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The role of job assignment and human capital endowments in explaining gender differences in job performance and promotion

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ABSTRACT

We test a job ladders theory of career progression within internal labor markets as developed by Lazear and Rosen (1990). The theory argues that gender promotion gaps are due to sorting of men and women into career tracks with different promotion opportunities based on *ex ante* quit probabilities. Analyzing US federal government employees using a dynamic unobserved panel data model, we find that job assignment is one of the strongest predictors of gender differences in promotion. We also find that women have to jump higher performance hurdles to promote across grades, but, within grades, their promotion probabilities are comparable to those of men. In this organization, women can be found in both fast- and slow-track jobs, based on their promotion history, suggesting that unobserved heterogeneity is revealed to the firm over the worker's career.

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1. Introduction

Research on the gender pay gap has recently focused on career differences within large hierarchical organizations. In part this trend has been driven by limited information on human capital endowments in standard public-use data (Donald and Hamermesh, 2004).[1] The data limitations present obstacles to distinguishing among competing theories on gender pay gaps, including discrimination, occupational sorting, and job assignment. Separating unobservable characteristics, such as ability or quit propensities, from discrimination and endowment differences has been especially difficult. While women's labor force participation, educational attainment, and representation in traditionally-male occupations has risen dramatically in recent years, the question remains: will these changes be enough to eradicate gender-based differences in wages and career progression?

Following the recent trend of studying male–female career differences in the context of firm-level decisions on optimal incentive pay and promotions, we focus on professional workers in a large hierarchical organization. Using longitudinal data on U.S. federal government employees, we test hypotheses generated from the Lazear and Rosen (1990) jobs-based model of gender differences in career progression. The model suggests that gender pay differences arise from the assignment of males to 'fast track' jobs that require heavier investments in specific human capital and thus stronger job attachment. Because women have higher productivity in non-market activities, they are more likely to separate and, therefore, are assigned to jobs that have flatter career paths. Using a dynamic unobserved panel data model, we find that job assignment is one of the strongest predictors of gender differences in promotions. However, we also find that women can be on both fast and slow tracks, based on their promotion history, suggesting that the separation probability is revealed to the firm over the worker's career. Contributing to the internal labor market literature more generally, we find that promotions resulting only in wage growth are characterized by different dynamics than promotions involving a change in responsibilities.

2. Background

Lazear and Rosen (hereafter L&R) distinguish between two types of jobs: type-A jobs that require extensive firm-specific training, and type-B jobs that do not require as much training or job attachment. In return for extensive training, type-A jobs offer better promotion prospects and higher pay over the life-cycle than type-B jobs. Organizations offer earnings-tenure profiles within each job ladder to create incentives for workers to undertake the required specific training. Since the payoff to training is delayed, workers who expect to leave are less likely to undertake, or to be offered, the required training. Asymmetric information is important in the optimal pay structure because firms cannot observe an individual's propensity to leave and workers have no incentive to voluntarily reveal their true propensities. To induce worker sorting, firms set higher ability

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[1] For a survey on the gender pay gap see Blau and Kahn (2000); for a survey on the 'glass ceiling' literature see McDowell et al. (2001).

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thresholds for groups with higher *ex ante* turnover probabilities. Even if firms are unable to design contracts that induce employees to self-select into different job ladders, the ability thresholds solve the internal promotion problem. As testable implications, this model suggests that: (1) average observed ability is higher for women than for men; (2) women earn less than men because they occupy lower-tier jobs; and (3) within jobs women earn at least as much as men (or more) because of their higher ability.

Lazear and Rosen build upon the idea that firms use promotions to sort employees by ability, thus resulting in individuals who move faster up the hierarchy as if they were on 'fast tracks.' Baker et al. (1994b) find that within a large firm employee wages are positively correlated over time. In addition, wage increases are positively correlated with current wage, suggesting that employees who are more able or who accumulate more human capital advance along the hierarchy more quickly.[2] The L&R model assumes that the human capital accumulation varies by gender, hence resulting in different tracks for men and women.

Winter-Ebmer and Zweimuller (1997) (hereafter W&Z) extend the L&R model to explain job assignment at entry. They argue that employers apply the same considerations when assigning workers to entry jobs that are considered 'promotion-track' positions. Using cross-sectional data, W&Z analyze gender differences in initial assignment and promotion. If a person is observed in a job rank that is higher than the corresponding endowment (mainly education) they assume that the person has been promoted. They decompose the gender gap into a portion explained by the ability threshold and a portion explained by endowment differences. They find that women are concentrated in lower-tier jobs and must possess higher endowments to reach higher-ranked positions. However, differences in endowments and predicted turnover account for only a small portion of the observed differences in promotion and initial placement. They conclude that there is unequal treatment of women in professional careers.

Jones and Makepeace (1996) use personnel data from a U.K. financial firm to test the L&R model. Contrary to W&Z, they find that 69–87% of gender differences in job grades are due to endowment differences, most notably differences in tenure. They also find that women face higher ability thresholds for promotion.

These represent only two studies in a growing literature on promotion and career progression, but are the only ones that explicitly test the L&R model.[3] However, neither study models the dynamic nature of promotions within a career ladder. This is important because higher-order promotions depend upon the entire history of past promotions, and L&R attribute gender differences to these career paths differences.[4]

3. Empirical approach

In testing the L&R hypotheses, we must distinguish two competing factors. First, as identical employees move up the hierarchy, fewer possible promotion steps remain and conditional promotion probabilities decline over time. Second, future promotions may depend on success at "key" career points, so promotions in previous periods may *causally* affect future promotions. In the L&R model future promotions depend on the past history of promotions when workers are placed on certain career tracks. This temporal correlation in promotions represents true state dependence. In contrast, the temporal correlation in promotions as a result of the constraints imposed by the hierarchy would be largely spurious. Unobserved heterogeneity complicates the estimation of state dependence. If unobserved heterogeneity persists over time, we cannot distinguish between the effects of job assignment (differences in state dependence) and unobserved heterogeneity. Therefore, we cannot distinguish whether women are in lower-level positions because of their endowments (including unobservables) or because they are assigned to different tracks.

The L&R model suggests that unobserved heterogeneity (which includes *ex ante* quit probabilities) explains the different career paths for men and women. Their model suggests positive state dependence, especially for the type-A jobs that provide more promotion possibilities. The L&R model, however, does not analyze these propositions against the constraints of a finite firm hierarchy. Incorporating a limited number of promotion steps induces negative state dependence, which may be stronger for type-A jobs because incumbents are more likely to face these constraints or to face them sooner. In addition, if we fail to account for the firm's hierarchy, differential job assignments by gender may generate the spurious finding that women promote at higher rates than men because men tend to hit the hierarchical constraints earlier. Therefore, we view state dependence as the *net effect* of a finite hierarchy and being in a fast or slow job track.[5] Finally, the L&R model also implies that the assignment of women to type-B jobs is optimal. Empirically, this can only be validated if we also observe that, within jobs, men and women promote at similar rates. Otherwise, the differential assignment could also be due to discrimination at entry.

To reduce the set of unobservables that drive promotion, we focus on high-ability white-collar workers within an organization and control for variables that are typically unavailable in public data, such as job performance, firm-specific human capital, and promotion history. We specify the following dynamic model for our latent variable:

$$y^*_{it} = \rho y_{i,t-1} + \delta \text{female}_i + \mathbf{z}_{it}\gamma + c_i + u_{it} \tag{1}$$

where y_{it} represents promotion at time t, $\mathbf{z}_{it}$ represents strictly exogenous variables, c_i represents unobserved heterogeneity and u_{it} represents a random disturbance.[6] Our exogenous variables include performance ratings, dummies for advanced degrees (master's and doctorate), race (black, Hispanic, and other), age, departments (Army, Air Force, and headquarters), occupation (professional, administrative, clerical, technical, other white collar), tenure, and time dummies. One assumption in Eq. (1) is that the model correctly specifies the promotion dynamics and only one lag of y_{it} belongs in the model.[7] We also assume that c_i does not vary by gender but by individual, to allow females to also be type A and males to also be type B. The L&R model suggests that the unobserved heterogeneity that drives job assignment and promotion is related to performance and job attachment rather than to gender itself.

Occupational sorting may partially explain observed gender differences in careers, in which case occupation may be endogenous in Eq. (1). However, occupational sorting may be driven by a similar

[2] This evidence is obtained across job levels. Within-job levels Baker et al. (1994a) find a negative correlation between both percentage and dollar increases in wages and current wages (referred to as the 'green card effect'). For a theoretical treatment of fast tracks, see Bernhardt (1995).

[3] Cabral et al. (1981) and Gerhart and Milkovich (1987) find that women enter in lower positions than men with comparable qualifications, which explains their lower promotion rates and salaries. Ginther and Hayes (1999) find substantial gender differences in promotion among academics even after controlling for productivity differences. McDowell et al. (1999, 2001) find that promotion rates of female academic economists are below those of men, but these differences have narrowed over time.

[4] Belzil and Bognanno (2008) model career progression within firms in a dynamic setting. Their data, however, do not include information on gender.

[5] See Belzil and Bognanno (2004) for an alternative way of investigating fast tracks while circumventing the spurious negative correlation due to the finite hierarchy. Our focus in this paper is in estimating the relative difference in state dependence between women and men, rather than obtaining estimates of the state dependence in promotions (free from any spuriousness induced by administrative constraints). Since both men and women face the same hierarchical constraints, for our purposes, the spuriousness induced by the finite hierarchy does not pose a problem. Additionally, women in our sample are observed to promote all the way to the top, thus eliminating the possibility that men and women face implicitly different hierarchies.

[6] We assume that unobserved heterogeneity remains fixed over time. Implicitly, this requires that a type-A worker remains a type A and does not become a type B, at least not during the period under consideration.

[7] We relax this assumption later.

heterogeneity as the one captured by c_i. Therefore, we estimate models with and without occupation dummies. Whether we should include tenure in Eq. (1) is also debatable. Since women have weaker labor force attachment, they also have lower tenure, which may account for their concentration in type-B jobs.[8] However, tenure also proxies for firm-specific capital, and in the federal personnel system is an indicator of hierarchical position in a firm, since workers are periodically reviewed and awarded step and grade increases.[9]

Testing H_0:$\rho = 0$ in Eq. (1) amounts to testing whether there is state dependence after controlling for unobserved heterogeneity (c_i) and observable characteristics. This is typically the focus of studies that specify models similar to Eq. (1). However, we are most interested in testing whether state dependence and the effect of performance ratings vary by gender. If state dependence varies by gender it suggests that men and women are on different career tracks. Also, finding that performance ratings have different impacts on promotion would imply that women must have higher ability for the same promotion. To test these hypotheses we include interactions of female with lagged promotions and performance ratings.

To address the issue of the finite hierarchy we include a variable controlling for job level in time $t-1$. This variable captures the employee's position in the hierarchy and proxies for the remaining steps available for advancement. Additionally, estimations that include pay grade yield implications for within-job gender promotion differences.

Estimating the parameters in Eq. (1) amounts to modeling the density of y_{it} conditional on a lagged dependent variable, strictly exogenous controls, and unobserved heterogeneity. The main problem is that c_i is unobserved. Ideally, we would like to avoid making restrictive assumptions about the relationship between z_i and c_i. Treating c_i as parameters to be estimated or transforming Eq. (1) to eliminate c_i, similar to the linear case, introduces the incidental parameters problem and leads to inconsistent estimates. Heckman (1981a) shows that the problem is exacerbated in fixed effects probit models that include lagged dependent variables. In the case where Eq. (1) does not contain lagged dependent variables, Chamberlain (1980) proposes approximating the conditional distribution of c_i given z_i with a normal distribution with an expectation linear in z_i and a constant variance. Specifying a dynamic model, however, introduces the initial conditions problem. That is, we must decide whether to model y_0 as a constant or a random variable. Ignoring how the process of promotions began would assume either that the history of promotions and their determinants prior to our first observation are irrelevant, or that this process is stationary. Of greatest concern is that treating y_0 as a constant implies that y_0 and c_i are independent.[10] In the context of this paper, this would amount to assuming that unobserved heterogeneity (including ability, motivation, or quit propensity) is uncorrelated with the first observed promotion. Since this assumption is quite strong, we assume instead that y_0 is stochastic, and possibly correlated with c_i.

Wooldridge (2005) offers a practical solution for the initial conditions problem in the non-linear dynamic case. In the spirit of Chamberlain's approach to probit models with unobserved heterogeneity, Wooldridge suggests modeling the distribution of c_i conditional on the exogenous controls $\mathbf{z}_i$ and the initial value y_0.[11] Following Wooldridge, we propose the following model to approximate the relationship among c_i, $\mathbf{z}_i$, and y_0:

$$c_i = \alpha_0 + \alpha_1 y_{i0} + z_i \alpha_2 + a_i \\ \text{where } a_i \mid (y_{i0}, \mathbf{z}_i) \sim \text{Normal}\left(0,\ \sigma_a^2\right) \tag{2}$$

Here z_i represents all of the exogenous variables in all time periods. Combining Eqs. (1) and (2) suggests the following latent variable model for estimation:

$$y_{it}^* = \rho y_{i,t-1} + \delta \text{female}_i + \mathbf{z}_{it}\gamma + \alpha_0 + \alpha_1 y_{i0} + z_i \alpha_2 + a_i + u_{it} \\ \text{where } u_{it} \mid \left(z_{it}, \text{female}_i, y_{i,t-1}, \ldots, y_{i0}, a_i\right) \sim \text{Normal}(0,1) \tag{3}$$

One useful aspect of this approach is that we can obtain consistent parameter estimates via standard conditional maximum likelihood methods. In addition, we can investigate how unobserved heterogeneity relates to observable covariates.

4. Personnel data

The U.S. Defense Department (DOD) employs nearly one-third of the entire U.S. federal civilian workforce. About 75% of DOD employees are in white-collar occupations, many of whom are scientists and engineers (Gibbs, 2006). Most college-educated employees are paid under the General Schedule or General Management (GS/GM) pay system, which consists of 15 grades and 10 steps within each grade. Within-grade step increases are based on satisfactory job performance and time-in-grade requirements. Jumps in grade levels, however, are largely based on performance. Certain grade levels are seldom used in the GS/GM system (typically 4, 6, 8, and 10), so workers may jump more than one pay grade upon promotion in the mid-range of the hierarchy.[12]

We define a promotion as a change in grade level from one period to the next. Although dependent on performance, these promotions may also depend on time-in-grade requirements and, often, do not involve a change in duties and responsibilities, but simply higher pay and a change in job title. Attaining a supervisory or managerial position represents a different kind of career advancement. Managers are responsible for the success of an agency or program and have budgetary authority. Supervisors plan, schedule, and coordinate work operations and have authority to hire, assign, promote, reward, and fire employees (Lewis, 1986). Since such positions require considerable firm-specific knowledge, this promotion will depend both on expected future performance and on predicted attrition. Whether an employee achieves a supervisory or managerial position constitutes our second measure of career advancement.[13]

[8] This holds true for our sample. Women have about three less years of tenure, but are only one year younger than men on average.

[9] To reduce multicollinearity between a time-varying tenure variable and the time dummies we include log(tenure$_t$) in the model. Controlling for the potentially higher separation rates of women (via tenure) is also important since we do not deal with sample attrition. We ignore this problem because our goal is to estimate gender differences among homogenous (and, therefore, comparable) workers to separate competing theories. Additionally, L&R assume that the same factor (higher non-market productivity) drives both quits and job assignment. Since model (1) explicitly includes unobserved heterogeneity, adjusting the parameters for attrition requires that we propose different reasons for women's weaker job attachment. Finally, attrition does not have a tractable solution in non-linear panel unobserved effects models. Available solutions (such as inverse probability weighting) assume away unobserved heterogeneity, whereas semi-parametric methods do not allow for an estimation of state dependence. We thank Jeff Wooldridge for clarifying these points.

[10] Even if we were to focus only on new entrants (for whom we observe the entire promotion history), by considering the first promotion as a non-stochastic event we would still be assuming that the initial promotion is independent of unobserved heterogeneity.

[11] Chamberlain (1980) offers a similar suggestion for the autoregressive case without any explanatory variables. Heckman (1981a) proposes a solution for the dynamic probit model with explanatory variables that involves modeling the distribution of y_0 conditional on ($\mathbf{z}_i$, c_i), and then specifying a distribution for c_i given $\mathbf{z}_i$. However, the distribution of y_0 given ($\mathbf{z}_i$, c_i) can be difficult to find or approximate (Hsiao, 1986), and, computationally, Wooldridge's approach is much simpler.

[12] Since pay in the federal system is a deterministic function of step, grade, supervisory duties, and area cost of living, we focus on promotions as indicators of career progression instead of wages. Grade levels may be misleading as indicators of advancement, since going from GS4 to GS6 is not twice as valuable as promoting from GS6 to GS7. Hence, we focus on whether a promotion occurs in any given period, conditional on the current grade level. For a description of the federal civil service internal labor market and promotion system, see Johnson and Libecap (1989).

[13] One additional step represents approximately a 3% pay increase, while a promotion to a higher grade represents about a 10% pay increase. The dollar value of a career step increase during this period was $789, whereas the value of a promotion was $2120 (U.S.GAO, 1999). Our data indicate that supervisors/managers, in the same grade, make about $3000 more than non-supervisors.

Civil servants are evaluated each year on their performance, based on a scale that ranges in descending order from 1 to 5. Employees who receive a rating of 5 can be reassigned, demoted, or removed from the job. If an employee's rating exceeds 3, the agency is required to deny within-grade pay increases. We employ these appraisals as proxies for performance, with the understanding that, being uniform within the organization, they carry more significance within a given job level.

Civil service data are advantageous for several reasons. First, unlike organizations in the private sector, where job levels must be inferred from often vaguely-defined job titles or empirically determined, the hierarchy in the GS/GM system is well-defined. Changes in grade level and attainment of supervisory positions constitute clear-cut promotions. Second, the causal link between promotions and pay in the internal labor market literature is subject to debate. In some organizations promotions serve as a non-pecuniary reward. Where promotions are associated with higher pay, some studies have found evidence that promotions result in higher wages (consistent with incentive pay schemes) and other studies have found that wage growth results in promotions (consistent with unobserved heterogeneity driving both wages and promotions) (Baker et al., 1994a,b). This complicates the analysis of gender differences, especially since L&R suggest that the heterogeneity that drives promotions varies by gender. Furthermore, a number of studies suggest that not only promotion rates, but also returns to promotion may differ by gender. Some studies find that females promote at lower rates but experience similar wage growth (McCue, 1996; Olson and Becker, 1983), whereas others find that women promote at higher rates but obtain lower raises (Barnett et al., 2000; Hersch and Viscusi, 1996). The L&R theory explains the wage gap as the result of the different promotion paths between A and B jobs. However, the theory assumes that wages are attached to jobs, thus implying that the same promotion would generate the same wage growth for a woman as for a man. In the federal civil service, pay is a deterministic function of job level; hence, promotions and pay move in tandem for both men and women. Gender differences in wages, therefore, would have to be the result of different promotion tracks, rather than differential incentive schemes for men and women, or different wage growth for women promoting to the same position.

We collected data for all GS/GM employees continuously employed between 1986 and 1992 from personnel files maintained by the Defense Manpower Data Center. The sample was restricted to full-time employees, to those with at least a Bachelor's degree, and to workers with ages 20 to 55. We removed veterans from the sample since they receive priority in hiring, their military service is counted as tenure in the federal civil service, and they are predominantly male.[14] The final sample contained 27,965 employees who were followed for a six-year period from 1986 until 1992.[15] Information on a worker's evaluations, grade promotions, and promotion to supervisor were available every two years.

Table 1 provides summary statistics. At first sight, the L&R implications with respect to differences in performance appear valid. While average performance ratings in 1986 are similar for men and women, in 1992 women receive better performance ratings than men, by about one-third of a standard deviation. Although the same rating system is used for all grades, obtaining a certain rating may be more difficult in higher grades or in certain occupations. Therefore, we investigate these performance differences separately for each grade level.

Table 2 compares performance ratings for males and females obtained from random effects Generalized Least Squares (GLS) estimations. Column (1) presents results that condition only on time fixed effects, whereas the models in column (2) also condition on race, education, service, occupation, and tenure. Column (1) shows that women receive higher evaluations in almost all grade levels. This result does not change when we control for demographics, education, service, occupation, and tenure in column (2), suggesting that the

Table 1
Summary statistics.

	Male		Female	
	Mean	Std. dev.	Mean	Std. dev.
Black	0.044	(0.204)	0.176	(0.381)
Hispanic	0.025	(0.157)	0.026	(0.161)
Master's degree	0.206	(0.404)	0.175	(0.380)
Doctorate	0.042	(0.200)	0.016	(0.126)
Army	0.906	(0.291)	0.909	(0.288)
Air Force	0.034	(0.180)	0.033	(0.178)
Professional	0.688	(0.463)	0.351	(0.477)
Administrative	0.253	(0.435)	0.424	(0.494)
Technical	0.044	(0.205)	0.082	(0.274)
Clerical	0.058	(0.233)	0.191	(0.393)
Performance rating (1 = highest, 5 = lowest), 1986	2.291	(0.767)	2.295	(0.821)
Performance rating (1 = highest, 5 = lowest), 1992	1.702	(0.702)	1.552	(0.675)
Grade level, 1986	11.549	(2.193)	9.362	(2.968)
Grade level, 1992	12.532	(1.571)	10.951	(2.497)
Promote to a higher grade level during 1986–1992	0.180	(0.384)	0.249	(0.432)
% Promote once	40.41%		42.19%	
% Promote twice	12.71%		21.7%	
% Promote three times	2.08%		4.68%	
In supervisory/managerial position any time during 1986–1992	0.314	(0.464)	0.164	(0.371)
Tenure	13.083	(7.743)	9.888	(6.093)
Age in 1986	37.608	(7.941)	36.510	(8.015)
Observations	19,462		8,529	
Time–person observations	77,848		34,116	

Table 2
Differences in performance by gender and pay grade.

Pay grade	Difference in performance ratings (1)	(2)	N
GS3	0.037 (0.098)	0.056 (0.108)	377
GS4	−0.272 (0.073)***	−0.193 (0.080)**	1198
GS5	−0.308 (0.035)***	−0.274 (0.036)***	3095
GS6	−0.299 (0.063)***	−0.304 (0.066)***	1237
GS7	−0.239 (0.026)***	−0.227 (0.027)***	3790
GS8	−0.558 (0.092)***	−0.546 (0.099)***	386
GS9	−0.269 (0.019)***	−0.290 (0.019)***	9057
GS10	−0.161 (0.092)*	−0.100 (0.126)	369
GS11	−0.232 (0.014)***	−0.222 (0.015)***	18,624
GS12	−0.159 (0.012)***	−0.142 (0.012)***	33,227
GS13	−0.093 (0.015)***	−0.102 (0.016)***	23,939
GS14	−0.138 (0.023)***	−0.104 (0.024)***	11,630
GS15	−0.146 (0.036)***	−0.123 (0.038)***	5022
All	−0.108 (0.007)***	−0.116 (0.007)***	111,964

Notes. The estimated differences in performance ratings for women versus men were obtained by running separate random effects GLS regressions for each grade level, initially adjusting for time effects (column 1) and next adjusting for variation in demographics, education, service, occupation, and tenure (column 2).
* significant at 10%; ** significant at 5%; *** significant at 1%.

[14] The sample is also restricted to individuals with non-missing observations in all four periods because our empirical strategy requires a balanced panel.
[15] We chose 1992 as the end date to avoid the turbulence introduced by the personnel drawdown of the 1990s when the government offered separation bonuses and the federal workforce fell dramatically (U. S. GAO, 1999).

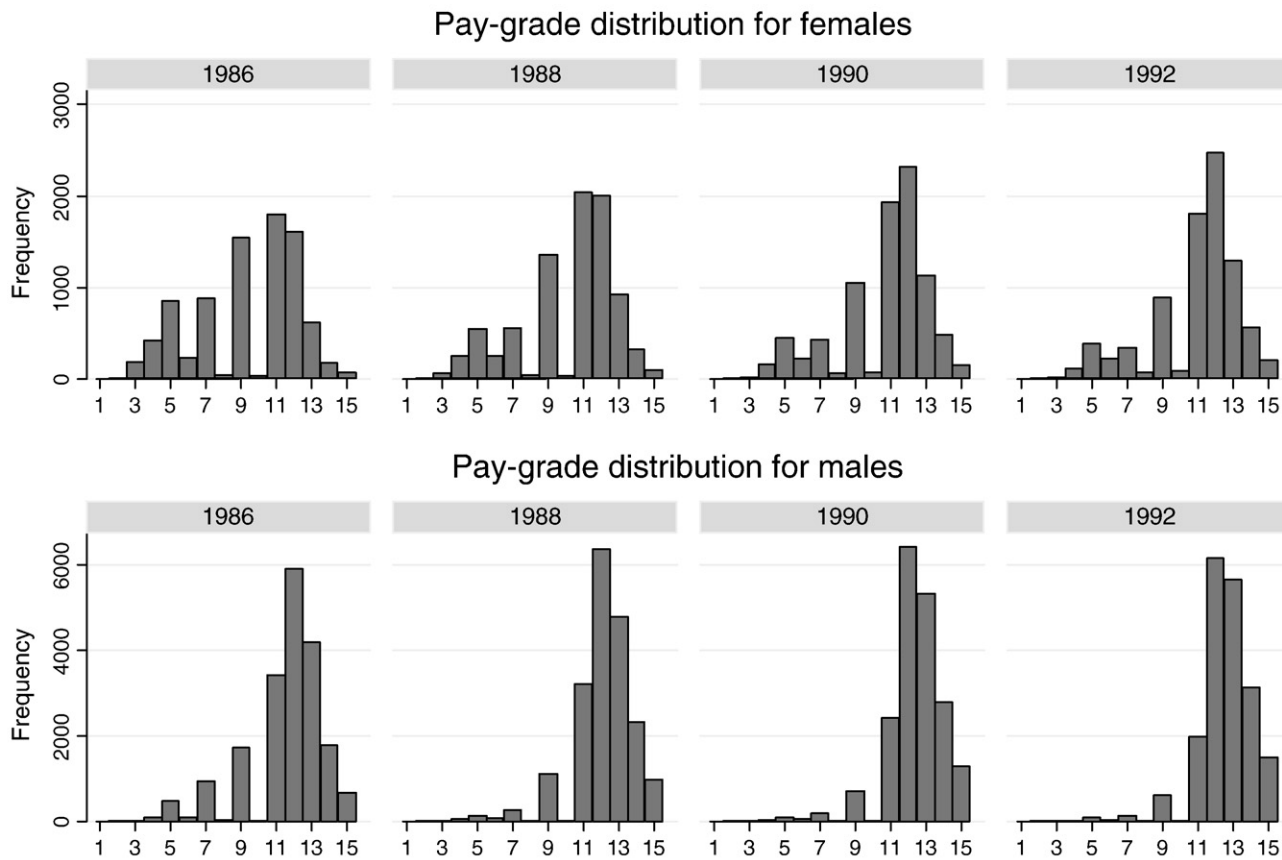

Fig. 1. Gender differences in career progression.

performance difference is not due to systematic variation in the observables. Interestingly, performance differences appear larger in lower grade levels, but narrow further up the hierarchy. This observation is consistent with the hypothesis that over time the true ability of the worker is revealed to the employer.

Perhaps due to their better performance females have much higher promotion rates (.25 versus .18 for men) and are also more likely to receive multiple promotions. However, while the average male is a GS11 in 1986, the average female is a GS9. Males move up to GS12 by 1992, while women move up to GS11. Fig. 1 illustrates the transition across grade levels for each gender. While females are more evenly distributed across grade levels in 1986, men are more tightly concentrated in higher grades. Therefore, another reason women promote at higher rates is because they are concentrated in lower-level positions and have more opportunities for advancement. Despite higher overall promotion rates, women are about half as likely to become supervisors and managers as men (.16 versus .31). This in part may be due to the large gender gap in tenure.

With respect to promotion dynamics, about 80% of individuals promoting in the current period did not promote in the previous period. Alternatively, about 74% of individuals who promote in $t-1$ do not promote at time t. These promotion patterns suggest a negative state dependence. This could be due to the limited number of steps in the hierarchy or the possibility that higher-level promotions are increasingly more difficult to attain. However, we also observe about 4584 individuals who promote both at time $t-1$ and at time t. The intertemporal correlation of promotions over time weakens substantially after two time periods, with only 803 occurrences of promotions three periods in a row (in $t-2$, $t-1$, and t). Supervisory positions are characterized by stronger persistence. About 91% of those in supervisory positions in time t also occupy such positions in time $t-1$. One-third of supervisors maintained these positions for three periods in a row. Therefore, it appears that promotions involving a change in responsibilities are characterized by entirely different dynamics than promotions that only result in wage growth. We believe the latter would be more prone to administrative constraints, such as limited hierarchical steps and so-called 'green card' effects.[16]

5. Findings

The L&R model produces testable implications for both the position of females relative to males within the organization as a whole and within each grade level. We investigate both sets of differences by first focusing on the distribution of females in the hierarchy for the entire organization, and later condition upon grade level to investigate within-grade dynamics. Table 3 presents estimates of grade promotions without conditioning on initial grade level, thus providing across grade comparisons.

5.1. Estimates of grade promotions

In Table 3 we find strong state dependence across all specifications. The negative sign of prior promotions suggests that a previous-period promotion makes a promotion in the current period less likely. This could be due to hierarchical constraints or to the possibility that higher-level promotions are more difficult to attain (or both). Models (1)–(4) assume that a single promotion lag adequately captures the promotion dynamics. If the previous-period promotion has taken into account the entire work history of the employee, then one lag may be sufficient. However, if time-in-grade requirements pose constraints that make it difficult to promote in two successive periods, then we should include

[16] Many firms set limits on pay increases or pay range within each job level. These administrative rules can induce pay compression, and their structure usually results in larger wage increases for those at the bottom of the wage distribution in a given job level, and smaller raises for those at the top. Baker et al. (1994a) provide evidence of 'green card' effects by showing that, within a given job level, those in higher salary quartiles earn lower percentage raises (see also Belzil and Bognanno, 2008).

more promotion lags. In models (5)–(8) we add a second promotion lag to our models.[17] Adding the second lag reveals even more negative persistence in the promotion process, with both lags carrying a similar weight in the promotion probability. The state dependence here is the net effect of hierarchical constraints, more challenging promotions along the hierarchy, and potential fast/slow tracks in the organization. Since these elements have opposing signs, empirically, state dependence can be either positive or negative. Given that we are focusing on highly-educated, white-collar workers, hierarchical constraints may be especially binding; thus, the hierarchy-driven negative state dependence may dominate.[18 19]

In column (1) women are *more* likely to be promoted than men by 6.2 percentage points. When we control for occupation and tenure in model (2), gender differences narrow substantially (to 3.4 points), suggesting that endowments are important in explaining gender differences. Similarly, in the more flexible models with two promotion lags, the gender gap narrows from 7.5 to 4.2 points when including occupation and tenure. Since all regressions control for performance ratings, the higher promotion rates for women are not due to their higher ratings, but may be driven by the fact that women are concentrated in lower-level positions and have more room for advancement. At this stage, this finding suggests that the incidence of promotions is more frequent among women.

Are men and women on different career tracks? In model (3) the interaction of female with lagged promotion indicates that women are on a faster track than men. The predicted state dependence for men is about −25.7 percentage points, whereas for women it is about −16.5 percentage points. Although both men and women face hierarchical constraints, women appear to be less bound by them. Among workers who do not promote in the previous period, women are also more likely to promote in the current period than men (by 2.2 points in model (3)). The more flexible models (5)–(8) that include two lags of promotions, confirm these results. The interactions of female with past promotions (y_{t-1} and y_{t-2}) suggest that women's careers are characterized by a significantly different state dependence than those of men.

The effect of performance ratings suggests that better performers are more likely to be promoted. This in itself is noteworthy, since some prior studies have failed to find a link between pay and performance in internal labor markets (e.g. Medoff and Abraham, 1980).

Do women have to jump a higher ability threshold to promote? In model (4) the interaction of female with performance ratings is positive and significant, suggesting that women do face higher promotion hurdles. The implied effect is also practically large: A male who improves his performance rating from 2 to 1, increases his promotion chances by 2.7 percentage points, compared to only 1.2 percentage points for a woman.

The effect of tenure is negative across all estimations. Although surprising, it partially reflects the fact that longer-tenured workers are higher in the hierarchy and have fewer remaining ranks. This finding is not unusual if we recall that grade promotions in this organization are more akin to wage growth in the private sector. Previous studies have found that green card effects can lead to smaller salary raises for workers toward the top of their grade. Baker et al. (1994a,b) also point out that in the presence of fast tracks, holding everything constant, employees with more tenure are the ones that have advanced more slowly, and may have lower ability or lower human capital accumulation rates.[20]

The estimated parameters of Eq. (2) in panel B of Table 3 indicate how unobserved heterogeneity is correlated with observables.[21] We find that the first promotion is very strongly correlated with unobserved heterogeneity. However, the correlation between unobserved heterogeneity and the initial promotion is significantly weaker for females. In models (1)–(4) a history of good performance is positively correlated with unobserved heterogeneity, suggesting that unobservables are ability-related. This finding is relevant for other studies that include a sparser set of controls and a more heterogeneous sample. In model (4) when we interact female with performance ratings we find that unobserved heterogeneity is negatively correlated with women's job performance. These findings are consistent with the L&R hypothesis that unobserved heterogeneity includes factors (e.g., higher productivity in non-market activities) that reduce the likelihood of females being on a fast track. Models (5)–(8) confirm the finding that the first promotion is correlated with important unobservables, but they do not indicate any differences by gender in this respect. Similarly, these models reveal no clear pattern on the relation between performance ratings and heterogeneity. These findings suggest that unobserved heterogeneity becomes more random in nature as we better capture the dynamics of promotions.

Next, we focus on within-grade gender differences in promotion. Estimates in Table 4 condition on pay grade in the previous period to control for each employee's hierarchical position. Due to the small number of individuals who promote three periods in a row (about 803 over the entire period and across all pay grades), when conditioning upon grade level we cannot obtain convergence for the models that include two promotion lags. Therefore, Table 4 presents models with only one performance lag, but a full history of progress across pay grades in all periods (in addition to the full history of performance ratings). The estimates indicate that state dependence declines substantially after controlling for hierarchical position. This may occur because including grade levels as an explanatory variable removes the spuriousness induced by the finite hierarchy. However, the estimated state dependence remains negative, consistent with the assumption that higher-level promotions are more challenging or

[17] Adjacent periods in these data are two calendar years apart. Therefore, when controlling for $promotion_{t-2}$, we are essentially controlling for promotions during a four-year period. More promotion lags are not possible with these data due to the relatively short panel.

[18] Another explanation is that continuous promotions and a general lack of demotions move individuals to the position beyond which they have little competence (also referred to as the "Peter Principle").

[19] It should be noted that controlling for past promotions and transitions through grade levels is a rough way of taking into account the entire history of individual achievements. For this purpose, Belzil and Bognanno (2004) construct a variable that takes into account both the first observed position in the firm and the history of promotions. This variable, termed "speed of promotion", is calculated as the ratio of the number of levels reached at any point in time and imputed experience. However, in this specific setting, using speed of promotion introduces a few problems. First, because individuals typically jump two levels with mid-range promotions but only one level in high-level promotions, such a variable would weigh more heavily mid-range promotions. This may distort our gender comparisons since women initially are more heavily represented in the middle of the hierarchy. Second, in our data, everyone has a college degree or more, so a good number of people promote to the top levels and remain there. In the Belzil and Bognanno data, the finite hierarchy is less binding, since about 0.2% of the individuals in their sample are in the top two positions compared to 15% in our data. In this paper, when conditioning upon age, education, tenure with the firm, as well as grade levels in all periods, we are essentially controlling for differences in upward movement among employees, although perhaps not in the most precise way. Future research, especially that focusing on state dependence in promotions, should investigate various definitions of state dependence insofar as the data and the institutional setting allow.

[20] Other explanations have been offered. Several studies have found a negative return to seniority in academia (see for example Ransom, 1993). One theory suggests that the firm has monopsony power over workers that have been with it longer, since they are more attached to the organization and the location (Hamermesh, 1988). When investigating returns to skills in the DOD, Gibbs (2006) finds that DOD did not experience problems in hiring and retaining high-skilled scientists and engineers even in the face of a growing earnings gap between the private and the public sector. He suggests that engineers and scientists in DOD may have a strong attachment to the organization, either due to job match, non-pecuniary factors (patriotism, job stability), or access to labs and research funding.

[21] Since unobserved heterogeneity does not have any well-defined units of measurement, we do not calculate marginal effects for the coefficients of Eq. (2).

Table 3
Across grade estimates of promotions to a higher grade level.

Eq. (1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Promote_{t-1}$	−1.058*	−1.100*	−1.217*	−1.100*	−0.644*	−0.629*	−0.740*	−0.611*
	(0.017)	(0.017)	(0.021)	(0.017)	(0.049)	(0.101)	(0.094)	(0.116)
	[−0.237]	[−0.241]	[−0.257]	[−0.241]	[−0.147]	[−0.144]	[−0.165]	[−0.141]
$Promote_{t-2}$					−0.650*	−0.602*	−0.662*	−0.584*
					(0.052)	(0.096)	(0.092)	(0.109)
					[−0.135]	[−0.128]	[−0.137]	[−0.125]
Female	0.203*	0.113*	0.073*	−0.071***	0.281*	0.158*	0.050**	−0.072
	(0.012)	(0.012)	(0.017)	(0.038)	(0.017)	(0.018)	(0.022)	(0.048)
	[0.062]	[0.034]	[0.022]	[−0.021]	[0.075]	[0.042]	[0.013]	[−0.018]
$Rating_{t-1}$	−0.047*	−0.078*	−0.077*	−0.093*	−0.148*	−0.152*	−0.152*	−0.185*
	(0.010)	(0.010)	(0.010)	(0.012)	(0.017)	(0.017)	(0.017)	(0.021)
	[−0.014]	[−0.023]	[−0.023]	[−0.027]	[−0.038]	[−0.039]	[−0.039]	[−0.048]
Log ($tenure_t$)		−0.464*	−0.469*	−0.467*		−0.656*	−0.670*	−0.657*
		(0.016)	(0.016)	(0.016)		(0.034)	(0.032)	(0.037)
		[−0.136]	[−0.137]	[−0.137]		[−0.168]	[−0.171]	[−0.169]
Female × $promote_{t-1}$			0.287*				0.233*	
			(0.030)				(0.046)	
			[0.092]				[0.065]	
Female × $promote_{t-2}$							0.097***	
							(0.052)	
							[0.026]	
Female × $rating_{t-1}$				0.040***				0.096*
				(0.019)				(0.034)
				[0.012]				[0.025]
Occupation	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Eq. (2)								
$Promote_0$	1.442*	1.396*	1.422*	1.395*	0.629*	0.492*	0.509*	0.473*
	(0.013)	(0.014)	(0.016)	(0.014)	(0.051)	(0.094)	(0.088)	(0.107)
Female × $promote_0$			−0.063**				0.011	
			(0.026)				(0.054)	
$Rating_1$	−0.023**	−0.021**	−0.022**	−0.031*	0.014	0.0001	−0.003	−0.006
	(0.009)	(0.009)	(0.009)	(0.012)	(0.014)	(0.014)	(0.014)	(0.018)
$Rating_2$	−0.002	0.004	0.003	−0.009	0.045*	0.042*	0.042*	0.033***
	(0.009)	(0.010)	(0.010)	(0.012)	(0.014)	(0.014)	(0.014)	(0.017)
$Rating_3$	−0.016***	−0.022**	−0.022**	−0.017	−0.028**	−0.033***	−0.035***	−0.027*
	(0.009)	(0.009)	(0.009)	(0.011)	(0.012)	(0.012)	(0.012)	(0.015)
Female × $rating_1$				0.039**				0.017
				(0.020)				(0.029)
Female × $rating_2$				0.029				0.025
				(0.019)				(0.029)
Female × $rating_3$				−0.012				−0.015
				(0.019)				(0.025)
$\hat{\sigma}_\alpha$	0.171	0.170	0.170	0.170	0.529	0.462	0.472	0.448

Notes: The sample includes a balanced panel of 27,965 individuals for three periods (83,895 total). All regressions include year dummies, service (Air Force, Army, other DOD), age, race (white, black, Hispanic, other), advanced degrees (Master's, Doctorate), and occupation where indicated (professional, administrative, clerical, technical, and other white collar). The estimates are obtained using the random effects probit routine of Stata®. Asymptotic standard errors appear in parentheses. Marginal probabilities appear in square brackets and are calculated as suggested in Wooldridge (2005). For Eq. (2) marginal effects were not calculated as the focus is on the sign of the relationship between c_i and observables.

* Significant at 1%.

** Significant at 10%.

*** Significant at 5%.

other administrative constraints (such as green card effects or time-in-grade requirements) may be in place. The internal labor market literature finds a similar convexity of earnings (Belzil and Bognanno, 2008).

When conditioning on hierarchical position, we find that within-grade level, there is no gender gap in promotions (Table 4, models (1)–(2)). Therefore, while women in the organization are observed to promote more frequently, compared to men in the same grade (and with similar tenure, education, and performance), they have an equal probability of promotion. This within-grade evidence, however, obscures the fact that among women there is a noticeable disparity in career tracks. Model (3) in Table 4, which includes an interaction of prior promotions with female, reveals that women are found in both 'fast tracks' and 'slow tracks,' depending upon their promotion history. Women who promoted in the past are more likely than men to promote in the current period. In contrast, among workers who *did not* promote in the past, women are less likely than men to promote in the current period. This suggests that the organization observes and incorporates heterogeneity that signals 'career-oriented' females.

Within-grade estimates of the effect of performance on promotions are about twice as large in magnitude as across grade estimates, suggesting that performance evaluations are more relevant in predicting promotions *within* a grade rather than across grades.

The L&R model suggests that within jobs and higher up in the hierarchy the differential thresholds for advancement disappear because the type of the worker is revealed to the organization. Indeed, we no longer find that women need to pass a higher performance threshold for promotion. In fact, we find the opposite: the same performance improvement counts more for women than for men (by a modest 0.5 percentage points more). This evidence suggests that the unobserved heterogeneity is most likely gender-neutral. Women who have overcome the earlier hurdles, and who are at the same grade level as men, are more likely to advance because of their better performance

Table 4
Within-grade estimates of promotions to a higher grade level.

Eq. (1)	(1)	(2)	(3)	(4)
$Promote_{t-1}$	−0.188* (0.028) [−0.051]	−0.182* (0.028) [−0.049]	−0.301* (0.031) [−0.079]	−0.179* (0.028) [−0.048]
Female	−0.024 (0.017) [−0.007]	−0.013 (0.018) [−0.004]	−0.149* (0.025) [−0.041]	−0.004 (0.052) [−0.001]
$Rating_{t-1}$	−0.174* (0.014) [−0.049]	−0.172* (0.014) [−0.049]	−0.172* (0.014) [−0.048]	−0.110* (0.017) [−0.031]
$Pay\text{-}grade_{t-1}$	−2.698* (0.026) [−0.764]	−2.709* (0.026) [−0.765]	−2.732* (0.027) [−0.772]	−2.719* (0.026) [−0.768]
Log ($tenure_t$)		0.033 (0.024) [0.009]	0.025 (0.024) [0.007]	0.032 (0.024) [0.009]
Female × $promote_{t-1}$			0.350* (0.039) [0.110]	
Female × $rating_{t-1}$				−0.177* (0.027) [−0.050]
Occupation	No	Yes	Yes	Yes
Eq. (2)				
$Promote_0$	0.954* (0.020)	0.958* (0.020)	0.930* (0.023)	0.956* (0.020)
Female × $promote_0$			0.080*** (0.035)	
$Rating_1$	0.040* (0.012)	0.039* (0.012)	0.037* (0.012)	−0.001 (0.015)
$Rating_2$	0.050* (0.013)	0.049* (0.013)	0.048* (0.013)	0.024 (0.016)
$Rating_3$	0.005 (0.012)	0.001 (0.012)	−0.001 (0.012)	0.005 (0.014)
Female × $rating_1$				0.116* (0.025)
Female × $rating_2$				0.069*** (0.028)
Female × $rating_3$				−0.011 (0.026)
Pay $grade_1$	0.603* (0.018)	0.601* (0.019)	0.615* (0.019)	0.605* (0.019)
Pay $grade_2$	1.048* (0.018)	1.050* (0.018)	1.059* (0.018)	1.055* (0.018)
Pay $grade_3$	1.120* (0.013)	1.126* (0.013)	1.125* (0.013)	1.127* (0.013)
$\hat{\sigma}_\alpha$	0.180	0.180	0.180	0.180

See notes for Table 3. There was not enough variation in the data to estimate models with two lags of promotions, when conditioning upon pay grade.

and because they have demonstrated that they are type-A workers. This hypothesis is further supported by estimates of Eq. (2) in panel B, which indicate that, given the same position in the hierarchy, the first promotion is more important for women than men. When conditioning upon the entire history of transitions across pay grades, performance ratings appear negatively correlated with unobserved heterogeneity. However, this finding is driven by the women in the sample, whose unobserved characteristics apparently are negatively correlated with performance. This observation is also consistent with the hypothesis that women have better alternative uses of time.

When including grade level in Eq. (1) (estimates presented in Table 4), the effect of tenure drops dramatically and is no longer significant, suggesting that tenure and position in the hierarchy are strongly correlated. Thus, our previous results suggesting a negative tenure effect were indeed driven by the limited hierarchical steps available to those who have been with the organization longer. Finally, in the estimates of Eq. (2), we notice that the history of hierarchical positions occupied is positively correlated with unobserved heterogeneity, as expected.

5.2. Estimates of supervisory–management promotions.

Next, we investigate gender differences in the likelihood of occupying supervisory or managerial positions. Across grade estimates are presented in Table 5 and use similar specifications as the overall promotion models. In all cases, employees who are supervisors in one period appear far more likely to continue holding such a position in the next period. In models (5)–(8) that include two lags of supervisory positions, the persistence appears to wane significantly after the first lag. While being a supervisor in $t-1$ carries with it a 0.75 higher probability of being a supervisor currently, a supervisor position in $t-2$ carries only a 0.07 higher probability of persisting in this position.

Overall, within the organization, females appear less likely to be in supervisory positions. In the simpler one lag specification we find no evidence that the state dependence differs by gender. However, in the more flexible two-lag models, we find that a $t-1$ supervisory position for a woman positively affects current supervisor status, whereas a $t-2$ supervisory position has the opposite effect. This finding is not puzzling if we consider that the negative $t-2$ effect represents women who are supervisors in $t-2$ but *not* in $t-1$. This suggests that there may be on- and off-ramps in this organization, where loss of a supervisory position negatively affects future promotions to supervisor for women.[22] Performance ratings have a stronger effect on supervisory promotions than on simple grade promotions, suggesting that these positions may require higher ability or a higher rate of human capital accumulation. In addition, tenure has a strong positive effect on promotions to supervisor, perhaps because firm-specific training is more important for these positions.

When looking at Eq. (2) estimates (panel B of Table 5), we find that the first supervisory promotion is positively correlated with unobserved heterogeneity, but this correlation is significantly weaker for women. Where significant, performance ratings over time appear to be positively correlated with unobserved heterogeneity.

Since supervisory promotions may depend on crucial promotion points, or minimum grade level requirements, we also investigate within-grade models for supervisor positions. The estimates are presented in Table 6. While the state dependence estimated by the first lag is of the same in magnitude as in the across grade results in Table 5, the effect of the second lag is about half as large as estimated previously. We again find that gender differences shrink considerably when conditioning upon job level. In fact, holding constant the prior job level, women appear slightly more likely to obtain supervisory positions (by about one percentage point). Similar to within-grade estimates of grade promotions, females do not appear to face higher hurdles to promote to supervisor. According to one-lag models, females are not in different career tracks from men. However, the two-lag models indicate that being a supervisor in $t-2$ but not in $t-1$ has a negative effect on holding a supervisory position in the current period. Alternatively, being a supervisor in $t-1$ but not in $t-2$ has a positive effect on current promotion to supervisor. For women who have been supervisors in both $t-1$ and $t-2$, these effects cancel out so that women appear to be just as likely to promote as men. These findings taken together suggest that there may be a penalty for women who step down from supervisory positions.

Estimates of Eq. (2) reveal that the first promotion is positively correlated with unobserved heterogeneity, for both men and women. Paired with the same conclusion for within-grade comparisons of grade promotions, we interpret this finding to be consistent with the L&R model, which suggests that worker heterogeneity in promotions is revealed over the course of the career and that, within-grade, men and women are similar. It is across grades that we find the first promotion (to a higher grade or supervisory position) to vary in importance for each gender. More specifically, across grades we find unobserved heterogeneity to be negatively correlated with the first promotion for women.

[22] When we estimate separate models with only one interaction of a lagged supervisor position and female at a time (not shown), the interactions appear individually insignificant.

Table 5
Across grade estimates of promotions to a supervisory or managerial position.

Eq. (1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Supervisor_{t-1}	2.205*	2.166*	2.152*	2.166*	2.387*	2.364*	2.339*	2.364*
	(0.037)	(0.034)	(0.037)	(0.034)	(0.025)	(0.025)	(0.029)	(0.025)
	[0.709]	[0.696]	[0.693]	[0.696]	[0.759]	[0.753]	[0.748]	[0.753]
Supervisor_{t-2}					0.221*	0.214*	0.265*	0.215*
					(0.040)	(0.040)	(0.047)	(0.040)
					[0.071]	[0.068]	[0.085]	[0.068]
Female	−0.229*	−0.174*	−0.160*	−0.316*	−0.161*	−0.111*	−0.099*	−0.279*
	(0.019)	(0.019)	(0.021)	(0.058)	(0.019)	(0.020)	(0.023)	(0.059)
	[−0.062]	[−0.046]	[−0.043]	[−0.082]	[−0.048]	[−0.033]	[−0.030]	[−0.082]
Rating_{t-1}	−0.185*	−0.166*	−0.166*	−0.173*	−0.149*	−0.150*	−0.149*	−0.151*
	(0.013)	(0.013)	(0.013)	(0.015)	(0.021)	(0.021)	(0.021)	(0.024)
	[−0.052]	[−0.046]	[−0.046]	[−0.048]	[−0.046]	[−0.046]	[−0.045]	[−0.046]
$\text{Log (tenure}_t)$		0.445*	0.444*	0.444*		0.375*	0.374*	0.373*
		(0.026)	(0.026)	(0.026)		(0.028)	(0.028)	(0.028)
		[0.123]	[0.123]	[0.122]		[0.114]	[0.114]	[0.113]
$\text{Female} \times \text{supervisor}_{t-1}$			0.056				0.097**	
			(0.053)				(0.057)	
			[0.016]				[0.031]	
$\text{Female} \times \text{supervisor}_{t-2}$							−0.200***	
							(0.092)	
							[−0.057]	
$\text{Female} \times \text{rating}_{t-1}$				0.023				0.005
				(0.027)				(0.045)
				[0.006]				[0.002]
Occupation	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Eq. (2)								
Supervisor_0	0.817*	0.776*	0.810*	0.776*	0.337*	0.294*	0.287*	0.294*
	(0.068)	(0.060)	(0.062)	(0.060)	(0.038)	(0.038)	(0.044)	(0.038)
$\text{Female supervisor}_0$			−0.162***				0.007	
			(0.064)				(0.088)	
Rating_1	−0.088*	−0.091*	−0.092*	−0.086*	−0.114*	−0.110*	−0.112*	−0.121*
	(0.013)	(0.013)	(0.013)	(0.016)	(0.016)	(0.016)	(0.016)	(0.019)
Rating_2	−0.003	−0.010	−0.010	−0.024	−0.005	−0.006	−0.006	−0.015
	(0.014)	(0.014)	(0.014)	(0.016)	(0.017)	(0.017)	(0.017)	(0.020)
Rating_3	−0.078*	−0.082*	−0.081*	−0.089*	−0.024**	−0.026**	−0.026**	−0.033***
	(0.013)	(0.013)	(0.013)	(0.016)	(0.014)	(0.014)	(0.014)	(0.016)
$\text{Female} \times \text{rating}_1$				−0.020				0.036
				(0.028)				(0.035)
$\text{Female} \times \text{rating}_2$				0.052**				0.030
				(0.031)				(0.038)
$\text{Female} \times \text{rating}_3$				0.031				0.029
				(0.030)				(0.032)
$\hat{\sigma}_\alpha$	0.195	0.204	0.203	0.204	0.210	0.210	0.210	0.210

See notes for Table 3.

We also investigated demotions (defined either as a drop in grade level or loss of a supervisory position). In our sample, there are 1227 demotions to a lower grade, but only 6 individuals are demoted more than once. About 1882 individuals lose their supervisory positions. In investigating both types of demotions, we found no systematic differences between men and women, after conditioning upon all observables.[23]

In addition to illustrating how unobserved heterogeneity relates to observables, our methodology provides consistent estimates of the state dependence in promotions. In contrast, simple pooled probit estimates (displayed in Appendix Table A1) overestimate the serial correlation in both types of promotions, the problem being more severe in grade level promotions.[24] In models with two lags in promotions, pooled probit estimates of the first lag are similar to the random effects probit estimates; estimates of the second lag, however, are substantially larger. Pooled probit estimates also tend to overestimate the gender gap in several specifications.[25] In a similar vein, pooled probit estimates also suggest that women have to jump higher performance hurdles both across and within grades compared to random effects estimates. These findings are consistent with the hypothesis that unobserved heterogeneity, when controlled for, explains away part of the gender differences in promotions. Admittedly, our approach does not impose sufficient structure to eliminate the spuriousness in the state dependence induced by administrative constraints. However, assuming the limited hierarchical steps equally affect both men and women in this organization, our estimates of the gender differences in promotion tracks should be free of this spuriousness. At a minimum, our results provide further descriptive evidence of the sources of gender career differences within organizations.

6. Conclusions

Our results suggest that gender differences in careers are driven by a combination of observed variables, most notably tenure, occupation,

[23] Results are available upon request.

[24] Other studies similarly find that state dependence is overestimated in models that do not condition upon unobserved heterogeneity (see Heckman, 1981b). Note that we estimate a negative state dependence for grade level promotions, so the bias should be interpreted in this context.

[25] Note that all models in the appendix include occupation and tenure. As a result, models (1)–(3) in Table A1 are comparable to models (2)–(4) in Tables 3 and 5, whereas models (4)–(6) in Table A1 are comparable to models (6)-(8) in Tables 3 and 5.

Table 6
Within-grade estimates of promotions to a supervisory or managerial position.

Eq. (1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Supervisor_{t-1}$	2.293* (0.023) [0.727]	2.286* (0.023) [0.725]	2.267* (0.027) [0.721]	2.285* (0.023) [0.725]	2.402* (0.027) [0.750]	2.400* (0.027) [0.749]	2.364* (0.031) [0.741]	2.399* (0.027) [0.749]
$Supervisor_{t-2}$					0.149* (0.043) [0.043]	0.148* (0.043) [0.043]	0.190* (0.049) [0.055]	0.148* (0.043) [0.043]
Female	0.044*** (0.017) [0.012]	0.029** (0.018) [0.008]	0.023 (0.020) [0.006]	0.093** (0.053) [0.026]	0.052*** (0.021) [0.015]	0.036** (0.022) [0.010]	0.019 (0.025) [0.005]	0.047 (0.064) [0.013]
$Rating_{t-1}$	−0.179* (0.012) [−0.049]	−0.171* (0.012) [−0.047]	−0.171* (0.012) [−0.047]	−0.170* (0.015) [−0.047]	−0.147* (0.022) [−0.041]	−0.146* (0.022) [−0.041]	−0.145* (0.022) [−0.041]	−0.140* (0.026) [−0.039]
$Pay\text{-}grade_{t-1}$	−0.111* (0.010) [−0.030]	−0.124* (0.010) [−0.034]	−0.124* (0.010) [−0.034]	−0.124* (0.010) [−0.034]	−0.339* (0.023) [−0.095]	−0.344* (0.023) [−0.096]	−0.344* (0.023) [−0.096]	−0.344* (0.023) [−0.096]
Log ($tenure_t$)		0.201* (0.023) [0.055]	0.201* (0.023) [0.055]	0.201* (0.023) [0.055]		0.217* (0.031) [0.061]	0.218* (0.031) [0.061]	0.217* (0.031) [0.061]
Female × $supervisor_{t-1}$			0.073 (0.051) [0.021]				0.139*** (0.060) [0.041]	
Female × $supervisor_{t-2}$							−0.167** (0.096) [−0.044]	
Female × $rating_{t-1}$				−0.002 (0.026) [−0.001]				−0.022 (0.048) [−0.006]
Occupation	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Eq. (2)								
$Supervisor_0$	0.409* (0.027)	0.375* (0.027)	0.391* (0.030)	0.375* (0.027)	0.297* (0.040)	0.266* (0.040)	0.248* (0.046)	0.266* (0.040)
Female × $supervisor_0$			−0.060 (0.059)				0.080 (0.093)	
$Rating_1$	−0.043* (0.012)	−0.042* (0.012)	−0.042* (0.012)	−0.026** (0.014)	−0.083* (0.017)	−0.081* (0.017)	−0.081* (0.017)	−0.080* (0.020)
$Rating_2$	0.012 (0.012)	0.013 (0.013)	0.013 (0.013)	0.003 (0.015)	0.002 (0.018)	0.003 (0.018)	0.002 (0.018)	−0.004 (0.021)
$Rating_3$	−0.034* (0.012)	−0.031* (0.012)	−0.031* (0.012)	−0.028*** (0.014)	0.008 (0.015)	0.009 (0.015)	0.009 (0.015)	0.011 (0.017)
Female × $rating_1$				−0.057*** (0.026)				−0.002 (0.037)
Female × $rating_2$				0.037 (0.028)				0.025 (0.039)
Female × $rating_3$				−0.012 (0.027)				−0.007 (0.033)
Pay $grade_1$	0.050* (0.013)	0.049* (0.013)	0.049* (0.013)	0.049* (0.013)	−0.005 (0.018)	−0.024 (0.019)	−0.025 (0.019)	−0.024 (0.019)
Pay $grade_2$	0.027 (0.017)	0.035*** (0.017)	0.035*** (0.017)	0.036*** (0.017)	0.183* (0.021)	0.187* (0.021)	0.187* (0.021)	0.187* (0.021)
Pay $grade_3$	0.312* (0.014)	0.314* (0.014)	0.315* (0.014)	0.315* (0.014)	0.453* (0.016)	0.460* (0.016)	0.461* (0.016)	0.460* (0.016)
$\hat{\sigma}_\alpha$	0.213	0.214	0.214	0.214	0.206	0.206	0.206	0.206

See notes for Table 3.

and position in the hierarchy, as well as unobserved heterogeneity. We find evidence that: (1) females promote more often because we initially observe them in lower-level positions; (2) females need higher performance ratings to move up the hierarchy; (3) within narrowly-defined jobs females can be both on fast and slow tracks, based on their history of promotions; (4) position in the hierarchy explains the largest portion of the gender gap in promotion probabilities; and (5) that unobservables work against women's promotion probability, consistent with the hypothesis that females have higher productivity in non-market activities.

Given that these models are equivalent to wage models (individual pay growth occurs primarily via grade changes), the L&R hypotheses with respect to gender wage differences are largely supported. In investigating 'glass ceilings' in the federal service, we find evidence of 'sticky floors.'[26] In our data, females are less likely to be in managerial positions primarily because they are concentrated in lower pay grades. However, within the same pay grade level (and also conditional on performance, specific and general human capital, occupation, and unobserved heterogeneity), women's promotion probabilities are similar to or better than those of men, suggesting that discrimination does not explain why women are concentrated in lower-level positions. An alternative

[26] 'Sticky floors' refers to the situation where women's promotion rates are similar to men, but their wage growth upon promotion is lower (see Booth et al., 2003). Since in our data wages are rigidly tied to job levels, promotions and wage growth move in tandem. However, for our purposes, the term adequately illustrates the situation in which women are not promoted to positions of higher responsibility because they are stuck in lower grade levels.

explanation following Winter-Ebmer and Zweimuller is that women are assigned to lower positions upon hiring. We explored this hypothesis by analyzing workers who were hired in 1986. We find that women do enter at lower grades, but endowments explain most of these differences.[27] As a result, while human capital endowments are important in explaining gender differences in career progression, job assignment is one of the strongest factors driving promotions to higher grades (pay differences) and to supervisory positions among professional workers.

One additional contribution of this paper is that it separates the effects of promotions that result in wage growth from promotions that involve a change in duties and responsibilities. Due to less-clear definitions of hierarchical steps and job titles in most prior studies using internal firm data, the literature often combines both events in the definition of a promotion. However, incentives and specific human capital may have varying importance for each type of promotion. Our data allow us to disentangle these effects and show that title-promotions, which involve a change in responsibilities, are characterized by entirely different dynamics than promotions that involve only salary growth. Most importantly, while administrative constraints (such as 'green card' effects, or time-in-grade restrictions) may induce negative correlation in wage growth over time, promotions that involve changes in responsibilities (and require different skills or higher ability) are characterized by substantial positive persistence over time.

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Appendix A

Table A1
Pooled probit estimates.

Outcome: promotion to a higher pay grade												
Panel A.	Across grade						Panel B.	Within-grade				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$Promote_{t-1}$	−0.230 (0.014)*	−0.307 (0.017)*	−0.231 (0.014)*	−0.188 (0.014)*	−0.271 (0.018)*	−0.190 (0.015)*	−0.126 (0.014)*	−0.213 (0.018)*	−0.125 (0.014)*	−0.107 (0.015)*	−0.199 (0.018)*	−0.109 (0.015)*
$Promote_{t-2}$				−0.125 (0.019)*	−0.151 (0.023)*	−0.126 (0.020)*				−0.047 (0.020)**	−0.083 (0.024)*	−0.046 (0.020)**
Female	0.135 (0.011)*	0.091 (0.013)*	−0.042 (0.028)	0.136 (0.014)*	0.046 (0.019)**	−0.069 (0.034)**	−0.030 (0.012)**	−0.082 (0.013)*	−0.243 (0.029)*	−0.004 (0.015)	−0.109 (0.020)*	−0.270 (0.046)*
$Rating_{t-1}$	−0.087 (0.007)*	−0.087 (0.007)*	−0.119 (0.008)*	−0.121 (0.008)*	−0.123 (0.008)*	−0.161 (0.010)*	−0.116 (0.007)*	−0.117 (0.007)*	−0.155 (0.008)*	−0.145 (0.008)*	−0.148 (0.008)*	−0.188 (0.011)*
Pay $grade_{t-1}$							−0.134 (0.003)*	−0.134 (0.003)*	−0.134 (0.003)*	−0.113 (0.004)*	−0.115 (0.004)*	−0.115 (0.004)*
Female × $promote_{t-1}$			0.088 (0.013)*		0.211 (0.028)*				0.106 (0.013)*		0.235 (0.028)*	
Female × $promote_{t-2}$					0.061 (0.033)***						0.089 (0.033)*	
Female × $rating_{t-1}$		0.191 (0.025)*				0.111 (0.017)*		0.221 (0.025)*				0.129 (0.018)*
Outcome: promotion to supervisor												
$Supervisor_{t-1}$	2.612 (0.015)*	2.627 (0.017)*	2.612 (0.015)*	2.370 (0.025)*	2.346 (0.028)*	2.370 (0.025)*	2.480 (0.016)*	2.498 (0.018)*	2.480 (0.016)*	2.251 (0.025)*	2.235 (0.029)*	2.251 (0.025)*
$Supervisor_{t-2}$				0.398 (0.027)*	0.444 (0.031)*	0.398 (0.027)*				0.381 (0.027)*	0.420 (0.031)*	0.381 (0.027)*
Female	−0.143 (0.016)*	−0.127 (0.018)*	−0.222 (0.038)*	−0.104 (0.019)*	−0.090 (0.022)*	−0.204 (0.046)*	−0.006 (0.017)	0.011 (0.018)	−0.042 (0.039)	0.023 (0.020)	0.039 (0.023)***	−0.015 (0.048)
$Rating_{t-1}$	−0.222 (0.009)*	−0.223 (0.009)*	−0.235 (0.010)*	−0.240 (0.011)*	−0.240 (0.011)*	−0.256 (0.013)*	−0.203 (0.009)*	−0.203 (0.009)*	−0.208 (0.010)*	−0.223 (0.011)*	−0.224 (0.011)*	−0.229 (0.013)*
Pay $grade_{t-1}$							0.172 (0.022)*	0.171 (0.022)*	0.172 (0.022)*	0.158 (0.006)*	0.158 (0.006)*	0.158 (0.006)*
Female × $superv_{t-1}$		−0.067 (0.035)***			0.091 (0.056)			−0.077 (0.035)**			0.063 (0.057)	
Female × superv $_{t-2}$					−0.201 (0.063)*						−0.172 (0.063)*	
Female × rating $_{t-1}$			0.042 (0.018)**			0.058 (0.024)**			0.019	(0.019)		0.022 (0.025)

Notes: The sample includes 27,965 individuals for three periods (83,895 total). All regressions include year dummies, service (Air Force, Army, and other DOD), age, race, advanced degrees, occupation, and tenure. Since all observables are included, models (1)–(3) in Table A1 are comparable to models (2)–(4) in Tables 3 and 5, whereas models (4)–(6) in Table A1 are comparable to models (6)–(8) in Tables 3 and 5. Similarly, models (7)–(9) above are comparable to models (2)–(4) in Tables 4 and 6, and models (10)–(12) above are comparable to models (6)–(8) in Table 6. The estimates are obtained via probit on the pooled sample.

* Significant at 1%.
** Significant at 5%.
*** Significant at 10%.

[27] Ordered probit estimates indicate that women are more likely to enter in grades 3 and 5 (by 0.03 and 0.10 percentage points, respectively) and less likely to enter in grades 7, 9, and 11 (by about 0.05 percentage points). However, education and occupation explain about half to two-thirds of these differences. Full results available upon request.

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