.003 | |
| | (0.004) | | (0.0002) | | (0.007) | (0.011) | (0.032) | (0.010) | | (0.010) | |
| ln(Private) Wages | -0.009 | | -0.003 | * | | | | | | 0.174 | * |
| | (0.033) | | (0.002) | | | | | | | (0.071) | |

Table F.7: Black Males: Intervention Results Without Unobserved Heterogeneity

| | No Intervention | White | Education | Occupation | Promotion | Salary Grade |
|---|---|---|---|---|---|---|
| Salary Grade | 59.05 | 59.54 | 59.44 | 59.46 | 59.25 | 63.99 |
| Earnings | 24,397 | 25,465 | 24,686 | 24,454 | 23,815 | 25,718 |
| Ever Promoted | 16.08 | 22.81 | 14.91 | 23.10 | 55.85 | 11.70 |
| Performance Evaluation | 2.98 | 3.08 | 2.95 | 2.97 | 2.97 | 2.99 |
| 1-2 | 0.96 | 0.41 | 1.08 | 0.98 | 0.83 | 0.82 |
| 3 | 22.03 | 17.57 | 23.81 | 22.08 | 22.91 | 21.34 |
| 4 | 55.34 | 55.85 | 54.04 | 55.95 | 54.84 | 55.63 |
| 5 | 21.67 | 26.17 | 21.07 | 20.98 | 21.42 | 22.21 |
| Spell Length | 4.90 | 5.68 | 4.59 | 5.06 | 4.93 | 5.37 |
| 1 Year | 29.24 | 23.39 | 33.04 | 28.95 | 29.24 | 25.44 |
| 2 Years | 15.79 | 12.57 | 15.79 | 14.91 | 15.79 | 14.91 |
| 3 Years | 7.89 | 7.60 | 7.31 | 7.60 | 7.02 | 7.31 |
| 4 Years | 5.56 | 5.56 | 4.97 | 5.26 | 5.85 | 5.56 |
| 5 Years | 3.80 | 4.09 | 4.39 | 3.51 | 4.09 | 3.22 |
| 6 Years | 1.75 | 1.46 | 1.46 | 1.46 | 1.75 | 1.75 |
| 7 Years | 1.46 | 2.05 | 2.05 | 1.46 | 1.46 | 1.75 |
| 8 Years | 0.58 | 0.88 | 0.58 | 0.58 | 0.58 | 0.58 |
| 9 Years | 0.58 | 0.58 | 0.88 | 0.58 | 0.58 | 0.58 |
| 10 Years | 33.33 | 41.81 | 29.53 | 35.67 | 33.63 | 38.89 |

Table F.8: White Females: Intervention Results Without Unobserved Heterogeneity

| | No Intervention | Male | Education | Occupation | Promotion | Salary Grade |
|---|---|---|---|---|---|---|
| Salary Grade | 63.25 | 63.64 | 63.46 | 63.49 | 63.49 | 64.71 |
| Earnings | 29,611 | 30,251 | 29,800 | 29,402 | 28,880 | 29,654 |
| Ever Promoted | 20.76 | 25.98 | 20.40 | 23.25 | 67.62 | 21.00 |
| Performance Evaluation | 3.40 | 3.34 | 3.39 | 3.33 | 3.39 | 3.40 |
| 1-2 | 0.53 | 0.42 | 0.50 | 0.52 | 0.49 | 0.48 |
| 3 | 8.67 | 9.66 | 8.74 | 10.25 | 9.26 | 8.91 |
| 4 | 41.42 | 45.75 | 42.26 | 45.28 | 40.61 | 40.82 |
| 5 | 49.38 | 44.17 | 48.51 | 43.95 | 49.64 | 49.79 |
| Spell Length | 5.83 | 6.47 | 5.96 | 5.72 | 5.84 | 5.92 |
| 1 Year | 23.49 | 18.86 | 21.59 | 23.72 | 23.49 | 23.13 |
| 2 Years | 10.08 | 9.49 | 10.20 | 10.79 | 10.08 | 9.49 |
| 3 Years | 5.93 | 4.74 | 5.69 | 5.69 | 5.69 | 5.34 |
| 4 Years | 5.93 | 5.34 | 6.29 | 6.64 | 5.93 | 6.52 |
| 5 Years | 3.32 | 2.97 | 3.91 | 3.56 | 3.44 | 3.56 |
| 6 Years | 4.39 | 3.91 | 4.39 | 4.03 | 4.39 | 3.80 |
| 7 Years | 2.49 | 2.25 | 2.49 | 2.85 | 2.61 | 2.61 |
| 8 Years | 2.14 | 1.54 | 2.14 | 2.25 | 2.02 | 2.14 |
| 9 Years | 1.90 | 1.54 | 1.66 | 1.78 | 1.90 | 2.02 |
| 10 Years | 40.33 | 49.35 | 41.64 | 38.67 | 40.45 | 41.40 |

Table F.9: Black Females: Intervention Results Without Unobserved Heterogeneity

| | No Intervention | White | Male | White Male | Education | Occupation | Promotion | Salary Grade |
|---|---|---|---|---|---|---|---|---|
| Salary Grade | 58.81 | 59.32 | 59.13 | 59.68 | 59.21 | 59.64 | 59.05 | 63.39 |
| Earnings | 24,391 | 24,823 | 24,406 | 25,374 | 24,797 | 24,793 | 23,793 | 25,714 |
| Ever Promoted | 17.88 | 18.99 | 17.60 | 23.46 | 17.32 | 27.65 | 67.60 | 13.41 |
| Performance Evaluation | 2.84 | 3.19 | 3.04 | 3.17 | 2.85 | 2.82 | 2.85 | 2.85 |
| 1-2 | 11.24 | 0.71 | 0.96 | 0.68 | 11.35 | 9.96 | 10.44 | 11.41 |
| 3 | 14.48 | 13.96 | 18.83 | 13.65 | 14.60 | 15.82 | 15.07 | 13.97 |
| 4 | 52.89 | 50.76 | 54.98 | 54.12 | 52.10 | 56.05 | 53.11 | 52.44 |
| 5 | 21.39 | 34.58 | 25.23 | 31.55 | 21.95 | 18.16 | 21.39 | 22.18 |
| Spell Length | 5.94 | 5.54 | 5.55 | 6.20 | 5.66 | 5.72 | 5.97 | 6.12 |
| 1 Year | 19.55 | 23.18 | 23.74 | 18.72 | 20.39 | 20.39 | 19.55 | 17.04 |
| 2 Years | 13.41 | 13.41 | 13.41 | 12.85 | 13.69 | 13.97 | 13.41 | 12.85 |
| 3 Years | 5.87 | 7.26 | 8.10 | 6.15 | 7.54 | 7.54 | 5.87 | 6.42 |
| 4 Years | 6.15 | 6.42 | 5.87 | 5.59 | 7.26 | 5.87 | 6.42 | 5.87 |
| 5 Years | 3.07 | 2.51 | 2.51 | 2.79 | 2.23 | 3.07 | 2.79 | 3.63 |
| 6 Years | 2.51 | 3.35 | 2.51 | 2.23 | 3.35 | 2.23 | 2.51 | 3.35 |
| 7 Years | 4.47 | 4.19 | 2.79 | 2.51 | 4.75 | 5.03 | 4.47 | 4.75 |
| 8 Years | 1.68 | 0.56 | 0.56 | 0.84 | 1.68 | 1.40 | 0.56 | 1.68 |
| 9 Years | 2.51 | 0.84 | 0.28 | 0.28 | 2.23 | 2.51 | 1.68 | 2.51 |
| 10 Years | 40.78 | 38.27 | 40.22 | 48.04 | 36.87 | 37.99 | 42.74 | 41.90 |

# Appendix G: Additional Data Tables

Table G.1: Promotion Rates within EEO Category

| | No Change | Promoted |
|---|---|---|
| Officials and Administrators | 86.51% | 13.49% |
| Professionals | 89.52% | 10.48% |
| Technicians | 90.07% | 9.93% |
| Protective Service | 95.89% | 4.11% |
| Paraprofessionals | 90.05% | 9.95% |
| Office and Clerical | 90.51% | 9.49% |
| Skilled Craft | 92.00% | 8.00% |
| Service and Maintenance | 95.32% | 4.68% |

Table G.2: 2003 Salary Grade Schedule

| Grade | Min | Max | Grade | Min | Max | Grade | Min | Max |
|---|---|---|---|---|---|---|---|---|
| 50 | 20,112 | 23,461 | 66 | 28,888 | 43,460 | 82 | 56,499 | 90,211 |
| 51 | 20,112 | 24,314 | 67 | 30,045 | 45,462 | 83 | 59,188 | 94,612 |
| 52 | 20,112 | 25,213 | 68 | 31,204 | 47,586 | 84 | 61,967 | 99,182 |
| 53 | 20,112 | 26,112 | 69 | 32,432 | 49,755 | 85 | 64,866 | 103,952 |
| 54 | 20,112 | 27,081 | 70 | 33,790 | 52,065 | 86 | 67,885 | 108,986 |
| 55 | 20,112 | 28,039 | 71 | 35,134 | 54,430 | 87 | 71,084 | 114,278 |
| 56 | 20,268 | 29,128 | 72 | 36,521 | 56,911 | 88 | 74,507 | 119,787 |
| 57 | 20,955 | 30,276 | 73 | 37,994 | 59,557 | 89 | 77,990 | 125,571 |
| 58 | 21,656 | 31,453 | 74 | 39,623 | 62,372 | 90 | 81,664 | 131,697 |
| 59 | 22,426 | 32,689 | 75 | 41,366 | 65,282 | 91 | 85,536 | 138,161 |
| 60 | 23,227 | 34,030 | 76 | 43,157 | 68,344 | 92 | 89,720 | 144,917 |
| 61 | 24,101 | 35,412 | 77 | 45,185 | 71,545 | 93 | 94,066 | 152,041 |
| 62 | 24,958 | 36,812 | 78 | 47,232 | 74,945 | 94 | 98,580 | 159,488 |
| 63 | 25,886 | 38,297 | 79 | 49,428 | 78,499 | 95 | 103,347 | 167,352 |
| 64 | 26,830 | 39,902 | 80 | 51,686 | 82,179 | 96 | 108,355 | 175,600 |
| 65 | 27,818 | 41,639 | 81 | 54,076 | 86,055 | | | |

Table G.3: Salary grades within EEO category

| Year | Officials and Admin. | Profes-sionals | Technicians | Protective Service | Paraprofes-sionals | Office and Clerical | Skilled Craft | Service Maintenance |
|---|---|---|---|---|---|---|---|---|
| 1994 | 53-90 | 50-90 | 53-82 | 50-76 | 56-65 | 50-77 | 50-77 | 50-74 |
| 1995 | 57-90 | 54-88 | 54-82 | 50-76 | 56-69 | 50-77 | 50-77 | 50-73 |
| 1996 | 57-90 | 50-88 | 54-82 | 50-77 | 54-69 | 50-80 | 50-77 | 50-73 |
| 1997 | 54-90 | 51-88 | 52-82 | 50-77 | 56-69 | 50-80 | 50-75 | 50-73 |
| 1998 | 57-90 | 50-88 | 50-82 | 50-77 | 56-69 | 50-80 | 50-77 | 50-70 |
| 1999 | 50-90 | 53-88 | 50-85 | 50-77 | 56-70 | 50-82 | 50-77 | 50-73 |
| 2000 | 65-91 | 50-88 | 52-85 | 50-77 | 56-70 | 50-82 | 50-77 | 50-73 |
| 2001 | 65-90 | 50-88 | 51-85 | 50-77 | 56-69 | 50-82 | 50-77 | 50-73 |
| 2002 | 58-90 | 50-92 | 52-85 | 50-77 | 55-69 | 50-80 | 50-77 | 50-73 |
| 2003 | 64-90 | 53-92 | 50-85 | 50-78 | 56-69 | 50-80 | 50-77 | 50-73 |

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