Gender Discrimination

– Pay and Promotions in Job-Ladders

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Abstract In Lazear and Rosen (1990), they described how discrimination in the promotion process stops women from progressing up the job-ladders. Such discrimination is presumably rational and operates on the belief that women are more likely to separate from labour market activities than men. Here we test this assumption – discrimination in promotion is driven by the likelihood of separation given the characteristics of the workers – by empirically estimating an extended form of their model. The personnel record of a large financial firm in Britain covering 155 months is used in this study. We estimated the L&R model under two specifications: gender discrimination and discrimination against people who are likely to separate from the firm. Our results show that the form of gender discrimination is just as it was described in the model, but the link between tendency to separate and discrimination is not. This shows that within this firm, gender discrimination is not really just rational statistical discrimination as assumed in L&R's model.

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1 Introduction

The fact that women are paid less than men is well established. Previous studies have found while men and women tend to be treated equally within jobs, women are still paid less than men as they are more likely to work in low paid jobs. Women tend to take jobs with fewer career prospects for promotions or they may be discriminated against in the promotion process. The reason suggested by Lazear and Rosen (1990) is that the distribution of non-market opportunities for women dominates that for men, so that women are more likely to separate from the labour force and they do so earlier than men. Workers who are going to separate from the job market would choose occupations that have lower requirements in human capital and where the income-tenure profiles are flatter. These tend to be females. On the other hand, employers are reluctant to provide trainings to female employees as the expected return from training them is low due to their high separation rates. Since many promotion-track jobs require on-the-job trainings, this results in fewer women being promoted and even less in well paid jobs. This also leads to lower human capital accumulation and lower pay amongst women even though no discernible differences can be found between men and women in the same jobs.

Since training is costly, employers would only want to train those who intend to stay on the job. However it is not obvious who would stay and who would leave. Employers therefore create income-tenure profiles for each job so that only staying workers would choose jobs that require training. Generally speaking, more training are make available to those who are more likely to stay as well as those who are to stay longer. These are the workers whose expected utility gain from working is higher than if they participate in non-labour market activities – those who have high ability and thus are likely to command high wages. Thus for each job that requires training, there will be a corresponding ability threshold. This threshold will be different between men and women as women are more likely to leave, which necessitate an upward adjustment of the threshold so that the average tendency to leave for men and women within the same job are the same.

While Lazear and Rosen's model was built to explain why women are frequently sidelined in promotions, it can also be applied to all promotion related discrimination against worker groups with high separation rates. Workers who are near to retirement, those who suffer from ill-health, foreign workers, and affluent workers who can afford taking early retirement are all potential subjects to such discriminatory practices. It is also possible that a nationwide company would administer promotion criteria that vary across regions so that one would find the highest promotion thresholds in the area with the highest turnover. In the spirit of Lazear (1992), where jobs slots are well defined building blocks of an organisation, one might even observe promotion thresholds and dynamic wage schedules that are specific to jobs and occupations. In short, Lazear and Rosen's paper modelled a situation where the direct link between ability and pay for workers is severed. Instead, workers' wages are tied to the separation rates of workers or the separation rates of workers as believed by employers, grouped by their characteristics that have very little relevance to their ability or productivity.

Inside a firm, L&R's model implies that the tendency for a group of workers to quit and the belief held by the employers is self-reinforcing. Whether workers are discriminated in promotion is not necessarily related to their non-labour market opportunities. If a worker is less likely to quit her job than her employer believes she would, her career prospect with her current employer would be unfairly limited. This pushes her to look for jobs elsewhere and reinforces the employer's belief about the quit patterns for workers with similar characteristics like hers.

Current Literature

So far we know of two empirical studies that examined several predictions of L&R's model. Winter-Ebmer and Zweimüller (1997) study the differences in promotion thresholds using economy wide cross-section data. Pekkarinen and Vartiainen (2003) study the differences in the complexity of jobs undertook by men and women within the Finnish metal industry using annual data that cover a span of 10 years. We are aware that there is a large body of literature on a similar theme. Those studies examine the differences in treatment faced by workers of different sexes and ages who have equal apparent qualifications, and the differences in treatment are driven by the differences in the sharing the costs of investments in firm-specific human capital between employer and employee.[1] We choose to neglect these studies as our emphasis is not on the human capital investment side of the story, but on the differences in treatment faced by workers on job-ladders.

The data used by Winter-Ebmer and Zweimüller (1997) was a cross-sectional sample of white-collar workers drawn from the Austrian microcensus. There are two main empirical findings. First they find that a good portion of the differences in the distribution of jobs between men and women remain unexplained even when their alternative uses of time, and

[1] The term that refers to the different treatments received by workers, usually in terms of different tenure-wage slopes, is 'dual labour market'. The earliest theoretical papers that purely focus on self-selection include Nickell (1976), Salop and Salop (1976), and Guasch and Weiss (1981). Later papers, e.g. Harshimoto (1979, 1981), suggested that it is the sharing of firm-specific human capital investment between employer and employees that determines the tenure-wage slopes of individual employees. One of the latest empirical works in this area is Becker and Lindsay (1994).

the values of these alternatives uses of time, are controlled for by a range of variables. Such variables include the risk of bearing a child in the next five years, number of children they already have, and home time. In other words the discrimination is not just targeted to women whose non-labour market alternatives are of high values but to all women. Their results also show that women must have higher human capital endowments than men in order to be employed in high positions. Despite the interesting findings, however, the results are not so clear cut due to the type of data that was used. First, the act of promotion in the data was not observed but inferred. The job hierarchy was also superimposed. All jobs are assigned into one of the six grades, and each of the grades corresponds to a level of education which is equivalent to the minimum education requirements at entry. If a worker is working in a job that correspond to a higher level of education than she endows, she is assume to have had been promoted. Second, as the sample covers many workers coming from an array of businesses and organisations, the overall hierarchical structure of all jobs in the economy is hard to define. Third, the active role played by individual employers in setting gender-specific pay and promotion structures that are tailored to the needs of their organisations goes amiss.

Pekkarinen and Vartiainen (2003) used an industry-wide data set that covers one out of every 15 workers in the Finnish metal industry. It is a 10-year long longitudinal data and the hierarchy of jobs is defined by the complexity of jobs, which also determines the job-related minimum wages as instigated by the nationwide collective agreement. The collective agreement also instructs that workers be paid bonuses that are symmetrically distributed. The average of bonuses must equal to 9.5% of their basic job-related salaries, with the lower bound at 2% and the upper bound at 17%. The evidence that they used to support L&R's model are as follows. (1) Female workers are less likely to work in jobs with high complexity. (2) Promotions, as measured by the size of positive change in job complexity, are of smaller magnitudes for women. (3) Women take longer to earn promotions. (4) Workers of both genders on average perform similarly well at the initial tasks they were assigned. However, females earn more performance-related bonuses than males, both amongst the promoted and the stagnant workers. 'Stagnant' workers are defined as those who have stayed at the initial assignments up to the date of comparison. The authors suggested that this result is driven by female workers having to jump higher hurdles to earn promotions. They acknowledged that the results could be driven by more productive men quitting early on in their career, but they found no evidence that this is the case.

This data again imposes limitations on what the authors can possibly do. First the data set contains only information on the age, gender, firm-specific tenure and pay of workers, information about marital status and the number of children within the workers' households were not collected. Consequentially they cannot control for the workers' attachment to the labour market. The complexity of the initial jobs held by the workers are not observed but inferred by comparing their salaries with the salary levels instigated by the national agreements. Furthermore, the sizes of bonuses paid to workers are also inferred by comparing workers' pay with the industry's and firms' standards. Second the scope and size of the data is quite small (the largest sample is less than 10,000 person-year observations), therefore depending on the size of the firms, it is quite impossible to study the active role played by the employers in the pay/promotion discrimination process. Regardless, the authors have done a fine piece of work in demonstrating how one can utilise very basic data to provide some evidence that L&R's type of discrimination are in place within the Finnish metal industry.

Researchers in this area invariably face difficulties when they use economy-wide or industry-wide datasets as the job hierarchies are not readily defined and are superimposed ex-post. As the number of observations they have from each company is also limited, it is hard to identify the setting of gender-specific pay and promotion structure. On the other hand, current studies that use personnel records from a single firm have well-specified job hierarchies, but their effort stops at estimating the differences in promotions probability between men and women (e.g. Jones and Makepeace (1996)). The gender-specific pay structure and promotion thresholds and the active role played by the employer in setting them remain neglected. It is via the employer's choice on pay structure and promotion thresholds that he encourages workers to self-select to jobs that are right for them, given their outside opportunities. This mechanism and its effects might not be obvious if studied on a national scale, as the firms' beliefs on separation rates vary widely from one another and the effects of their beliefs might cancel off one another. Thus if the pay and promotion structure as predicted by L&R is to be found, it will emerge most obviously from the personnel records of a single firm.

Lastly, regardless of what kind of data that are being used, there is no sure way to control for relative differences in the distribution of ability across genders amongst the workers we observe. An element of self-selection will always persist, workers might choose jobs that they perform best instead of the one that is higher up in the hierarchy. This should be most frequently observed in firms where the wage bands of grades overlap. There is another problem lays in identifying those who are in probation for promotion-tracking jobs from those who are in dead-end jobs. This procedure is essential for testing some of the implications of L&R's model as listed in Lazear (1995) but there are no hard and fast rules about how this should be done. The fact that we observe a worker has not been promoted in the current period imparts no information on whether this worker will gain promotion in the next and the coming periods. There is no sure way to tell whether a worker is in a dead-end or that she is in probation. There are many ways a researcher can segregate workers into dead-end or probation. Different segregate methods make it hard to compare results of similar works by different researchers using different datasets. This is especially given that the proportion of workers on probation across genders can vary an awful lot depending on the occupation. Combining these two factors, it becomes perfectly possible to find both promoted and stagnant females perform better than their male counterparts. Yet due to the lack of background information one cannot feel any surer whether he or she has actually observed the relationships between genders, performance thresholds for promotions and pay that was specified in L&R's model.

Summing up, both studies compare the job distribution across genders. Winter-Ebmer and Zweimüller controlled for labour market attachment by a number of personal characteristics and promotion thresholds are assumed to be a function of tenure and education. Pekkarinen and Vartiainen compare the bonuses of stagnant and promoted workers by genders as well as a duration model for promotion. Both studies examined the predictions of L&R's model in piecemeal. Such predictions, when viewed in separation, can equally be the results of any discrimination model. Neither succeeds in studying all facets of L&R's model in one fell scoop. That is, the inquisition as to whether the choice variables – the promotion thresholds, the salaries paid prior to promotions and the length of time spent in grade prior to promotions – are interacting as they were described in the model has remain unexplored. Furthermore, neither study answers the following questions. Do women suffer promotion thresholds and pay levels that are different from men because firms have correctly expected and responded to women's higher tendency to separate from the labour market? Or are these practices purely driven by discrimination and irrational beliefs that has no relevance to workers' tendency to separate from the firm? In short, do firms *statistically discriminate* or do they just *discriminate*? In this study we seek to examine both issues using the personnel records of a single firm.

Our data is drawn from the monthly payroll records of a financial firm in Britain. The hierarchical structure of jobs in the firm is well specified. We have information on workers regarding promotions, grades, pay, tenure and tenure within grade, performances, contract hours, marital status, age, gender, disability, ethnic origin and the number of children. We also have information regarding overtime and pay, education and professional qualifications, and number of children. Promotions are directly observed without making any ad hoc assumptions.

For examining the first issue, we estimate the normal form of L&R's model, with a dummy for males to control for their lower tendency to quit from the labour market and also from their jobs. To examine the second issue, we first create an index of workers' tendency to separate from the firm. We then estimate the normal form of L&R's model again, but replacing the male dummy with the negative value of this tendency to separate index. The results of the first and the second L&R estimations are then compared. If pay and promotion discrimination against women within this firm is really because women are more likely to quit, then the properties of the results for these two estimations should be the same. If, however, we find women are being punished for their lower attachment to the labour market but the same punishment were not levied on workers with other attributes that can equally contribute to lower labour market attachment, then the case for rational statistical discrimination in this firm is a fallacy.

In the next section we shall present a modified edition of Lazear and Rosen's model. In section 3 we describe the data, the econometric model that we shall estimate and the predictions we drawn from the modified L&R model. The results are presented in section 4 and we shall conclude in section 5.

2 Model

L&R's model has two periods and two types of job. Everybody in job B is paid the same rate for both periods, no training is needed and positions can be filled by new recruits. For job A it is more complicated. Workers in job A must participate in training in the first period, after which they will be promoted. Participation in training is costly and workers' productivity is adversely affected while they train but the trainings boost their productivity once they are promoted. In the training, or pre-promotion period, workers in job A are paid a wage that is lower than that of job B. In the post-promotion period, however, workers in job A are paid a rate that is higher than job B. All workers are given a choice to quit their jobs in the second period shall they wish it.

It is assumed that workers of either gender are identical in all attributes except for their tendency to quit in the second period. This is because females tend to have more valuable non labour market opportunities than men. This is illustrated in Figure 1. The value of non labour market opportunities is denoted by ω, and the two overlapping bell-shaped curves are the distribution of ω for males and females. The probability in realisation of a specific value of ω or greater is higher for women than men. Workers' utility function is $U = q$, where $q = \max(\omega, \delta)$. Workers work if $\omega > \delta$ and quit if $\omega > \delta$. Mathematically, the distribution of outside opportunities for males, $F_m(\omega)$, is stochastically dominated by the distribution function for females, $F_f(\omega)$, so that $F_m(\omega) > F_f(\omega),\ \forall\ \infty > \omega > 0$. With no prior knowledge on workers' outside opportunities values, employers are reluctant to assign female workers to jobs that involve costly trainings which may lead to better career prospects and higher total life-time earnings.

<<Figure 1 about here>>

L&R's model is similar to the human capital theory models in that it generates the results where females are placed in low-pay jobs because they have less human capital than males and also why they do not make human capital investments that are essential for high paid jobs. Their model take another step further as it captures the promotion process that is observed within companies. It also implies that although males and females within the same job are equally treated in almost aspects, they might be subject to subtly segregated promotion and pay mechanisms.

The model has some implications for the working of an internal labour market with an integrated hierarchy for men and women. First of all, there will be separate sets of promotion mechanism and wage structure for men and women. Women will on average be given a lower salary in the pre-promotion period. Their pre-promotion periods are also longer than men. Lastly, they will have to clear higher performance hurdles to win promotions. Women in every grade will experience one or more of the three discriminations specified above. For example men and women might face identical performance hurdle, but the women will have to spend more time in training. Another example is that workers of both genders face the same performance hurdle for promotion and are trained for the same amount of time, but the women would be paid less during training. In short, according to the model the intensities of the three types of discrimination are co-determined.

The original model has two time periods of equal lengths. In here, we accommodate the panel character of our data better by introducing a time variable, whereby the amount of time spend in the first and second periods can vary.[2] Workers in job A will spend a proportion of their time, v, in the training or pre-promotion period. The total amount of time is normalised to 1, so that workers will only spend $(1-v)$ in the post-promotion period. In this latter period workers will choose whether they stay in their jobs or quit to pursue their outside opportunities, depending on the relative values of the remuneration they receive at work and the value of their outside opportunities. In job B the amount of time spent in the first and second periods is irrelevant as they do not participate in any costly training. Again, workers in job B are given a choice of staying or leaving in the latter period, dependent on the relative values of labour market remuneration and non labour market opportunities.

The rest of the model's set up is as follows. Workers' own ability levels are represented by δ. Output of job A in period 1 is $\delta\gamma_1$ and $\delta\gamma_2$ in period 2 with $1-\gamma_1 < \gamma_2 - 1$ and $0 < \gamma_1 < 1$, so that the loss of productivity during the pre-promotion or training period is more than compensated by the gain in productivity in the post-promotion period. The output of job B is δ in both periods. The expected life-time earnings from taking job A is

$$\delta\gamma_1 v + (1-v)\cdot\left[\delta\gamma_2 \int_0^{\delta\gamma_2} dF + \int_{\delta\gamma_2}^{\infty} \omega dF\right]. \tag{1}$$

The first term represents the earnings in first period, second term is the second period earning times the probability of staying in the labour market, and the third term is the utility gain from non-labour market activities times the probability of leaving work. The distribution of the value of non-labour market alternatives is denoted by F. The expected life-time earning for choosing job B is

[2] Pekkarinen and Vartiainen (2003) introduced a similar alteration to L&R's model where the productivity, that is the effective ability of workers, is a function of innate ability and labour market experience. The characterization of effective and innate ability in their model follows that of Gibbons and Waldman (1999).

$$\delta v+(1-v)\cdot\left[\delta\int_0^{\delta} dF+\int_{\delta}^{\infty}\omega dF\right] \tag{2}$$

The difference in life-time earnings between taking job A and B is $D(\delta)$, which is the difference between (1) and (2). After rearranging the terms and applying integration by parts, we arrive at:

$$D(\delta)=\delta v(\gamma_1-1)+(1-v)\int_{\delta}^{\delta\gamma_2} F(\omega)\,d\omega \tag{3}$$

Differentiating $D(\delta)$ with reference to δ,

$$D'(\delta)=v(\gamma_1-1)+(1-v)\left[\gamma_2 F(\gamma_2\delta)+F(\delta)\right] \tag{4}$$

Cross derivative of $D(\delta)$ with reference to δ and v is:

$$\partial D'(\delta)/\partial v=(\gamma_1-1)-\gamma_2 F(\gamma_2\delta)+F(\delta) \tag{5}$$

For $\delta=0$, $\partial D'(\delta)/\partial v=(\gamma_1-1)<0$. As $D(0)=0$, this means that at any given v there are values of δ that are sufficiently low where the workers are better off choosing job B. To find the ability cut-off point, δ^*, where workers with $\delta>\delta^*$ choose job A and those with $\delta<\delta^*$ choose job B. We set $D(\delta)=0$ and solve for δ^*,

$$\delta^* v(\gamma_1-1)=(v-1)\int_{\delta^*}^{\delta^*\gamma_2} F(\omega)\,d\omega\,. \tag{6}$$

Let $u\equiv\left[\gamma_2 F(\gamma_2\delta)-F(\delta)\right]$ and that $u^*\equiv\left[\gamma_2 F(\gamma_2\delta^*)-F(\delta^*)\right]>0$, the rate of return for training which is always positive, we can rewrite (4) and (6) respectively as:

$$D'(\delta)=v(\gamma_1-1)-(v-1)u \tag{7}$$

$$\delta^* v(\gamma_1 - 1) = (v-1)\delta^* u \tag{8}$$

So that if xa worker's $D(\delta)$ is larger than zero, it means that $v(\gamma_1 - 1) - (v-1)u > 0$ and the worker should be in job A. Workers should be in job B if $v(\gamma_1 - 1) - (v-1)u < 0$.

Differentiating equation (8) with reference to v, we arrive at:

$$\frac{\partial \delta^*}{\partial v} v(\gamma_1 - 1) + \delta^*(\gamma_1 - 1) = \frac{\partial \delta^*}{\partial v}(v-1)u + \delta^* u \tag{9}$$

and by rearranging the terms we discover the equation that describes the correlation between δ^* and v,

$$\frac{\partial \delta^*}{\partial v} = \frac{\delta^*(1-\gamma_1+u)}{v(1-\gamma_1+u)+u} \tag{10}$$

Since the numerator on the RHS is always positive, therefore whether $\partial\delta^*/\partial v$ is negative or positive is determined by the denominator. The result is that $\partial\delta^*/\partial v > 0$ if $D(\delta) > 0$ and $\partial\delta^*/\partial v < 0$ if $D(\delta) < 0$. This proof shows that the ability cut-off point (δ^*) is an increasing function of the amount of time spent in the pre-promotion period. This means that the more training one needs to take up for job A, the higher is the performance thresholds for promotion. Since workers in job B do not participate in trainings and do not experience promotions, therefore the case where $\partial\delta^*/\partial v < 0$ and $\delta < \delta^*$ shed no lights on what we expect to observe. The slope of this relationship between δ^* and v is determined by the adverse effects of trainings on productivity, $v(1-\gamma_1)$, and the rate of return from training, $(v-1)u$. Empirically the latter can be measured by the expected salary (mean salary of all employees in the grades above the worker's) multiplies by the number of working years prior to retirement (average retirement age minus the worker's age).

As F the distribution of alternatives shifts, so will δ^*, which is why the male and female thresholds differ. Let $F_m(\omega) \equiv F_m(\omega;\alpha_m)$ and $F_f(\omega) \equiv F_f(\omega;\alpha_f)$, where α_m and α_f are distribution shifters. We can also view α as a measure of how closely are workers attached to the labour market or their current jobs, so that a worker with a large α is more attached to his current job than someone who has a small α. Assuming that $\partial F/\partial\alpha > 0$ and $\alpha_m > \alpha_f$, so that the $F(\omega;\alpha)$ of the group of workers with high level of α is stochastically dominated by that with a low α. Differentiating (3) with respect to α,

$$\frac{\partial\delta^*}{\partial\alpha} v(\gamma_1 - 1) + (1-v)\left[\int_{\delta^*}^{\delta^*\gamma_2} \frac{\partial F}{\partial\alpha} d\omega + u\frac{\partial\delta^*}{\partial\alpha}\right] = 0 \tag{11}$$

Rearranging terms and substituting in (4), then we find:

$$D'(\delta^*)\frac{\partial\delta^*}{\partial\alpha} = (v-1)\int_{\delta^*}^{\delta^*\gamma_2} \frac{\partial F}{\partial\alpha} d\omega \tag{12}$$

As $D'(\delta^*)$ must be positive because a worker must have $v(\gamma_1 - 1) - (v-1)u > 0$ in order to take job A. Also, since $\partial F/\partial\alpha > 0$ by definition and $(v-1)$ must be negative, thus $\partial\delta^*/\partial\alpha < 0$. Summing up, the conclusion is that $\partial\delta^*/\partial\alpha < 0$ if $D'(\delta) > 0$ for workers in job A and that $\partial\delta^*/\partial\alpha > 0$ if $D'(\delta) < 0$ for workers in job B.

By chain-rule, $\partial\delta^*/\partial\alpha = \partial\delta^*/\partial v \times \partial v/\partial\alpha$. Since $\partial\delta^*/\partial\alpha < 0$ and as we have shown earlier in (10) that $\partial\delta^*/\partial v > 0$, we can conclude that $\partial v/\partial\alpha < 0$. The significance of this result is that the amount of time spent in pre-promotion period is a decreasing function of a worker's attachment to the labour market. Therefore workers whose non labour market alternatives are better than the others will find themselves having to spend more time in the pre-promotion stage than the others. In our context, it means that women in job A will spend longer time in the pre-promotion period than men.

Again, taking δ^* from both sides of (8) and differentiating with respect to γ_1,

$$\frac{\partial v}{\partial \gamma_1} = \frac{v}{1-\gamma_1+u} \tag{13}$$

This solution shows us that $\partial v/\partial\gamma_1$ is positive as the denominator on the LHS is positive. It implies that the amount of time spent in the probation period is a positive function of pay in the probation period. The more intensive is the training, the higher is the pay discount during probation $(1-\gamma_1)$, the shorter will the probation period be. Employers can choose to give workers intensive training that last a short while with great negative impacts on their productivity over the training period, or light training that last a long time but affect their productivity ever so slightly. If a worker has high ability so that u is relatively big, the corresponding v for a given γ_1 would be lower than that of another worker with low ability. This relationship is illustrated in Figure 2.

<< Figure 2 about here.>>

As $\partial v / \partial \alpha = \partial v / \partial \gamma_1 \times \partial \gamma_1 / \partial \alpha$, and earlier discussion shows that $\partial v / \partial \alpha < 0$ and $\partial v / \partial \gamma_1 > 0$, we can conclude that $\partial \gamma_1 / \partial \alpha < 0$. This result implies that workers whose attachment to the labour market is strong (high α) will be given higher training wages than those whose attachment is weak. In our context it means that we expect men to have higher salaries than women in their pre-promotion stage.

Lastly since $\partial \delta^* / \partial \gamma_1 = \partial \delta^* / \partial v \times \partial v / \partial \gamma_1$, it thus follows that $\partial \delta^* / \partial \gamma_1 > 0$. It means the ability cut-off point for taking job A is an increasing function of the wage paid in the pre-promotion period, ceteris paribus.

Summing up our findings and assuming that the promotion threshold are identical for both genders, women will spend significantly longer time in pre-promotion stage than men. If they do not, they will find themselves being paid less than their male colleauges while they are in the pre-promotion stage. Or they might find themselves in a situation that is a combination of the two above with the time discrimination and the wage discrimination substituted for one another. Furthermore, if we allow the promotion threshold to differ between males and females, the wages and length of pre-promotion time for males and females might not differ at all. A summary on how these three types of discrimination will interact against one another is shown in Table A.

<<Insert Table A here>>

Alternative Non-Labour Market Activities Distribution Assumption

Barron and Kreps (1999) suggested that the reason why employers favour men over women is because women's ability is more widely distributed or their day-to-day performances fluctuate more than men's.[3] This is illustrated in figure 3. When employers cannot observe the ability of their employees but know that women's ability is more varied, they would favour males over females for some jobs. If female performance fluctuates more than males, pyramid like hierarchical organisations would appoint males for high grade jobs with great responsibilities. Hiring males for important jobs with a lot of responsibilities and females for jobs with few responsibilities and where errors are cheap to correct would generate a steadier production stream. This is because male employees have steady performances, and the summation of female employees random performances would level out the instability.

<<Figure 3 about here>>

We can also turn the Barron and Kreps argument around, follow the example of L&R and assume that the non-labour market alternatives for women are more diversely distributed than men's. We can keep everything else in the model unaltered and generate the same results. Since the employer is less certain about the value of non-labour market alternatives of women, they would again prefer to promote men as the chance of any given man would quit is lower than any given woman. Similar to L&R model where the gender specific promotion thresholds are determined by the shifters of alternatives distributions α_f and α_m, the promotion thresholds in Baron and Kreps for jobs left of point F in figure 3 would be determined by the standard deviations of alternatives distributions. For jobs that pay wages at levels that are lower than E, the female participation rates would increase relative to men's

[3] Baron and Kreps (1999), Figure 14-2, p. 356.

due to more women having low values for non-labour market alternatives than men at the lower end. As fewer women would pass the upper threshold near to the top end of the pay distribution, and because they have higher labour market participation at the bottom end, these two forces combine to drive down the average pay of females.

We have yet to find out whether the two different models would have implications that differ from one another, both in labour market participation rates and pay levels, which concern the higher end of the ability distribution. We would, however, disregard the differences predicted for the lower end in this study as the firm where we drawn our data from is the British branch of a large international financial firm. The majority of the employees are white-collar workers. We also exclude all part time workers as their pay tend not to reflect the real worth of their human capital in the labour market. Furthermore, both models are concerned with the 1-0 switch between labour and non labour market participation, the inclusion of part time workers in our sample would be inappropriate for studying the model as they now stand.

3 Data

The dataset we use in here is the monthly personnel payroll record of a British firm in the financial sector. The sample period starts from January 1989 and the last month of observation is November 2001, covering a period of 155 months. On average there are around 40,000 full time and 20,000 part time employees in each month. In the early 90s the firm has gone through a phrase of downsizing which reduced the number of full time employees to just under 35,000 in mid-90s. Since then the number of employees is on the rise again, currently reaching a level that is on a par to the period prior to the downsizing.

Each worker is assigned a numerical staff identification number, which enable us to trace their career movements within the firm over time. For each worker we have information on gender, marital status, age, ethnic origin, number of children, salary, overtime payment, job code, branch code, hierarchical grade, date of entry to the firm, date of entry to the current grade, performance rating, partial postcode of home and work, the value of territorial and other allowances, education and professional qualifications.

Workers are regularly evaluated for their performances at work. There are six categories of performance ratings. For workers whose performances have yet to be evaluated because they have just joined the firm or have been recently promoted or demoted, they are recorded as unrated. All others are rated on a scale of 5: (1) Unsatisfactory, (2) Not Fully Effective, (3) Satisfactory, (4) Very Good, and (5) Outstanding. In our sample, the percentage of workers being rated as (1) or (2) is persistently less than 2% of the workforce, just less than half were rated (3), about 25% were rated as (4) and about 10-15% as (5). About 15% of all workers are unrated. The information regarding workers' performance would help us to assess whether female workers would often have to jump higher performance hurdles than men to gain promotion. If they do and given that performance rates should act to reveal the underlying ability of individuals, we should be able to infer whether the promoted women are indeed of higher calibre than the promoted men.

All jobs in this firm fall into one of the 14 hierarchical grades of this firm, which are Grade 1 to 13 and grade 99. Grade 99 and 1 are all part time or temporary workers, although some of them are full time workers drawn from the firm's operations in other parts of the world. These workers are excluded from our analysis as they are not part of the internal labour market hierarchy that we seek to analyse in here. Grades 2 to 13 can be broadly divided into four main levels. Grades 2 to 4 are training grades where workers receive training and would then be promoted to higher grades almost with certainty. Grades 5 to 6 are clerical grades. Workers in grade 7 and 9 are middle managers and those in grades 9 to 13 are senior managers.

Studying Summary Statistics

In here we look at the summary statistics to study the gender differences in performance ratings, salaries and overtime payment, promotion rates, and amount of time spent in grades prior to promotions. We also tabulate the salaries before and after promotion for both males and females.

We compare the various distributions by using test statistics. Let us assume that both distributions are normally distributed. Making no assumptions regarding the similarity of the standard deviations of the distributions, we use the following formula to calculate a t-statistics which compares the means,

$$t = \frac{\mu_f - \mu_m}{\sqrt{\frac{s_f^2}{N_f} + \frac{s_m^2}{N_m}}} \tag{14}$$

The corresponding degree of freedom is unknown, but can be estimated with the Welch-Satterthwaite (WS) approximation with this formula:

$$v = \frac{\left(\frac{s_f^2}{N_f} + \frac{s_m^2}{N_m} \right)^2}{\frac{s_f^4}{N_f^2 \left(N_f - 1 \right)} + \frac{s_m^4}{N_m^2 \left(N_m - 1 \right)}}. \tag{15}$$

Where μ is the mean, s is the standard deviation, and N is the number of observations. The subscripts f and m respectively denotes the values for females and males, respectively.

For comparing the variances, we will first calculate the sample variances of the two sub-samples:

$$
\begin{aligned}
s_m^2 &= \frac{1}{N_m - 1}\sum_{i=1}^{N_m}\left(Y_i - \overline{Y}\right)^2 \\
s_f^2 &= \frac{1}{N_f - 1}\sum_{i=1}^{N_f}\left(Y_i - \overline{Y}\right)^2
\end{aligned} \tag{16}
$$

After that we can calculate the test statistics, which is:

$$
F = \frac{s_m^2}{s_f^2} \tag{17}
$$

Econometric Modelling

The model indicates that performance threshold for promotion (δ^*), pay in pre-promotion period (γ_1), the length of the pre-promotion period (v) are all co-determined. They are all affected by the strength of workers attachment to their jobs and to the labour market. Summarising what we have found in section 3, the relationships we seek to estimate are essentially described in the following equations:

$$
\begin{aligned}
&\frac{\partial \delta^*}{\partial v} = \frac{\delta^*\left(1-\gamma_1+u\right)}{v\left(1-\gamma_1+u\right)+u} > 0 \\
&\frac{\partial \delta^*}{\partial \gamma_1} = \frac{v}{v\left(1-\gamma_1+u\right)+u} > 0 \\
&\frac{\partial \delta^*}{\partial \alpha} = \frac{-\left(v-1\right)}{v\left(1-\gamma_1+u\right)+u}\int_{\delta^*}^{\delta^*\gamma_2} \frac{\partial F}{\partial \alpha} d\omega < 0 \\
&\frac{\partial^2 \delta^*}{\partial v \partial \gamma_1} = \frac{\delta^*\left(v-1\right)}{v\left(1-\gamma_1+u\right)+u} < 0 \\
&\frac{\partial^2 \delta^*}{\partial v \partial \alpha} = \frac{\left(\gamma_1-1\right)-2u}{\left[v\left(1-\gamma_1+u\right)+u\right]^2}\int_{\delta^*}^{\delta^*\gamma_2} \frac{\partial F}{\partial \alpha} d\omega < 0 \\
&\frac{\partial^2 \delta^*}{\partial \gamma_1 \partial \alpha} = \frac{-v\left(v-1\right)}{\left[v\left(1-\gamma_1+u\right)+u\right]^2}\int_{\delta^*}^{\delta^*\gamma_2} \frac{\partial F}{\partial \alpha} d\omega > 0
\end{aligned} \tag{18}
$$

These equations only describe the relationship between the three factors for those workers who are in job A. On account of this we therefore restrict our sample to cover only promotion incidences, i.e. when $\delta > \delta^*$. That is, we only include an observation if a promotion took place. Say if 5 workers were promoted in March 2000, then there would only be 5 observations in that month. This choice is justified both on the basis of the model's structure, and on the difficulty in identifying the stagnant workers from those who are still in their pre-promotion stage in a right censored monthly personnel record.

The inequalities specified in (18) are of opposite or undeterminable signs if $\delta < \delta^*$, that is the cases where workers have chosen or are allocated to job B. Since the inequalities do not describe these cases, it means that all the observations where no promotion occurs are irrelevant to our study.

From (18) we learn that the partial derivatives are themselves functions of other terms and the cross derivatives are not equal to zero. With these information we can express δ^* as a function of v, γ_1, α, and their interactive terms. Since v, γ_1, and δ^* are all codetermined, strong endogeneity will affect the results of the equation that we shall estimate, as shown in here:

$$\delta^* = \beta_1 + \beta_2 v + \beta_3 \gamma_1 + \beta_4 \alpha + \beta_5 v \gamma_1 + \beta_6 v \alpha + \beta_7 \gamma_1 \alpha \quad (19)$$

As this model assumes men to be more attached to their jobs than women and have larger α, we therefore take the liberty of using a male dummy in place of the conventional female dummy. We have $\alpha = 1$ for men and $\alpha = 0$ for women. We also estimate (19) using an attachment index (or negative separation index) in place of the male dummy. This index measures how unlikely a worker is going to leave this firm.

The variable v is measured by the amount of time a worker spent in the grade prior to the promotion. The variable γ_1 denotes the discounted wage the worker receives in the pre-promotion period. We measure this value by dividing the worker's wage over the average wage within their grade, and then we take the average of this value throughout the worker's pre-promotion period. For example if worker i works for v_i periods in grade g, her γ_1 would equals to $\gamma_1^i = \sum_{j=1}^{v_i} \left(w_j^i / \overline{w}_j^g \right)$. The $\overline{w}_j^g$ is the mean wage for grade g in period j and w_j^i is the wage of worker i receives in period j.

We expect to find the estimates for $\beta_2, \beta_3, \beta_7$ to be positive and the rest negative. First, $\beta_2, \beta_3, \beta_4$ are respectively the estimated values of $\partial \delta^* / \partial v > 0$, $\partial \delta^* / \partial \gamma_1 > 0$, $\partial \delta^* / \partial \alpha < 0$, and should therefore carry values that correspond to our model's findings. Second, β_5 represents how the changes in γ_1 affects $\partial \delta^* / \partial v$ or it is the cross derivatives $\partial^2 \delta^* / \partial v \partial \gamma_1$.

Since the numerator $\delta^*(v-1)$ is always negative, therefore we expect to find the estimator of β_5 to be negative. Third, the estimator of β_6 would also be negative as the numerator $(\gamma_1 - 1) - 2u$ is negative while both $\left[v(1-\gamma_1+u)+u\right]^2$ and $\int_{\delta^*}^{\delta^*\gamma_2} \frac{\partial F}{\partial \alpha} d\omega$ are positive. Finally, the estimator of β_7 would be positive as it represents $\partial^2 \delta^* / \partial \gamma_1 \partial \alpha$ and the numerator $-v(v-1)$ is positive.

We expect to find similar results in the second estimation where we replace the male dummy with the negative value of a separation index. This separation index is calculated using the estimates from a separation logit estimation. This logit estimation calculates the likelihood to separate from this firm based on the following attributes of a worker: gender, age, age square, marital status (married, divorced, widowed), number of children under 12, the square of the number of children under 12, and a fertility index for women.

The fertility index measures the probability that a woman will bear a further child within the next 5 years.[4] It is derived using the estimates of a pregnancy logit estimation, where the incidence of pregnancy is a function of age, age square, number of children, and the square of the number of children. We used the full sample of the UK-based General Household Survey for this estimation. The fertility index is calculated as follows:

$$\text{Fertility} = 1 - \prod_{n=1}^{5} \left[1 - \Pr\left(\text{birth} \middle| \text{age} + n,\ \text{number of children}\right)\right]. \qquad (20)$$

Results of the pregnancy logit and the separation logit are respectively produced in Table B and Table D.

[4] This process is adopted from Winter-Ember and Zweimüller (1997).

4 Results

The first part of this section discusses the summary statistics with references to the basic predictions of L&R's model. All figures are tabulated using the full sample. In the second part we estimate the empirical model we have set out in section 3 and only a subset of the sample is selected for the estimation.

First, we shall se the scene by looking at the distribution of male and female across grades in this firm, presented in Table 1. We use the Duncan and Duncan Index of dissimilarity to measure the differences:[5]

$$I = \frac{1}{2}\sum_i |m_i - f_i| \tag{21}$$

where m_i and f_i are the proportion of workers of each gender being in grade i. The index shows the percentage of women who should change grades to achieve the same distribution as men's. The index for the entire period is 39.4, starting from 43.6 in 1989 and it slowly decrease, down to 35.6 in 2001. Women are over-represented in grades 2 to 6 and under-represented for grade 7 and above. This point where women go from being over to under-represented seems to have been shifting upwards slowly. From 1989 to 1990, women were under-represented in grades 6 and above. From 1991, this under-representing line has moved to grade 7 and above. These "switching" boxes are highlighted. Although the proportion of women working in grade 6 is now bigger than men, it is not significant. Given that the proportion of women working in lower grades is still very high, this small shift change has

[5] Duncan and Duncan (1955).

contributed very little in reducing the differences in job distribution between the genders within this firm.

Performance

L&R's model predicts that the promoted women have higher ability than the promoted men. To find out whether this is the case for our firm, we calculate the mean and standard deviation of performance rates by gender for all grades within the hierarchy. The statistics are presented in Table 2. Although the distributions of performance rates are truncated on both ends and are discrete in nature, their averages are random variable and can lie anywhere between 1 and 5. Therefore there is no justification to forgo using the comparative t-statistics specified in section 3.

We can state with 95% confidence that the mean performance rate for women is higher than men's for all grades except for 2 and 13. We are not interested in grade 1 because it does not belong to the hierarchy. For grade 13 we do not have enough information or observations to compare the performance of workers by gender. So far, what we find in this firm are confirmatory of L&R model's predictions.

Salaries and Overtime Pay

In here we test another hypothesis generated by L&R's model. They argued that promoted women on average would be paid better than their male colleagues due to their higher average ability, a by product of the higher performance threshold for promotion. The means and distributions of salaries, net of any territorial and other allowances as well as overtime pay, are presented in Table 3. We find that women did not get higher wages in all grades but for the highest grade. In fact, the annual salaries of female workers are significantly lower than male workers in almost every grade except for grade 13 when we use all the observations. When we restrict to exclude all observations where the workers' performances are unrated (see Table 4), the pay for females in grades 12 and 13 are both higher than males.

These figures provide some validation of L&R's explanations for the occurrences of wage and job distribution differences between males and females in a hierarchical firm. The numbers show that there might be an unofficial gender-specific wage structure that operates to encourage workers to choose their career path based on their attachment to the labour market and their jobs. Workers whose attachment is low would prefer jobs that pay them a high wage upfront instead of low paid jobs with prospects of promotion and high pay in the future. Women who choose jobs with low starting pay but tied with trainings and prospects are paid a lower starting wage than men who choose similar career paths. This explain why we should observe lower average salaries for all grades that may lead to promotion except for the CEO and vice presidents in the top grades. It is because it is impossible for these workers to earn more promotions.

In table 5, we show the mean and standard deviations of the monthly overtime earnings by grade and gender. Workers in high grades are not paid for working overtime. As overtime pay forms part of the remuneration package, we are therefore interested in finding out whether there are any differences between male and female workers in this area. The only information we have on overtime pay is the amount being paid on a monthly basis and the type of overtime that the workers had participated. We do not know how many hours they have worked and have no information on the hourly rate.

Before we proceed we have to make some small assumptions. First, overtime work is paid by the hour. Second, similar to the set up of most labour-supply theory, workers are willing to keep on working until they reach the point where their privately determined reserve price for their time is equal to the hourly wage paid by the company. It means that, if given the chance to work overtime, they would only stop working when their marginal cost is equal to the marginal utility. Let us assume that males and females are given the same hourly rates for their overtime. Let us also assume, although we are uncertain about how valid this is, that males and females are given the same opportunity to participate in overtime work. These overtime earning figures would give us some indications on the workers' reserve prices for their time. The more overtime hours they work, the less they value what they would otherwise do if they did not work. Workers whose attachment to the labour market is strong would be willing to work more overtime and vice versa.

The mean overtime earnings for women are lower than men in all grades. This indicates that the women in this firm are less interested in working overtime and are less attached to their jobs than men.

Salaries and Expected Pay Rise upon Promotion

In table 6 we present the mean expected pay rise upon being promoted by gender and grade. If the firm has gender specific wage structure, L&R's model predict that the gap between pre and post promotion pay should be larger for women than it is for men. This is not what we found in here. We have to reject the hypothesis that the pre and post promotion wage gap for women is larger than men. A more detailed investigation is needed.

Promotion Rates

In Table 7 we present the promotion rates by grades and genders. There are no systematic differences between the promotion rates of males and females. The overall promotion rate for women is higher. Women are more likely to promote at both the low and high ends of the hierarchy. The only grades where men are more likely to promote are grades 5 to 8 and 10. As these grades are the most important part of this ILM with the majority of employees being employed in these grades, the promotions

<<Insert Table 7 here>>

Results of the Norminal Form of L&R's Model (Modified)

The results are presented in Table E (OLS) and Table F (ordered logit). We have calculated three estimations where the dependent variable is the workers' performance ratings at the time of promotion (δ^*). Please note that only promotion incidences are used in the estimation for reasons we have discussed above. In the first and second estimations, we use a gender dummy (male = 1) to control for the strength of attachment to the firm. In the first estimation all estimators are significant, except for the Salary in Grade Prior to Promotion (γ_1). However, the interactive terms $\gamma_1 \alpha$ and $v \gamma_1$ are both significant, meaning that γ_1 does correlate with the performance rating at the time of promotion via indirect mechanisms. The second estimation is identical to the first one, except that we were dealing with the means by grade and gender. Again all estimators are significant, including that of γ_1.

The results of estimations 1 and 2 are very promising. All the estimators are of the signs as predicted in the modified L&R model, showing that the form and structure of discrimination as described in the model really do exist in real life. However the estimators for the coefficients for α and the coefficient for $\gamma_1\alpha$ are insignificant for estimation 1.

<<Insert Tables E and F here>>

The second step of our study is to see whether these types of promotion-related discrimination really are statistical, in the way that a group of workers would be discriminated if they are perceived to have higher rates of separation (low rates of attachment to the firm).

Therefore we replace the gender dummy with a negative measurement of the tendency to leave. This measurement is created using the estimates of a separation logit as described in section 3. All estimators are significant but some of them have signs that are not as predicted in the model. Most notably, the estimated value for $\partial\delta^*/\partial\alpha$ is not negative as expected. That is, the workers whose attachment to the firm is very strong do not get to jump over a lower performance hurdle to be qualified for promotion as it is predicted in the model, but instead are given a higher hurdle to jump. Secondly, the promotion threshold is also a decreasing function of the salary in the pre-promotion period, which is exactly the opposite of what is predicted in the model. The estimator for the interactive term $v\ \alpha$ also has a positive sign instead of an negative as predicted in the model.

We can think of no reason why the signs of the estimators we have found in estimation 3 are not the same as estimations 1 and 2, which is what it is predicted in the model. The only thing we can say from what we observed from the results is that discrimination does occur, but it has nothing to do with the tendency to leave the firm. Therefore the inertia in promotion and low salaries experienced by women are not tied to the tendency of them being more likely to separate from their jobs. The story of rational statistical discrimination does not stand up to scrutiny in this firm.

5 Conclusion

From the personnel records of a large firm, we drew a mixed bag of results regarding the differences in career advancements and pay structures between men and women in this firm.

From the summary statistics, what we observed from the promotion rates and performance rates are confirmatory on what L&R's model predicts – women who choose to enter in jobs that lead to promotions are better qualified than men who did the same. It is also possible what we observed was due to the firm setting a higher promotion thresholds for women than men. Either way, whether it is higher promotion thresholds or self-selection encouraged by gender-specific wages that generate what we observed, it fits.

Salaries of women are not higher than men, except for those at the very top. This is indicative of the use of gender-specific wage at every grade of the hierarchy to encourage optimal self-selection. Lastly, the Duncan-Duncan Index of dissimilarity shows that women are under-represented in the higher grades and over-represented in the low grades. This seems to be changing within this firm as the dissimilarity has slowly decreased over the years.

In estimating the nominal form of L&R's model, however, we have found that these patterns of discrimination are not really linked to the tendency to separate from the firm. Although the patterns fit L&R's rational statistical discrimination story perfectly when we are comparing men and women, it falls apart when we are considering other factors instead of only genders.

This firm's discriminatory practices are not related to the tendency to leave but to do with elements that are not accounted for in the model.

As it is the same with all single-firm empirical studies, we cannot make general comments on whether the discriminatory practices in other firms can or cannot be explained with the rational statistical discrimination story. We look forward for more similar studies on other firms from other countries and industries.

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Table 1 Grade Distribution (%) and Duncan-Duncan Index of Dissimilarity, by Years. (Duncan Index in Bold Italics)

	All Years			1989			1990			1991			1992			1993			1994		
Grade	**M**	**F**	**% Diff**	**M**	**F**	**% Diff**	**M**	**F**	**% Diff**	**M**	**F**	**% Diff**	**M**	**F**	**% Diff**	**M**	**F**	**% Diff**	**M**	**F**	**% Diff**
2	0.35	0.49	0.14	1.47	2.31	0.84	0.98	1.46	0.48	0.23	0.35	0.12	0.11	0.14	0.03	0.16	0.15	0.01	0.31	0.32	0.01
3	2.34	3.65	1.31	5.61	9.31	3.7	5.02	8.54	3.52	3.88	6.69	2.81	2.06	3.61	1.55	1.18	2	0.82	1.1	1.52	0.42
4	11.35	23.18	11.83	11.94	26.81	14.87	11.57	25.05	13.48	11.88	24.15	12.27	11.51	23.66	12.15	10.77	22.84	12.07	9.71	21.12	11.41
5	14.64	37.6	22.96	15.24	39.37	24.13	14.03	38.64	24.61	14.12	39.55	25.43	14.17	40.14	25.97	14.81	40.8	25.99	15.11	40.7	25.59
6	17.82	21.01	3.19	17.57	14.3	3.27	17.5	16.58	0.92	18.43	18.83	0.4	18.67	20.76	2.09	18.77	21.87	3.1	18.87	23.16	4.29
7	22.15	9.58	12.57	24.2	6.47	17.73	24.04	7.44	16.6	23.54	7.8	15.74	23.61	8.61	15	24.52	9.12	15.4	24.01	9.49	14.52
8	15.37	3.05	12.32	11.97	0.96	11.01	13.56	1.55	12.01	13.95	1.82	12.13	14.77	2.09	12.68	14.81	2.19	12.62	15.3	2.55	12.75
9	10.35	1.06	9.29	8.03	0.35	7.68	8.55	0.56	7.99	9.03	0.59	8.44	10.01	0.74	9.27	10.19	0.79	9.4	10.58	0.88	9.7
10	3.92	0.3	3.62	3.01	0.1	2.91	3.44	0.15	3.29	3.62	0.19	3.43	3.63	0.21	3.42	3.5	0.2	3.3	3.55	0.21	3.34
11	1.43	0.07	1.36	0.8	0.01	0.79	1.11	0.02	1.09	1.17	0.03	1.14	1.24	0.03	1.21	1.08	0.03	1.05	1.17	0.04	1.13
12	0.25	0.01	0.24	0.17	0	0.17	0.18	0	0.18	0.16	0	0.16	0.2	0	0.2	0.19	0	0.19	0.23	0	0.23
13	0.04	0	0.04	0	0	0	0	0	0	0	0	0	0.03	0	0.03	0.02	0	0.02	0.07	0	0.07
Obs/Duncan	2796852	3314209	***39.435***	232850	293379	***43.55***	230958	292560	***42.085***	215274	276400	***41.035***	206183	258943	***41.8***	202345	247807	***41.985***	204796	246898	***41.73***

	1995			1996			1997			1998			1999			2000			2001		
	Male	**Female**	**% Diff**	**Male**	**Female**	**% Diff**	**Male**	**Female**	**% Diff**	**Male**	**Female**	**% Diff**	**Male**	**Female**	**% Diff**	**Male**	**Female**	**% Diff**	**Male**	**Female**	**% Diff**
2	0.32	0.36	0.04	0.22	0.2	0.02	0.19	0.18	0.01	0.15	0.17	0.02	0.14	0.12	0.02	0.08	0.06	0.02	0.07	0.02	0.05
3	1.39	1.94	0.55	1.54	2.19	0.65	1.67	1.92	0.25	1.68	2.08	0.4	1.87	2.07	0.2	1.67	1.83	0.16	1.13	1.18	0.05
4	9.71	19.77	10.06	11.05	21.43	10.38	12.13	23.46	11.33	11.71	22.6	10.89	11.71	23.29	11.58	11.78	23.2	11.42	11.7	22.67	10.97
5	15.04	40.38	25.34	14.08	37.74	23.66	14.98	36.23	21.25	14.78	34.91	20.13	15.06	34.37	19.31	14.61	33.24	18.63	14.28	31.74	17.46
6	19.33	23.98	4.65	19.67	24.43	4.76	18.53	23.47	4.94	16.57	21.72	5.15	16.48	21.76	5.28	16.32	22.09	5.77	15.78	22.94	7.16
7	23.13	9.49	13.64	22.27	9.51	12.76	20.02	9.62	10.4	20.19	12.31	7.88	19.57	11.56	8.01	19.65	11.75	7.9	19.61	12.7	6.91
8	15.03	2.82	12.21	15.1	3.08	12.02	16.12	3.51	12.61	16.76	4.17	12.59	16.79	4.52	12.27	17.41	5.32	12.09	18.13	5.97	12.16
9	10.8	0.98	9.82	10.53	1.09	9.44	10.75	1.19	9.56	11.25	1.45	9.8	11.4	1.63	9.77	11.56	1.81	9.75	12.04	2.03	10.01
10	3.67	0.23	3.44	3.79	0.27	3.52	3.77	0.34	3.43	4.74	0.47	4.27	4.62	0.54	4.08	4.57	0.53	4.04	4.91	0.58	4.33
11	1.29	0.05	1.24	1.43	0.06	1.37	1.52	0.07	1.45	1.78	0.1	1.68	1.99	0.14	1.85	1.98	0.15	1.83	1.96	0.15	1.81
12	0.27	0	0.27	0.25	0.01	0.24	0.26	0.01	0.25	0.33	0.02	0.31	0.33	0.02	0.31	0.32	0.02	0.3	0.32	0.01	0.31
13	0.03	0	0.03	0.07	0	0.07	0.07	0	0.07	0.06	0	0.06	0.05	0	0.05	0.06	0	0.06	0.06	0	0.06
Obs/Duncan	202156	243479	***40.645***	194672	234160	***39.445***	203985	237379	***37.775***	219332	253143	***36.59***	223767	246049	***36.365***	234405	253143	***35.985***	226129	239780	***35.64***

Table 2 Means and Standard Deviations of Performance Rates by Gender and Grades, All Years.
t-distribution for comparison of mean rates, with no prior assumption regarding the relative size of standard deviations
v is the Welch-Satterthwaite degree of freedom approximation
The minimum significance level where H0 can be rejected.

	Male			**Female**			**Comparison Statistics**		
Grade	**Mean**	**Sd**	**Observations**	**Mean**	**sd**	**Observations**	**t-dist**	**v**	$H_0 : \mu_m \geq \mu_f$
2	3.131295	0.699312	556	3.2	0.598183	295	1.501942	684.3513	10%
3	3.256206	0.617468	30,374	3.368094	0.591593	58,428	25.98369	59261.99	0.5%
4	3.438449	0.694177	217,373	3.493873	0.644409	549,004	32.14276	373784.7	0.5%
5	3.598239	0.709023	299,661	3.774786	0.719715	1005083	119.2184	498041.1	0.5%
6	3.815804	0.763696	401,106	3.927241	0.755493	550,078	70.5966	858893.4	0.5%
7	3.176944	0.534043	460,269	3.309901	0.571915	216,282	91.05879	398395.7	0.5%
8	3.318825	0.599692	329,664	3.45752	0.617697	68,362	53.69402	96927.85	0.5%
9	3.472999	0.638733	223,846	3.585672	0.67725	22,557	23.93708	26759.13	0.5%
10	3.570382	0.659347	78,656	3.701774	0.714344	6,314	14.13999	7203.301	0.5%
11	3.851431	0.652203	26,762	3.938487	0.666183	1,203	4.437906	1307.698	0.5%
12	3.961366	0.574756	4,012	4.738095	0.442312	84	15.81744	88.97006	0.5%
13	4.323529	0.721548	68	4	0	4	-3.69745	67	Not rejected

Table 3 Means and Standard Deviations of Annual Salary by Gender and Grades, All Years. (Adjusted to 2001 prices)
t-distribution for comparison of mean rates, with no prior assumption regarding the relative size of standard deviations
WS d.f. is the Welch-Satterthwaite degree of freedom approximation.
The significance level where H0 is accepted.

	Male			**Female**			**Comparison Statistics**		
Grade	**Mean**	**Sd**	**Observations**	**Mean**	**Sd**	**Observations**	**t-dist**	**WS d.f.**	$H_0 : \mu_f \geq \mu_m$
2	7883.046	2803.354	9,785	7472.705	1470.684	16,227	-13.4093	13083.70738	Rejected
3	8767.115	2636.926	65,451	8328.686	1540.182	120,934	-39.0811	90186.11582	Rejected
4	11506.2	2017.043	317,344	11324.03	1688.99	768,243	-44.8015	510117.0042	Rejected
5	14886.93	3525.26	409,442	14502.82	2133.094	1246161	-65.871	511443.7076	Rejected
6	18242.07	2848.007	498,455	17727.29	2390.303	696,439	-104.051	954167.4965	Rejected
7	23118.78	4266.858	619,453	21923.19	3693.397	317,579	-140.566	726485.6338	Rejected
8	31600.04	7074.338	429,781	30154.71	6447.8	100,990	-62.8933	163134.8329	Rejected
9	44816.95	11451.73	289,560	43898.91	11701.64	35,141	-13.9202	43711.82623	Rejected
10	70360.3	20745.36	109,620	68852.38	20158.01	10,014	-7.14793	12034.01858	Rejected
11	103495.6	27793.66	39,980	94396.14	24682.64	2,211	-16.7572	2530.118243	Rejected
12	151793.8	43265.39	6,867	147814.9	28065.82	237	-2.09818	276.2359832	Rejected
13	248383.9	97976.22	1,114	291964.4	130958.5	33	1.896027	33.0697005	5%

Table 4 Means and Standard Deviations of Annual Salary by Gender and Grades, All Years
Observations with Unrated performance ratings are dropped. (Adjusted to 2001 prices)

t-distribution for comparison of mean rates, with no prior assumption regarding the relative size of standard deviations
WS d.f. is the Welch-Satterthwaite degree of freedom approximation.
The significance level where H0 is accepted.

	Male			Female			Comparison Statistics		
Grade	Mean	Sd	Observations	Mean	Sd	Observations	t-dist	WS d.f.	$H_0 : \mu_f \geq \mu_m$
2	12268.8	6662.869	747	10905.2	4710.74	446	-4.12672	1157.685782	Rejected
3	9295.705	3300.112	31,817	8615.148	1667.895	59,286	-34.496	40726.10252	Rejected
4	11900.03	1960.248	218,150	11610.54	1589.593	550,000	-61.429	337673.6215	Rejected
5	15316.42	3660.236	330,287	14799.74	2058.75	1048168	-77.3612	398173.6097	Rejected
6	18628.99	2698.857	409,771	18132.23	2230.974	563,231	-96.2953	778493.7062	Rejected
7	23621.46	4086.99	469,342	22471.48	3708.886	224,380	-116.826	482733.0304	Rejected
8	31991.49	6951.173	350,041	30691.6	6449.869	76,089	-49.6744	117727.4344	Rejected
9	45209.2	11360.63	245,332	44532.67	11671.11	27,040	-9.07003	32941.75759	Rejected
10	70832.91	20582.55	93,270	70013.28	19943.23	8,168	-3.55234	9754.237837	Rejected
11	104786.8	27884.59	35,213	93241.71	24749.39	1,885	-19.598	2148.215249	Rejected
12	151514.4	40685.11	5,996	156233.9	25289.38	182	2.424216	210.5167717	1%
13	230430.9	95474.78	917	291964.4	130958.5	33	2.673749	33.23543227	1%
Total			2,190,883			2,558,908			

Table 5 Means and Standard Deviations of Overtime Pay by Gender and Grades, All Years
Observations with Unrated performance ratings are dropped. (Adjusted to 2001 prices)

t-distribution for comparison of mean rates, with no prior assumption regarding the relative size of standard deviations
WS d.f. is the Welch-Satterthwaite degree of freedom approximation.
The significance level where H0 is accepted.

	Male			Female			Comparison Statistics		
Grade	Mean	Sd	Observations	Mean	Sd	Observations	t-dist	WS d.f.	$H_0 : \mu_f \geq \mu_m$
2	60.27771	80.08645	7,464	40.57117	10,391	10,391	0.193314	10391.71841	45%
3	73.12408	100.9487	52,123	51.36317	80,065	80,065	0.076905	80064.39102	Rejected
4	163.1844	213.4439	273,223	76.10849	474,518	474,518	0.126407	474517.3335	45%
5	214.6929	287.1922	347,149	98.27822	739,127	739,127	0.135409	739126.4752	45%
6	209.8481	252.8967	382,556	163.2126	399,458	399,458	0.073787	399457.3344	Rejected
7	508.0807	538.8721	103,218	334.0726	32,343	32,343	0.967521	32347.62659	20%
8	640.1835	686.3218	25,704	444.6491	2,216	2,216	4.136661	2251.772586	1%
9	766.5538	1086.021	1,299	726.3464	135	135	1.245007	1410.609352	15%
10	841.9797	968.9121	66	508.7179	6	6	2.793711	65.05469759	1%
11	69.45139	6177.996	4			0			
12			0			0			
13			0			0			
Total			1,192,806			1,738,259			

Table 6 Means and Standard Deviations of Difference between Expected Pay upon Promotion and Current Pay, All Years By Gender and Grades (Figures adjusted to 2001 prices)

t-distribution for comparison of mean rates, with no prior assumption regarding the relative size of standard deviations
WS d.f. is the Welch-Satterthwaite degree of freedom approximation.
The significance level where H0 is accepted.

	Male			Female			Comparison Statistics		
Grade	Mean	Sd	Observations	Mean	Sd	Observations	t-dist	WS d.f.	$H_0 : \mu_f \geq \mu_m$
2	-12.8268	777	10,738	815.9508	1162.89	469	15.28595	486.4210216	1%
3	2488.68	36,663	74,996	2588.43	463.5807	65,071	0.745013	75022.63767	Rejected
4	3346.541	268,284	381,928	3171.367	224.5437	604,936	-0.40352	381927.3378	Rejected
5	3345.565	398,561	492,420	3136.131	153.0264	1136255	-0.36874	492419.0629	Rejected
6	4871.269	473,945	576,316	4160.364	691.5735	615,067	-1.13871	576317.2996	Rejected
7	8393.874	488,656	642,950	8052.171	928.2469	228,282	-0.5607	642962.0686	Rejected
8	13240.77	355,962	436,577	13782.55	1978.199	76,399	1.005568	436730.0334	20%
9	25225.87	245,509	289,785	24704.82	4421.456	27,062	-1.1405	291762.6812	Rejected
10	32377.59	93,277	109,627	25309.43	9182.925	8,168	-23.6013	114088.3327	Rejected
11	48516.16	35,213	39,979	53039.77	21471.31	1,697	8.222284	2104.195105	1%
12	99714.41	4,981	5,687	198907.6	76602.61	57	9.77612	56.0047464	1%
13	207227.5	1	1			0			
Total	10352.38	10537.95	3,061,004	4370.39	3651.206	2,763,463	-933.064	3853723.812	Rejected

Table 7 Overall Means and Standard Deviations of Promotion Rates, by Grades and Gender.
t-distribution for comparison of mean rates, with no prior assumption regarding the relative size of standard deviations
WS d.f. is the Welch-Satterthwaite degree of freedom approximation.
The significance level where H0 is accepted.

	Male		Female		Differences
Grade	Mean	Sd	Mean	Sd	F - M
2	0.147141	0.354263	0.162812	0.369205	0.015671
3	0.05687	0.231595	0.058848	0.235341	0.001978
4	0.018354	0.134229	0.018651	0.135288	0.000297
5	0.013724	0.116343	0.008522	0.091918	-0.0052
6	0.011095	0.104745	0.006746	0.081854	-0.00435
7	0.00973	0.098161	0.006787	0.082106	-0.00294
8	0.00763	0.087015	0.006804	0.082207	-0.00083
9	0.004641	0.067969	0.005459	0.073687	0.000818
10	0.004607	0.067715	0.003795	0.061487	-0.00081
11	0.002001	0.044688	0.002261	0.047511	0.00026
12	0.001456	0.038136	0.004219	0.064957	0.002763
Total	0.0122528	0.1100122	0.0128714	0.1127198	0.000619

Figure 1 Values of Outside Opportunities for Male and Female

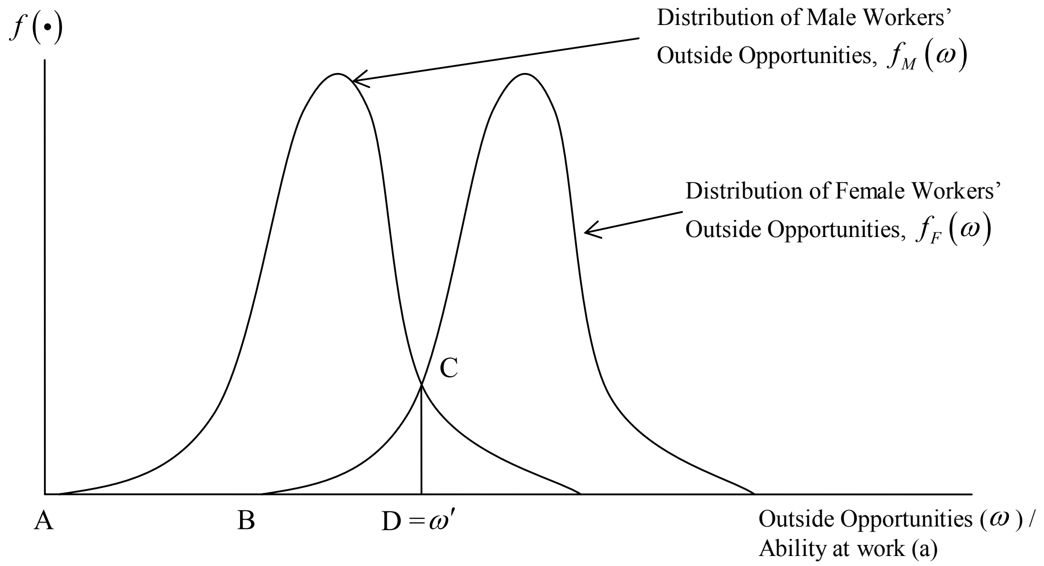

Figure 2 Relationship between v, γ_1, and δ.

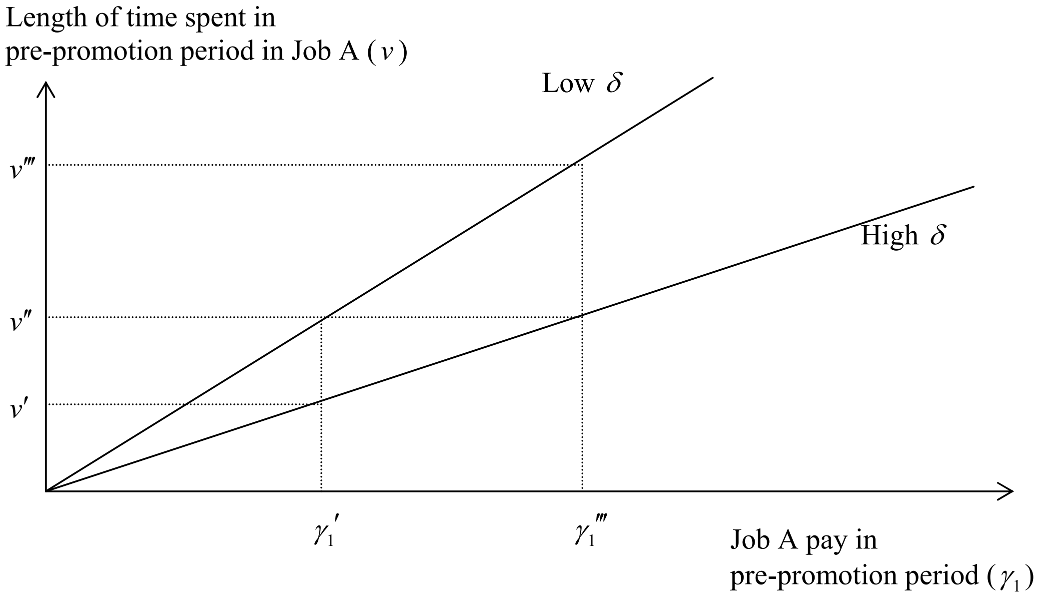

Figure 3 More Dispersed Ability Distribution Among Females

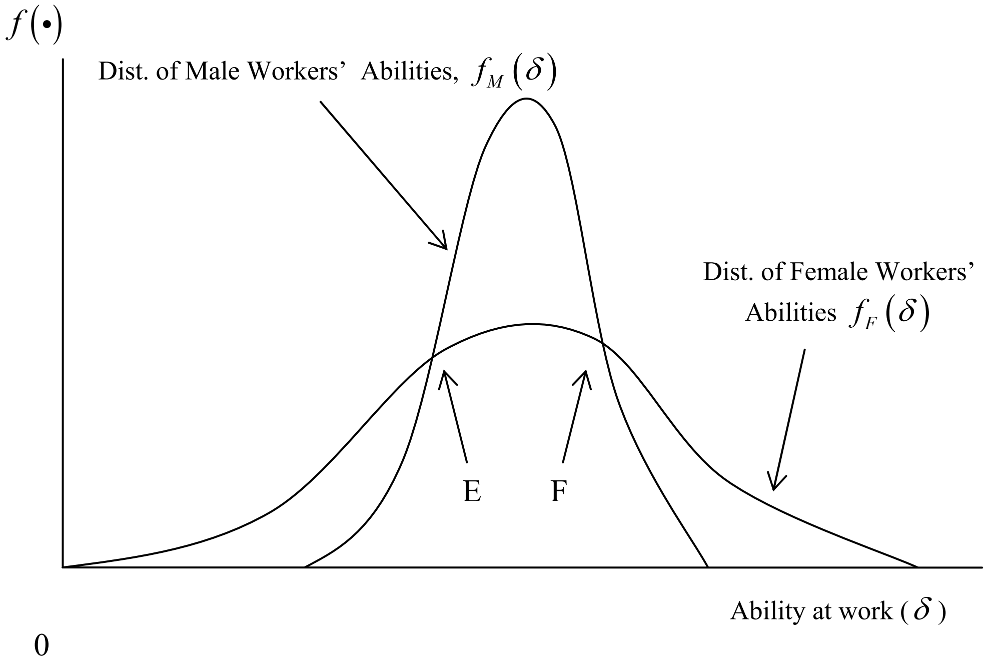

Table A Signs of partial derivatives

	v	γ_1	α
δ^*	$\partial\delta^*/\partial v > 0$	$\partial\delta^*/\partial\gamma_1 > 0$	$\partial\delta^*/\partial\alpha < 0$
v		$\partial v/\partial\gamma_1 > 0$	$\partial v/\partial\alpha < 0$
γ_1			$\partial\gamma_1/\partial\alpha > 0$

Table B Pregnancies for British Women
Aged 16 – 49 for years 1989/1990 to 1996/1997, and aged 16 – 59 for years 1998/1999 to 2001/2002.

Data source: General Household Survey (GHS), 1989 – 2001*.
* Years 1997/1998 and 1999/2000 are unavailable due to the survey method was being reviewed and consequently redeveloped in those two periods.

	All Years	
	Coeff	**SE**
Age	0.766***	(0.042)
Age^2	-0.013***	(0.001)
Child No.	0.328***	(0.088)
$(Child\ No.)^2$	-0.157***	(0.032)
Constant	-13.656***	(0.620)
Obs. Number	59680	
Log Likelihood	-4865.46	
LR Chi-Square (4)	1692.83	
Prob > Chi	0.000	
Mean Age (Years)	40.96	
Pregnancy Rates	1.94%	
Average number of Child per woman	0.59	

Table C Fertility Index of Female Workers by Grade

Grade	Mean Value of FertilityIndex
2	.0985915
3	.1210488
4	.1626903
5	.1708377
6	.1116264
7	.0713229
8	.0331947
9	.0181631
10	.0115626
11	.0040585
12	.0010188

Table D Separation Logit
Dependent variable: Separation from firm

Variables	Coefficients	SE	z	P>|z|
Total absence in the past year (Days)	-0.00394	0.000477	-8.26	0.000
Gender (Male = 1)	0.345418	0.016971	20.35	0.000
Age	-0.04897	0.002905	-16.86	0.000
Age^2	0.001026	3.51E-05	29.26	0.000
Married (Ref group = Single)	-0.08771	0.012763	-6.87	0.000
Divorced (Ref group = Single)	-0.10694	0.028157	-3.8	0.000
Widowed (Ref group = Single)	0.107416	0.080294	1.34	0.181
Number of Child under 12	-2.77884	0.111782	-24.86	0.000
$(\text{Number of Children under 12})^2$	0.472311	0.027946	16.9	0.000
Fertility Index (Derived from GHS)	1.437497	0.063469	22.65	0.000
Tenure	-0.17029	0.00172	-99.03	0.000
$Tenure^2$	0.004563	4.84E-05	94.24	0.000
Disable (1 = Disabled, 0 = Otherwise)	-0.13939	0.01024	-13.61	0.000
Ethnic – White (Ref Group = Unknown)	-0.20507	0.015331	-13.38	0.000
Ethnic – Non-Whites (Ref Group = Unknown)	-0.04365	0.028181	-1.55	0.121
Grade Dummies for Grades 2 to 11, All insignificant	-	-	-	-
Constant	-3.16393	0.066082	-47.88	0.000
Obs. Number	6295080			
Log Likelihood	-260167.09			
LR Chi-Square (25)	22883.50			
Prob > Chi	0.0000			

Table E Linear Regression - Estimation Results for the Nominal Form of L&R 1990 Model (Modified)
Dependent Variable = Performance Rating at Promotion

		[1] Gender (α = Male = 1)			[2] Gender (α = Male = 1), Grade Avg			[3] α = Attachment Index		
Variables	Derivatives	Coeff	SE	Z	Coeff	SE	Z	Coeff	SE	Z
Constant		3.489299	0.040666	85.8	3.380782	0.144986	23.32	4.00798	0.065495	61.2
Time in Grade Prior to Promotion (v)	$\frac{\partial \delta^*}{\partial v} > 0$	0.074557	0.00372	20.04	0.098282	0.018153	5.41	0.013166	0.00376	3.5
Salary in Grade Prior to Promotion (γ_1)	$\frac{\partial \delta^*}{\partial \gamma_1} > 0$	0.120677	0.043191	2.79	0.206182	0.138702	1.49	0.047017	0.070312	0.67
Positive F-Shifter (α, being Male or being attached to current job)	$\frac{\partial \delta^*}{\partial \alpha} < 0$	-0.03352	0.043212	-0.78	-0.31257	0.172374	-1.81	54.82591	6.369615	8.61
$v\ \gamma_1$	$\frac{\partial^2 \delta^*}{\partial v \partial \gamma_1} < 0$	-0.03456	0.003331	-10.38	-0.05158	0.014914	-3.46	-0.00946	0.003606	-2.62
$v\ \alpha$	$\frac{\partial^2 \delta^*}{\partial v \partial \alpha} < 0$	-0.02588	0.001199	-21.59	-0.02318	0.007519	-3.08	-0.59205	0.145208	-4.08
$\gamma_1\ \alpha$	$\frac{\partial^2 \delta^*}{\partial \gamma_1 \partial \alpha} > 0$	0.01476	0.045891	0.32	0.308386	0.166387	1.85	-10.4794	6.947499	-1.51
Number of Obs		52874			2233			52874		
Prob>F		0.0000			0.0000			0.0000		
R-square		0.0617			0.0763			0.0857		

Table F Ordered Logit Regression - Estimation Results for the Nominal Form of L&R 1990 Model (Modified)
Dependent Variable = Performance Rating at Promotion

		[1] Gender (α = Male = 1)			[2] α = Attachment Index		
Variables	Derivatives	Coeff	SE	Z	Coeff	SE	Z
Time in Grade Prior to Promotion (v)	$\frac{\partial \delta^*}{\partial v} > 0$	0.215723	0.011372	18.97	0.036339	0.011072	3.28
Salary in Grade Prior to Promotion (γ_1)	$\frac{\partial \delta^*}{\partial \gamma_1} > 0$	0.346965	0.120263	2.89	0.264715	0.183395	1.44
Positive F-Shifter (α , being Male or being attached to current job)	$\frac{\partial \delta^*}{\partial \alpha} < 0$	-0.09198	0.118906	-0.77	151.2516	15.96928	9.47
$v\ \gamma_1$	$\frac{\partial^2 \delta^*}{\partial v \partial \gamma_1} < 0$	-0.10088	0.01024	-9.85	-0.02973	0.010773	-2.76
$v\ \alpha$	$\frac{\partial^2 \delta^*}{\partial v \partial \alpha} < 0$	-0.07642	0.003504	-21.81	-1.93892	0.512952	-3.78
$\gamma_1\ \alpha$	$\frac{\partial^2 \delta^*}{\partial \gamma_1 \partial \alpha} > 0$	0.058032	0.12606	0.46	-19.183	17.20965	-1.11
_cut1 _cut2 _cut3 _cut4		-6.3428 -4.3485 0.2497 2.6145	0.1818 0.1248 0.1136 0.1143		-7.8694 -5.8735 -1.1663 1.2220	0.2243 0.1795 0.1730 0.1732	
Number of Obs		52874			52874		
Log likelihood		-53312.143			-52588.476		
Wald chi2(6)		2503.03			4461.56		
Prob > chi2		0.000			0.000		
Pseudo R2		0.0302			0.0434		