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Abstract

This paper presents a model of promotion which features two different sources of asymmetric information—disutility of working long hours and on the job training (OJT) ability, or the ability to accumulate human capital on the job via learning by doing. The former is the worker's private information while the latter is the employer's. The firm decides whether or not to reveal its private information on the worker's OJT ability to him/her and how much training it provides to him/her. The worker chooses working hours to signal its commitment to the firm. We show that there always is a separating equilibrium in which the worker's working hours fully reveal his/her commitment level. The firm's optimal feedback policy depends on the nature of the training and learning, and the level of overtime pay. Not revealing private information on the worker's ability could be optimal for the firm under certain circumstances. We argue that two recent changes in the Japanese human resource management system—more selective training and an increasing share of occupations exempt from overtime work payment—may be making information revelation optimal for many firms. We further show that revealing information on the worker's ability tends to be optimal for the firm when many in the workforce have high disutility of working long hours. As such, if the firm can use different feedback policies for men and women, it may reveal its private information on the worker's ability only to women but not to men. If this is the case, there is a testable implication: the incidence of promotion should be more highly correlated with the number of hours worked for women than for men. Using personnel records of a large Japanese manufacturing firm, we find evidence in support of this prediction.

Keywords: Working hours, Promotion, Gender gap, Signaling
JEL classification: J16, J31, M51

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1. Introduction

We develop a new model of promotion within the firm which provides fresh insight on interplay between working hours and the odds of subsequent promotion. Specifically the worker differs in his/her level of disutility of working long hours as well as in his/her ability to accumulate human capital on the job though learning by doing or On-the-Job Training (OJT) ability. The productivity of the worker with a higher OJT ability will grow more rapidly over time. In addition, he/she will become a more productive manager if and when gets promoted, for he/she can acquire a variety of skills and knowledge by experiencing a wide range of jobs more effectively thanks to his/her higher OJT ability (see, for instance, Gibbons and Waldman, 2004; Lazear, 2012, Frederiksen and Kato, 2016). The worker’s cost of working long hours is known to the worker but not to the firm at the beginning of his/her tenure at the firm---the worker’s cost of working long hours is his/her private information. The worker’s OJT ability is initially unknown to both parties when he/she starts working at the firm, yet it is revealed to the employer earlier than the worker himself/herself at a relatively early stage of his/her tenure.

It is highly unlikely that either the firm or the worker knows accurately how well the worker accumulates human capital (in particular firm-specific human capital) on the job before he/she starts actually working at the firm. As he/she starts working and engaging in learning-by-doing, it is reasonable to assume that the firm continues to observe the worker’s progress in his/her accumulation of human capital on the job and collect/keep relevant information (not only formal but also informal) on the worker's OJT ability. At some point the firm will have a sufficient amount of information to discern the worker's OJT ability with precision. We argue that such information is the firm's private information which the worker cannot access unless the firm decides to share it with him/her. The worker himself/herself can probably learn his/her own OJT ability as he/she continues to work. However, having observed many workers and have discerned their OJT abilities in the past as well as understanding deeply what type of human capital is more valuable for the firm, the firm has a clear advantage over the worker in figuring out the worker's OJT ability quickly. Prendergast (1993) have shown that the model with this feature can illustrate how late promotion policy, an important characteristics of the Japanese human resource management system, arises in the equilibrium.

After learning each worker's OJT ability and having observed his/her hours worked in the first period, the employer will then decide which worker will receive a sufficient amount of managerial training. Only those workers who have completed such training can potentially perform managerial tasks effectively and thus get promoted to managers.

Using this model, we illustrate how a "rat race" equilibrium in which a substantial portion of workers work inefficiently long hours could arise. We also examine under what conditions it is optimal for the firm to share its private information on the worker's OJT ability with the worker. The firm's revealing its private information on the worker's OJT ability to the worker (thereafter we call it information revelation) has two effects. First, information revelation affects who get promoted to managerial positions. If training and OJT ability are complementary inputs in the production of promotion, more high-ability workers will get promoted with information revelation, for such workers with high OJT ability who become aware of their high ability through information revelation have a higher incentive to work long hours, knowing that doing so will lead to more training, which in turn further increases their chance of promotion. Without knowing that they have high OJT ability, some workers with relatively high cost of working long hours would give up working hard to receive more training. So, information revelation could improve the ex-post efficiency in having the right kind of workers (or workers with high OJT ability) receive training and get promoted to managerial positions.

Second, information revelation affects the number of hours worked by each worker. In general information on the worker's OJT ability when shared with the worker could raise or lower the average incentive for workers with high cost of working long hours to mimic the low-cost workers. When training and OJT ability are complementary inputs in the production of promotion, information revelation will intensify competition for promotion which leads to more excessive efforts among qualified workers. Here, information sharing aggravates the ex-ante efficiency in terms of how much effort the workers put forth in order to be selected as managers.

There are three factors that affect the trade-offs involving the above sorting and incentive effects. First, the nature of training matters. If the training programs are designed to target high-performers and thus complement worker ability, information revelation of worker ability is likely to motivate high-ability workers to work harder and longer, and thereby receive more managerial training. In contrast, if the training programs mainly target bottom workers to develop uniform skill distribution among workers, thus training and ability are substitutable inputs in the production of promotion, the information revelation policy will discourage high-ability workers from working longer. Second, overtime hourly wage is also important. If overtime pay is zero, the firm will always prefer to maximize working hours whereas, if overtime pay is very high, the firm will try to minimize overtime work hours. Thirdly, the distribution of the disutility of working long hours is an important determinant. When training complements ability, if a majority of workers have high disutility of working long hours, revealing ability information tends to improve the *ex ante* efficiency, for such information sharing significantly reduces the number of hours worked for low-ability workers while having a positive but relatively limited impact on the working hours of high-ability workers due to the complementarity between ability and low disutility of working long hours in the production function . In contrast, if a majority of workers have relatively low costs, revealing ability information is more likely to lower the *ex ante* efficiency by inducing high-ability workers to raise their working hours excessively while reducing working hours of low-ability workers to a limited extent. In this case, concealing information on worker ability to ease the rat-race competition tends to be efficient.

We then consider the implications for gender differences in promotion. Under a plausible assumption that female workers face more demanding obligations at home than male workers, the distribution of commitment (lower disutility of working long hours) for women should be downward skewed. Then, based on the above deliberation, if different promotion policies can be applied to men and women separately, it is quite possible that information sharing is efficient for women but not for men. This gives us a new empirical prediction that the relationship between working hours and promotion rates is stronger for women than for men. For women, only those informed of their high OJT ability tend to work long hours and receive more managerial training. As such, the correlation between working hours and the odds of promotion is quite high. For men, such information is concealed, and the firm treats all workers equally as if they were of equal OJT ability. Since everyone thinks that he has some chance to get promoted, everyone works long hours to signal their low cost. But, in fact, only those with high OJT ability are chosen for managerial training and get promoted to management positions. Therefore, the correlation between working hours and promotion is weaker for men.

After presenting the model, we demonstrate its utility by using the model to provide a coherent interpretation of stylized facts about international differences in the gender gaps in the labor market. Finally we provide rigorous econometric evidence on the key prediction from the model by analyzing unique longitudinal personnel data that we recently obtained from a large Japanese firm. The longitudinal personnel data contains information on both hours worked and job assignment records for all domestic workers who ever worked for the firm's domestic establishments between FY2004 and FY2009.

Our model of promotion within the firm and evidence from an econometric case study contribute to the literature on gender discrimination in the labor market in general and the gender gap in promotion in particular. Relative to the vast literature on the gender pay gap, the literature on the gender gap in promotion is relatively small. Most early works focus on documenting that promotion rates are lower for women than for men with similar observed characteristics (e.g., Cabral, Ferber, and Green 1981, Cannings 1988, Cobb-Clark 2001, Paulin and Mellor 1996, Pekkarinen and Vartianinen, 2004).

Two competing explanations for such "unexplained" gender differences in promotion were proposed. First, there may be unobserved productivity differences or female preferences for different job characteristics (e.g. for less authority or fewer working hours required).[1] Such differences may be caused, for example, by a division of labor in the family—married

[1] The sociological literature emphasizes that the disadvantages associated with being in an occupation dominated by women persistently exists simply because bureaucratization and rationalization institutionalize the disadvantage in formal job description, job ladders, and patterns of pay progression. See Barnett, Baron, and Stuart (2000) for example.

women allocate more effort to child care and housework, and exert less effort on each hour of market work and seek less demanding work (Becker 1985). More recent variants of this line of theorizing include behavioral models of the gender gap in promotion tournament with the gender difference in preferences for competition and risk (e.g., Booth and Nolen, 2012 and Niederle and Vesterlund (2007).

The second explanation attributes the differences to taste-based discrimination or statistical discrimination (Becker 1957, Phelps 1972, Arrow 1973, Lazear and Rosen 1990). Later works extend the statistical discrimination model to focus on more specific aspects of the gender gap in promotion. For instance, Booth, Francesconi, and Frank (2003) focus on the limited outside job opportunities for female managers due to their demanding obligations at home and show that promotion is accompanied by smaller pay raise for women than for men. Most recent works explore the dynamics of the statistical discrimination model and derive somewhat more mixed predictions on the gender gap in promotion (Fryer, 2007 and Bjerk, 2008).

Recent evidence on the gender gap in promotion is rather limited mostly due to the scarcity of the data suitable for testing alternative hypotheses concerning the gender gap in promotion. Blau and DeVaro (2006), using the Multi-City Study of Urban Inequality, find that gender differences in the odds of promotion still remain even after accounting for job performance, occupation, and detailed firm characteristics. Their work reinforces the view that some form of discrimination may be at work behind the gender differences. Similar results are also found by McCue 1996; Cobb-Clark 2001; and Frederiksen and Kato 2016. Most recently Smith, Smith, and Verner (2013) take advantage of detailed and reliable registry data from Denmark and confirm that the significant gender gap in the odds of promotion to top management is still pervasive and that such gender gap cannot be explained fully by a variety of individual and firm characteristics.

As mentioned, the literature on the gender pay gap is immense. We refer to only a few recent contributions to the literature that are of particular relevance to our study. Among other things, a number of researchers started to pay particular attention to the importance of the gender difference in working hours as a major culprit for the persistent gender wage gap. For example, Bertrand, Goldin and Katz (2010) use a panel of MBAs from the University of Chicago find that much of the gender pay gap can be accounted for by career interruptions due to parenting and short working hours. More recently similar evidence on the importance of the gender difference in working hours for the gender pay gap is found for a more general sample of workers (Cha and Weeden, 2013 for the U.S. and Frederisen, Kato, and Smith 2015 for Denmark) and for the population of all employees at a large manufacturing firm in Japan (Kato, Kawaguchi and Owan, 2013). Goldin (2014) also shows that occupations characterized by high returns to overwork are also those with the largest gender gap in earnings. Taking a step forward, Cortes and Pan (2014) have shown that low-skilled immigration leads to a reduction in the gender gap in weekly hours worked, as well as the gender pay gap, particularly in occupations that disproportionately reward longer hours of work.

On our reading of the literature, although there are a plenty of circumstantial evidence, no rigorous attempt has been made to examine the gender difference in working hours as a possible culprit for the gender gap in promotion although we are certainly not the first to suggest the possibility that the gender gap in hours may account for the gender difference in promotion. For instance, Bardsley and Sherstyuk (2006)'s theoretical work considers possible linkage between rat race and glass ceiling in an overlapping generation model of rat race with the agent becoming the principal after promoted successfully in an continuous organization such as law firms in the U.S.. More recently Gicheva (2013), after presenting rigorous evidence on the relationships between working hours and wage growth (and promotion) in general, provide additional insight on the gender gap in pay and promotion in the context of her dynamic labor supply model. In fact, in developing our empirical strategy to yield evidence that is consistent with our model, we draw on her approach.[2]

In the next section we present the model, and demonstrate its utility by deriving

[2] Gicheva (2013) finds that the relationship between hours and wage growth is non-linear—for workers who put in 48 hours per week or more, working 5 extra hours per week increases annual wage growth by 1 percent, but when hours are less than 48, the average effect is zero. She also shows that working five extra hours per week increases the probability of receiving a promotion by more than 2.5%. We will identify similar non-linear relationships between hours and promotion odds. However unlike Gicheva (2013), we study the gender differences in the relationships between hours and promotion odds explicitly and uncover significant gender differences.

numerical examples from the model which will help providing a coherent interpretation of stylized facts about international differences in the gender gaps in the labor market. In section 3, from the model (signaling regime), we derive a prediction concerning the gender difference in the hours-promotion linkage and provide econometric evidence that is consistent with the prediction. Concluding remarks are given in section 4.

2. The Theory

2.1 Set up

There are many firms and workers in a competitive labor market. Firms can enter the market without cost. All workers are employed for two periods. We assume the discount rate to be zero. Workers are different in their commitment level and their ability—learning capability.

A worker's commitment level b determines his/her disutility of working long hours with $b \in B = \{b_1, b_2, b_3, \ldots, b_n\}$ where $b_1 < b_2 <..< b_n$. More precisely, Type-i's utility is given by $w_1 + w_2 - \frac{ch}{b_i}$ where w_t is the wage in period t, c is the cost parameter, and h is the overtime working hours. Let q_i be the probability that $b = b_i$. A worker's ability or learning capability is denoted by $a \in \{a_H,\ a_L\}$ where $a_L < a_H$. The ability affects the probability that he/she gets promoted to a manager $\mu(a, \delta)$ and the speed of learning-by-doing $f(a)$ where

δ is the amount of training provided by the employer. Let p be the share of the workers with ability a_H.

A worker become privately informed about his/her commitment level b_i (or type i) after the worker enters the firm and its distribution $\{q_i\}$ is public knowledge. A worker's OJT ability is initially unknown for all participants (even for the worker himself/herself) but is revealed to the firm soon after the entry but not to the worker. The key assumption in the model is that the firm can share this private information with the worker in order to influence his/her choice of hours of work. We assume that, when private information on the worker's OJT ability is shared with the worker, the employer can verify the accuracy of the information with sufficient persuasive evidence. In other words, although concealing the information is feasible, presenting fabricated information is not allowed. Let $s \in \{R, N\}$ be the information revelation strategy where $s = R$ indicates that the firm truthfully signals a_H or a_L while $s = N$ indicates that the firm sends no signal. We assume that the firm can commit to its information revelation policy.

When workers are employed, workers produce output by working in each period. In the first period, they are assigned to easy jobs and their marginal productivity is constant and independent of their ability and the same across firms. Then, their output depends only on the number of hours worked. We assume workers produce $y_1 = x_1 + mh$, where x_1 is the productivity during regular hours which is constant, $m > 0$ is the marginal productivity of overtime work, and h is the overtime working hours in period 1.

In the second period, the worker gets promoted with the probability $\mu(a, \delta)$ and produces $y_2 = x_2 + 2f(a)h + 2R(b)$ whereas those who do not get promoted (with the probability 1- $\mu(a, \delta)$) produce $y_2 = x_2 + 2f(a)h$. x_2 is again constant. Note that overtime work done by a young worker positively affect the productivity when he/she gets older. So, we assume learning-by-doing here. Their ability is fully revealed to the workers themselves perhaps as a result of training before the production starts in the second period. We assume $f(a_H) > f(a_L)$, $\mu(a_H, \delta) > \mu(a_L, \delta), \mu_\delta > 0, \mu_{\delta\delta} < 0$, and $R(b)$ is increasing in b. Simply said, workers who have high learning capability are more likely to be qualified for managerial jobs (μ is increasing in a) and more committed managers generate more value (R is increasing in b).

Note that the worker's learning ability and his/her overtime working hours in period 1 are complementary in the second-period productivity, which gives the employer an incentive to reveal the worker's ability to the worker himself/herself in period 1. The firm can increase the probability that a worker is qualified for a managerial position by training the worker (*i.e.* $\mu_\delta > 0$) with the cost $\kappa(\delta)$ where $\kappa(\delta)$ is increasing and convex in δ. We argue that workers who receive managerial training experience a wider range of tasks and thus become more capable of identifying the cause of a problem and better coordinating with other workers (for theory and evidence on the importance of job rotation and broadening the scope of human capital for appointments to top management, see Gibbons and Waldman. 2004, Lazear, 2012, and Frederiksen and Kato, 2016)

In our model, the long-term contract is not feasible. When hiring workers, a firm can only offer a first-period base wage w^B. We assume that the regular working hours $\underline{h}$ is determined exogenously by working hour regulations, whereas the overtime hourly wage is also legally determined by w^{OT}= ρ· $w^B/\underline{h}$. Therefore, the first-period wage is given by $w_1 = w^B + w^{OT}h$. Note that the training level δ is not part of the initial contract and we assume that the firm cannot commit to a specific level of δ. Also that, since the workers' commitment type and ability type are unknown for all participants before the firm hires them, it is impossible to screen out the workers through designing the base wage and information revelation policy. Then, in competitive labor market the equilibrium base wage is simply pinned down as to make the expected profit of the firm to be zero.

In the second period, the firm and the worker bargain over wage. Note that at this point, there is no asymmetric information between the firm and the worker. We assume that skills acquired through learning-by-doing and managerial training are firm-specific and those who quit at the beginning of the second period produce x_2 by working for other firms. Assuming the Nash bargaining solution, the second period wage is determined by $w_2 = x_2 + f(a)h + R(b)$ for managers and $w_2 = x_2 + f(a)h$ for regular workers.

As we state earlier, the worker's ability is the employer's private information in the first period. The firm has to decide whether to feedback this ability information to the worker or not. Our key assumption is that the firm can commit to its feedback policy—either information revelation (early selection) or non-information revelation (late selection). We postulate that the reputation mechanism works until some parameter change makes it profitable for the firm to switch. Otherwise, the firm often has an incentive to reveal the information to a high-ability worker and hide it from low-ability one (or vice versa).

The game flow is depicted in Figure 1:

1. Firms offer base wage w^B to workers in the labor market and the workers decide whether to accept it or not. A worker who accepts the contact enters the firm. Firms also decide on their feedback policy (either information revelation or non-information revelation).
2. In the first period:
   (a) each worker recognizes his/her commitment level *b*;
   (b) the firm observes each hired worker's ability to acquire human capital on the job and decides whether to reveal this assessment to the worker or not; and
   (c) after receiving the assessment, the worker chooses hours of work and earns a wage according to the contract.
3. In the second period:

(a) the firm provides each worker with a certain amount of training δ and the size of δ is determined by the firm, based on its assessment of the worker ability and the hours of work in the first period;

(b) workers are promoted with the probability $\mu(a, \delta)$;

(c) the firm and the worker bargain over the wage and hours of work after the worker's ability and commitment type are known to both parties; and

(d) the worker works and the wage is paid out.

Note that the worker does not make any decisions in the second period. The above game of flow is illustrated in Figure 1.

The solution concept we use is the notion of perfect Bayesian equilibrium, which requires the following elements:

(i) the firm's feedback policy s and its strategy in training $\delta^*(a, h)$ maximize the firm's expected profit given the belief function $\lambda(b|a, h, s)$;

(ii) a worker's strategy in choosing working hours $h(s, a, b)$ maximizes the worker's utility; and

(iii) the belief function $\lambda(b|a, h, s)$ is consistent with $h(s, a, b)$; for any i,

$$\lambda(b_i|a, h, s) = \begin{cases} 0 & \text{if } h \notin h(s, a, b_i), \\ \dfrac{q_i}{\sum_{h \in h(s,a,b_j)} q_j} & \text{if } h \in h(s, a, b_i) \end{cases}$$

Note that $h(s, a, b)$ becomes a set when the maximization problem in (ii) has multiple solutions.

As we explain in more details later, perfect Bayesian equilibrium cannot rule out some unreasonable equilibria. We refine the set of equilibria by further imposing D1-Criterion.

2.2 Results

Preliminary

Let $u(a, b, h, \delta)$ be the utility of the worker with ability a and the commitment type b when he/she chooses the hours of work h in the first period and the employer provides the amount of training δ. Then,

$$u(a, b, h, \delta) = w^B + h\left(w^{OT} + f(a) - \frac{c}{b}\right) + x_2 + \mu(a, \delta)R(b) \qquad (1)$$

Our baseline scenario is that nobody wants to work overtime if there is no information asymmetry. The following assumption precisely describes such situation.

Assumption 1: $w^{OT} + f(a) - \frac{c}{b} < 0$ for any a and b

Let $\pi(a, b, h, \delta)$ be the firm profit when the worker's ability and commitment type is (a,b), he/she chooses the hours of work h in the first period and the employer provides the level of training δ. Then,

$$\pi(a, b, h, \delta) = x_1 - w^B + (m + f(a) - w^{OT})h + \mu(a, \delta)R(b_i) - \kappa(\delta) \qquad (2)$$

Note that, if $m + f(a_k) - w^{OT} > 0$, overtime work is profitable. We consider both cases when it is profitable and unprofitable.

We solve the model backward. Since the worker does not make any decisions in the second period, we first solve for the firm's choice of training. If the firm can observe the worker's commitment type b (we later show that a separating equilibrium exist), it solves

$$\delta^*(a,b) = arg\max_{\delta} \mu\,(a,\delta)R(b) - \kappa(\delta)$$

From the concavity assumed, there is a unique solution. Furthermore, there are some comparative statics results as follows:

- When $\mu_{a\delta} > (<)0$, $\frac{\partial \delta^*}{\partial a} = -\frac{\mu_{a\delta}R(b)}{\mu_{\delta\delta}R(b)-\kappa''(\delta)} > (<)0$
- $\frac{\partial \delta^*}{\partial b} = -\frac{\mu_{\delta}R'(b)}{\mu_{\delta\delta}R(b)-\kappa''(\delta)} > 0$ because $R(b)$ is increasing in b.

To simplify our notation, let us redefine $\mu^*(a,b) \equiv \mu(a,\delta^*(a,b))$. Then,

- $\frac{\partial \mu^*}{\partial a} = \mu_a(a,\delta^*) + \mu_\delta \frac{\partial \delta^*}{\partial a} > (<)0$ if $\mu_{a\delta} > (<)0$,
- $\frac{\partial \mu^*}{\partial b} = \mu_\delta \frac{\partial \delta^*}{\partial b} > 0.$
- $\frac{\partial^2 \mu^*}{\partial a \partial b} = \mu_{a\delta} \frac{\partial \delta^*}{\partial b} + \mu_{\delta\delta} \frac{\partial \delta^*}{\partial a} \frac{\partial \delta^*}{\partial b} + \mu_\delta \frac{\partial^2 \delta^*}{\partial a \partial b}$

  $= \frac{(1+\mu_\delta)\mu_{a\delta}R'(b)\kappa''(\delta)}{(\mu_{\delta\delta}R(b)-\kappa''(\delta))^2} > (<)0$ if $\mu_{a\delta} > (<)0$

These analyses show that the sign of $\mu_{a\delta}$ determines the key comparative statics results. We consider both cases, $\mu_{a\delta} > 0$ (Case 1) and $\mu_{a\delta} < 0$ (Case 2). Before solving for the equilibrium, let us discuss the interpretation of the two cases.

First, $\mu_{a\delta} < 0$ is a reasonable assumption for Japan's post-war period of high growth. During the period, coordinating activities across firms and across businesses in growing markets was a primary task for managers rather than devising innovations and formulating strategies. The main focus of managerial training was placed on expanding cross-functional knowledge and developing relations with colleagues and customers. Those who got promoted were not necessarily those who were smartest or those with highest leadership skills. Training had an effect of offsetting ability differences. In other words, in the production function of promotion to management positions, training and ability are two substitutable inputs.

In contrast, the case of $\mu_{a\delta} > 0$ has become a more realistic assumption in recent years. According to our interview with a senior manager of a leading training company in Japan, there has been a trend toward more human resources development budget spent on more selective training programs targeting future leaders and women those aimed at developing strategies and leadership skills and tailored for high-ability workers over the past decade or two. As such, the same training benefits high-ability workers more than low-ability workers. In other words, training and ability are now complementary (rather than substitutable) inputs for promotion.

Working hours in separating equilibria

We next solve for a Perfect Bayesian equilibrium given the firm's feedback policy. In both cases, a separating equilibrium exists in which the commitment type is fully revealed to the employer. We state our first main results in Proposition 1 and 2.

Proposition 1 (information revelation case): *Suppose the firm has revealed the worker's ability to the worker himself/herself. In this subgame, there is a unique Perfect Bayesian equilibrium that satisfies D1 criterion. In this equilibrium, for k = H, L,*

- *types are fully separating,*
- ***e**ach commitment type chooses the minimum working hours that are not mimicked by another. Namely,* $h(R, a_k, b_i) = h_i^k$ *such that,*

$$\left(w^{OT} + f(a_k) - \frac{c}{b_{i-1}}\right) h_i^k + \mu^*(a_k, b_i) R(b_{i-1})$$
$$= \left(w^{OT} + f(a_k) - \frac{c}{b_{i-1}}\right) h_{i-1}^k + \mu^*(a_k, b_{i-1}) R(b_{i-1}) \quad (3)$$

- *the firm forms the belief* $\lambda(b_i|a_k, h, R) = 1$ *if* $h = [h_i^k, h_{i+1}^k)$ *for* $i = 1,2, \dots n-1$ *and* $\lambda(b_n|a_k, h, R) = 1$ *if* $h \geq h_n^k$,
- *and the firm provides training* $\delta^*(a_k, b_i)$ *if* $h = [h_i^k, h_{i+1}^k)$ *for* $i = 1,2, \dots n-1$ *and* $\delta^*(a_k, b_n)$ *if* $h \geq h_n^k$.

By iteration, we obtain

$$h_i^k = \sum_{j=2}^{i} \frac{\Delta_j^k}{A_j^k} R(b_{j-1})$$

where $h_1^K = 0$, $\Delta_j^k \equiv \mu^*(a_k, b_j) - \mu^*(a_k, b_{j-1})$ *is the marginal probability gain from mimicking,* $A_j^k \equiv \frac{c}{b_{j-1}} - w^{OT} - f(a_k) > 0$ *is the net cost of working overtime.*

There is a quite similar result under the non-information revelation policy.

Proposition 2 (non-information revelation case): *Suppose the firm does not reveal the worker's ability to the worker himself/herself. In this subgame, there is a unique Perfect Bayesian equilibrium that satisfies D1 criterion. In this equilibrium, for k = H, L,*

- types are fully separating,
- *the worker with the commitment type b_i chooses the minimum working hours that cannot be mimicked by the worker with b_{i-1} and the working hour is independent of the ability type. Namely, $h(N, a_H, b_i) = h(N, a_L, b_i) = h_i^N$ such that,*

$$\left(w^{OT} + pf(a_L) + (1-p)f(a_H) - \frac{c}{b_{i-1}}\right) h_i^N + \left(p\mu^*(a_L, b_i) + (1-p)\mu^*(a_H, b_i)\right) R\left(b_{j-1}\right)$$
$$= \left(w^{OT} + pf(a_L) + (1-p)f(a_H) - \frac{c}{b_{i-1}}\right) h_{i-1}^N$$
$$+ \left(p\mu^*(a_L, b_{i-1}) + (1-p)\mu^*(a_H, b_{i-1})\right) R\left(b_{j-1}\right) \qquad (4)$$

- *the firm forms the belief $\lambda(b_i|a_k, h, N) = 1$ if $h = [h_i^N, h_{i+1}^N)$ for $i = 1,2, \ldots n-1$ and $\lambda(b_n|a_k, h, N) = 1$ if $h \geq h_n^N$,*
- *and the firm provides training $\delta^*(a_k, b_i)$ if $h = [h_i^N, h_{i+1}^N)$ for $i = 1,2, \ldots n-1$ and $\delta^*(a_k, b_n)$ if $h \geq h_n^N$.*

By iteration, we obtain

$$h_i^N = \sum_{j=2}^{i} \frac{\Delta_j^N}{A_j^N} R\left(b_{j-1}\right)$$

where $h_1^N = 0, \Delta_j^N \equiv p\left(\mu^*\left(a_L, b_j\right) - \mu^*\left(a_L, b_{j-1}\right)\right) + (1-p)\left(\mu^*\left(a_H, b_j\right) - \mu^*\left(a_H, b_{j-1}\right)\right)$ *is the marginal probability gain from mimicking,* $A_j^N \equiv pA_j^L + (1-p)A_j^H = \frac{c}{b_{j-1}} - w^{OT} - pf(a_L) - (1-p)f(a_H) > 0$ *is the net cost of working overtime.*

The proofs are presented in the Appendix.

D1-criterion is necessary to rule out equilibria that are supported by unreasonable beliefs. For example, consider a pooling equilibrium where all types choose $h = 0$. This could constitutes a perfect Bayesian Nash equilibrium with the belief that anybody who deviates from this action has the lowest commitment. However, suppose somebody deviates from this equilibrium strategy (*i.e.* $h = 0$) and work overtime. The type of workers who are most likely to benefit from this deviation is the one who has the highest commitment (i.e. b_n or lowest disutility). If the employer believes that only those with b_n deviate, they are better off by deviating than in the equilibrium if the overtime work hours are not excessively high. Hence, the above pooling equilibrium does not survive D1-criterion.

How D1 criterion works can be illustrated by Figure 2. Consider three commitment types b_1, b_2, and b_3, and suppose that their equilibrium strategies are to choose $h_1^k, h_2^k,$ and h_3^k, respectively. The indifference curves for each type are drawn in the chart. Note that the slopes of the indifference curves are decreasing in the worker's commitment type because, from equations (3) and (4), $\frac{d\delta}{dh} = \frac{\frac{c}{b_i} - w^{OT} - f(a_k)}{\frac{\partial\mu}{\partial\delta}R(b_i)}$, which is decreasing in b_i. Suppose a worker whose commitment type is unknown for the employer has worked *x* hours where $h_2^k < x < h_3^k$. Which type of workers are more likely to deviate from their equilibrium strategy and choose *x*? Note that the commitment type *i* will deviate if the firm's resultant choice of training exceeds P_i, which is the point on type *i*'s indifference curve corresponding to the hours worked *x*. Namely, the commitment type *i* is indifference between $\delta^*(a, b_i)$ and P_i. As the figure shows, if some types find it beneficial to deviate to working *x* hours, it must be type 2 because $P_2 < P_3 < P_1$. This means that the commitment type 2 is most likely to deviate. If deviation comes only from the commitment type 2, the firm will offer the original level of training $\delta^*(a, b_2)$. Since $\delta^*(a, b_2) < P_2$, this deviation by type 2 does give the worker a higher payoff than their equilibrium payoff, which means that the equilibrium in Proposition 1 and 2 survive D1-criterion.

Next, we characterize the working hours in the equilibrium.

Lemma 1 When Assumption 1 holds, $h_i^L < h_i^N < h_i^H$ for any i in case 1 (i.e. $\mu_{a\delta} > 0$) and $h_i^H < h_i^N < h_i^L$ for any i if $f(a_H) - f(a_L)$ is small enough in case 2 (i.e. $\mu_{a\delta} < 0$).

Proof: We first show $\frac{\Delta_j^L}{A_j^L} - \frac{\Delta_j^H}{A_j^H} < 0$ for any j in case 1.

- $A_j^L > A_j^H$ from the assumption $f(a_L) < f(a_H)$.
- $\Delta_j^L < \Delta_j^H$ if $\frac{\partial^2 \mu^*}{\partial a \partial b} > 0$ (case 1). Then, $\frac{\Delta_j^L}{A_j^L} - \frac{\Delta_j^H}{A_j^H} < 0$. Thus,

$$h_i^L - h_i^N = \sum_{j=2}^{i} \left[\frac{\Delta_j^L}{A_j^L} - \frac{\Delta_j^N}{A_j^N} \right] R(b_{j-1}) = (1-p) \sum_{j=2}^{i} \frac{A_j^H}{A_j^N} \left[\frac{\Delta_j^L}{A_j^L} - \frac{\Delta_j^H}{A_j^H} \right] R(b_{j-1}) < 0$$

$$h_i^H - h_i^N = \sum_{j=2}^{i} \left[\frac{\Delta_j^H}{A_j^H} - \frac{\Delta_j^N}{A_j^N} \right] \Delta_R(b_{j-1}) = p \sum_{j=2}^{i} \frac{A_j^L}{A_j^N} \left[\frac{\Delta_j^H}{A_j^H} - \frac{\Delta_j^L}{A_j^L} \right] R(b_{j-1}) > 0$$

Similarly, in case 2, when $f(a_H) - f(a_L)$ is small enough, $\frac{\Delta_j^L}{A_j^L} - \frac{\Delta_j^H}{A_j^H} > 0$. This concludes the proof. Q.E.D.

Lemma 1 implies that more capable workers, if they are told so, work longer when the training is more selective while less capable workers, if they are told so, work longer when the training is more leveling. In case when the workers are not informed of their ability, the hours of work are chosen between the levels for the high-ability workers and the low-ability ones when the worker ability is revealed. The next proposition compared the average working hours between the information revelation and non-information revelation policies.

Proposition 3: Under Assumption 1, $p\sum_{i=1}^{n} q_i\, h_i^L + (1-p)\sum_{i=1}^{n} q_i\, h_i^H > \sum_{i=1}^{n} q_i\, h_i^N$ holds in case 1. In case 2, on the other hand, $p\sum_{i=1}^{n} q_i\, h_i^L + (1-p)\sum_{i=1}^{n} q_i\, h_i^H < \sum_{i=1}^{n} q_i\, h_i^N$ if $f(a_H) - f(a_L)$ is small enough.

Proof: In case 1, since $A_j^H - A_j^L = f(a_L) - f(a_H) < 0$ and $\frac{\Delta_j^L}{A_j^L} - \frac{\Delta_j^H}{A_j^H} < 0$ for any j,

$$ph_j^L + (1-p)h_j^H - h_j^N = p(1-p)\sum_{j=2}^{i} \frac{A_j^H - A_j^L}{A_j^N}\left[\frac{\Delta_j^L}{A_j^L} - \frac{\Delta_j^H}{A_j^H}\right] R(b_{j-1}) > 0$$

Therefore, $p\sum_{i=1}^{n} q_i\, h_i^L + (1-p)\sum_{i=1}^{n} q_i\, h_i^H > \sum_{i=1}^{n} q_i\, h_i^N$. The proof is similar for case 2.

Q.E.D.

This result comes from the complementarity among the ability, training, commitment, and working hours. When information on worker ability is revealed, knowing that a greater amount of training is provided, more capable workers work longer to signal their commitment so that the firm further increases the amount of training securing the opportunity of promotion. Less capable workers work less but the average working hours are still higher than when the ability information is not revealed. The result changes when $\mu_{a\delta} < 0$ under which ability and training are substitute in producing promotion. Although the worker still has an incentive to work longer to signal their commitment, this signaling has a lower return for capable workers. Therefore, the average working hours are shorter when the ability information is revealed.

Optimal Feedback Policy

Finally, we examine the optimal feedback policy for the firm. Let $\pi^s(b_i)$ be the expected equilibrium profit of the firm when the firm employs type-b_i worker under information revelation policy *s*. Comparing $\pi^R(b_i)$ with $\pi^N(b_i)$, we get

$$\pi^R(b_i) - \pi^N(b_i) = p(m + f(a_L) - w^{OT})(h_i^L - h_i^N) + (1-p)(m + f(a_H) - w^{OT})(h_i^H - h_i^N)$$

$$= p(1-p)(f(a_H) - f(a_L)) \times \sum_{j=2}^{i} \frac{2w^{OT} - m - \frac{c}{b_{j-1}}}{\frac{c}{b_{j-1}} - w^{OT} - pf(a_L) - (1-p)f(a_H)} \left[\frac{\Delta_j^L}{A_j^L} - \frac{\Delta_j^H}{A_j^H}\right] R(b_{j-1})$$

The following proposition is straightforward from this equation.

Proposition 4: $\sum_i q_i \pi^R(b_i) < \sum_i q_i \pi^N(b_i)$ if $2w^{OT} - m - \frac{c}{b_i} > 0$ for any i, in case 1; or if $2w^{OT} - m - \frac{c}{b_{i-1}} < 0$ for any i and $f(a_H) - f(a_L)$ is small enough, in case 2.

Note that $2w^{OT} - m - \frac{c}{b_i} > 0$, the condition in the first case does not necessarily violate Assumption 1 ($w^{OT} + f(a) - \frac{c}{b} < 0$ for any a and b), which requires the overtime hourly wage not to be too high, if both the first-period marginal productivity and the learning-by-doing effect are sufficiently low.

Our results are summarized in Table 1. Note that there are two cases in which non-information revelation is the optimal feedback policy for the firm. First, it is so when: (1) the training program is equal and inclusive focusing more on leveling individual performance differences, resulting in offsetting ability differences (*i.e.* $\mu_{a\delta} < 0$); (2) learning by doing is not drastically different between more capable and less capable workers (*i.e.* $f(a_H) - f(a_L)$ is small); and (3) the overtime hourly wage w^{OT} is sufficiently low. Another case is when: (1) the training program is selective focusing more on developing capable leaders (*i.e.* $\mu_{a\delta} > 0$); and (2) the overtime hourly wage w^{OT} is sufficiently high. In all other quadrants, revealing the worker ability is optimal. As we have argued earlier, during the post-war period of high growth, training opportunities were offered equally to all employees and helped to improve the standard and to level performance differences. Furthermore, many workers voluntarily worked without overtime pay because such efforts were rewarded by promotion. According to our model, non-information revelation was presumably optimal in those days.

In recent years, we believe that there have been two major changes. First, our interview with a senior manager at a leading training company and our casual conversations with Japanese HR managers reveal that Japanese firms are reducing the budget for periodical cohort training programs and increasing more selective training programs designed to make high-performers more productive. If our interpretation is correct, we now have $\mu_{a\delta} > 0$. Second, overtime regulations are being more strictly enforced and fewer non-managerial workers are willing to work voluntarily without overtime pay because of limited promotion opportunities. According to Table 1, these changes may still imply that non-information revelation is optimal.

There is another view, however. Overtime pay is not calculated for an expanding set of workers: (1) discretionary working hour system which target professionals; and (2) deemed overtime pay system under which fixed overtime pay is paid out to those whose working hours are hard to monitor such as sales people. White-collar exemption is also being considered to exempt high-income white-collar workers from overtime pay regulations. If so, at least for those whose marginal pay for overtime work is very low, information revelation may be optimal lately.

Efficiency

Note that, if there is no asymmetric information, the working hours should be minimal $h(a, b_i, s) = \underline{h}$ for all i. Then, the efficient level of training is obtained by solving

$$\max_{\delta} 2\mu\,(a, \delta)R(b) - \kappa(\delta).$$

Given the information asymmetry, the second best can be achieved by a long-term contract. The efficient information revelation policy minimize the total cost of working hours $c \sum_{i=1}^{n} q_i \frac{h_i}{b_i}$ with the incentive compatibility constraints for each type. The employer should solve $\delta^*(a, b) = arg\max_{\delta} 2\mu\,(a, \delta)R(b) - \kappa(\delta)$. Without long-term contracts feasible, the total cost of working hours won't be minimized.

Heterogeneity among work groups

In the rest of the discussion, we assume $\mu_{a\delta} > 0$ because we believe that the inequality best describes the current situation of human resource development policy among Japanese firms. With this condition, revealing the firm's private information on the worker's ability to himself/herself encourages high-ability workers work longer but low-ability workers work shorter.

Proposition 4 implies that $\pi^R(b_i) > \pi^N(b_i)$ is more likely for low commitment types whereas $\pi^R(b_i) < \pi^N(b_i)$ is more likely for high commitment types. We illustrate this comparison in Figure 3. Therefore, if low-commitment (high-commitment) types have a high share of the total population, information revelation (non-information revelation) is optimal.

Suppose it is feasible to employ different information revelation policies for demographically clearly distinct groups: men and women. The pattern we observe in the gender division of household labor in Japan appears to suggest that the distribution of the cost of working long hours is quite different between men and women. Fuwa (2006) reports that among 22 industrialized nations Japanese husbands share housework with their wives the least, and argues and provide evidence that gender ideology plays a significant role in explaining cross-national variations in gender division of household labor. It is plausible that male workers in Japan are more likely to enjoy greatly reduced cost of long working hours due to social norm that favors the division of household labor that assigns more tasks to women. The other side of the coin is that female workers in Japan are more likely to face greatly elevated cost of long working hours due to the same social norm. As such, it is probably safe to assume that work hour flexibility (i.e. parameter *b*) has larger density for higher values with men whereas it has larger density for lower values with women—Japan is subject to great inequality in the cost of working long hours between men and women.[3] In sum, low-commitment types with higher cost of working long hours are likely to have a higher share among women than among men in Japan.

It follows that adopting non-information revelation policy for women is likely to be suboptimal because there are more "low commitment" types among women than among men. If firms can adopt different information revelation policies for men and women, they might adopt information revelation policy for women while choosing non-information revelation for men. This is especially likely in the current policy situation where the Abe administration is pressing the industry to increase the number of female managers. Then, we would observe distinctly different promotion patterns between male and female workers. Figure 4 illustrates such a likely pattern. If women are informed of their ability, more capable women work longer hours, knowing that the return to doing so is higher than otherwise while less able women work shorter hours, knowing that their chance of promotion is lower than otherwise (thus any voluntary overtime work is likely to be a waste of time). There will be a substantial difference in the promotion rate between the two groups. In contrast, there will be little dichotomy between high- and low-ability men since there is no information revelation for

[3] For stylized facts about the status of Japanese women in the labor market in international perspective, see Steinberg and Nakane, 2012

men, and men decide on their working hours without knowing their ability types. To the extent to which commitment types and ability types are uncorrelated, the slope of the hours-promotion profile should be flatter.

The discussion so far generates the following testable implication.

Hypothesis: The incidence of promotion should be more highly correlated with hours of work for women than for men.

3. Evidence from an Econometric Case Study of a Large Japanese Firm

We provide evidence from our econometric case study of a Japanese manufacturing firm in support of this hypothesis—the relationship between working hours and promotion rates is stronger for women than for men.

Specifically we use longitudinal personnel records from a large Japanese manufacturing company, which employs about 6,000 regular employees within Japan, including affiliated firms, 10,000 employees domestically, and well over 20,000 employees worldwide.[4] We are granted access to detailed personnel records between FY2004 and FY2009 on all domestic employees directly employed by the firm. It is one of the first firms which participated in our IAG (Industry-Academia-Government) personnel data repository project.[5]

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[4] Our confidentiality agreement with the firm prohibits us from revealing the name of the firm as well as further details on their product lines

[5] Our partner, Works Applications, Co. is a major ERP software package provider in Japan with approximately 300 listed firms in their user network. The Research Institute of Economy, Trade and Industry (RIETI), a think tank established by the Ministry of Economy, Trade, and Industry for

Important employee characteristics available in the dataset include gender, date of birth, date of hire, nationality, education, and marital status among others.

Although data are available from FY2004 in general, our analysis in this paper needs to be restricted to the period between FY2005 and FY2009 since working hour information is available only after FY2004. Employee performance was evaluated annually using a seven-point scale (SS, S, A1, A2, A3, B, and C).

A major advantage of our dataset over many data used in the literature is the availability of the accurate job assignment history data that allow us to define promotion with precision, which is our key dependent variable. In addition, the job assignment data enable us to find who takes a parental leave and when, and most importantly when he/she returns from his/he parental leave.

We first describe employee composition by gender and marital status. Since pregnant women are entitled to maternity leave of fourteen weeks (eight weeks immediately after delivery is mandatory) and we have the precise records of maternity leave since FY1999, we can utilize the incidence of maternity leave as an indicator of having small children. Table 2 shows the composition of single/married men and women, and married women who took at

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policy-oriented research provided us with technical resources to store the data in a secure environment. In this project, almost all personnel records stored in the firm's human resource management system were deposited into RIETI's high-security server (with the exception of sensitive identity information such as names and addresses). Researchers analyze the data remotely using RIETI's virtual private network.

least one maternity leave since FY1999.[6] As Table 2 shows, the share of female employees hovered around 11% during the period under observation, which is lower than the 16-18% average of large manufacturing firms with 1,000 employees or more according to Basic Survey on Wage Structure from the Ministry of Health, Labour and Welfare. As in the case of most large Japanese firms in manufacturing, overall separation rates at the firm are low, and we did not find much significant correlation between separation rates and individual worker characteristics.

Table 3 shows the raw (unadjusted for observable individual characteristics) gender pay gap. Compared to married men, single men, single women, married women without small children, and married women with small children earn 28%, 36%, 32%, and 43% less, respectively.[7] Since married men are 5-10 years older than the other groups on average, a substantial portion of the gaps may come from differences in the amount of human capital accumulated through working in the firm. Furthermore, women, especially those who are married and have small children, work substantially fewer hours than men. Single women, married women without small children, and married women with small children work 7%, 12%, and 22% fewer hours, respectively, than married men, while single men do not work

[6] We include a very small number of single women with small children in this category, for they will be subject to at least the same level of motherhood/ immobility penalty as married women with small children. In principle if a woman with small children is entering the firm, our definition of married women with small children will fail to count her unless she has another childbirth after entering the firm and hence take a mandatory maternity leave. Based on our interviews with the firm's HR managers, we are reasonably confident that our definition of married women with small children will capture most if not all of married women with small children at the firm.

[7] There is a companion paper which analyzes the same data and studies the nature and scope of the gender pay gap of the firm (Kato, Kawaguchi, and Owan, 2013)

significantly different hours than married men. Since we excluded records in the years when employees took at least one month of leave, low numbers for women with small children are not the result of parental leave. One relevant company policy that contributed to the observed difference is that women with children less than three years old can reduce their work hours to 6 hours per day. The provision of this policy or an equivalent substitute is required by the 2002 Amendment to the 1992 Child Care and Family Care Leave Act.[8]

Table 4 shows the changes in the distribution of education levels by gender over the past two decades. Due to a major shift in this firm's hiring policy in the 1990s, the gender gap in educational background has narrowed substantially since then. In the 1990s, the share of college graduates (including those with graduate degrees but excluding those with 2-year college degrees) was 43% for men and 18% for women. In the 2000s, this gender gap reversed with the share becoming 52% for men and 59% for women.[9] As the firm slashed administrative assistant jobs, it stopped hiring women with 2-year college degrees or less. Instead, it recruited more women with 4-year college degrees, master's degrees, and more women from vocational schools.[10] Almost all men with high school diplomas are hired as production workers, and they are not expected to decline in number as drastically as women

[8] See Asai (2013) for the efficacy of parental policy reforms in Japan.

[9] See Abe (2010) for Japan's increasing female enrollment in college and a rise in the recruitment of college-educated women by large firms following the enactment of Equal Employment Opportunity Act (EEOA) in 1986.

[10] The company also beefed up its hiring of medical technicians from medical vocational schools as it expanded its line of healthcare products.

with similar educational background, unless the company decides to shut down many of its domestic plants.

The higher education level of women should naturally lead to an increase of women in upper-level jobs in the hierarchy. The firm has a job grade system where each job is assigned a specific job grade level based on an evaluation of the job content value. Each job grade level corresponds to a particular pay range, according to which monthly salary is set (100 percent for managers and 50% for non-managers). Therefore, moving up to a higher job grade level is associated with a discrete pay raise, and as such is announced and more importantly recorded as a promotion.

Figure 5 illustrates the promotion ladders observed in the company. Solid lines indicate typical paths for those who get promoted and dotted lines represent atypical but not unusual cases of promotion. College graduates on the management track are first assigned to J1 but quickly move up to J2. Almost all members of this group move to SA and SB, and the majority eventually move to the management ranks of G6 and up. Production workers start at the same level (J1) but more slowly climb to J2 and J3. Some highly talented blue-collar workers may be considered for managerial positions and they will be typically assigned to J4. Some of them may move up to the management track (e.g. SA, SB or G6) or get promoted to level JH, which is the level of foremen. Administrative support staff members who typically have high-school or two-year college degrees can move up to J2 and J3 levels, but it is extremely rare for them to get promoted to managerial positions.

Table 5 shows the distribution of the workforce across job grade levels, gender and marital status in FY2004 and FY2009. Since our dataset does not include employees who left the firm before FY2004, the precise employee composition can only be calculated for the period between FY2004 and FY2009. Although a higher percentage of women are observed in higher level positions in FY2009 than in FY2004, there are still far fewer women in upper-level positions. For example, as of FY2009, only 3.4% of managers are filled by women. Among senior managers, only 19 (1.6%) are women. None of the women with small children are managers. Given that 11% of its workforce are women, this share of women in managerial positions is disproportionately low.

We first examine how the odds of promotion differ between men and women. Table 6 shows the frequency of promotion by gender and marital status. We compress the original 11 job grade levels (J1 to G3) to 8 levels in order to study the white-collar track and blue-collar track on a comparable scale. In this table, promotions from J2 to J3 for production workers and administrative assistants are not counted as promotions because these two job grades are combined as one job level in our analysis. High odds of promotion at the entry level J1 are not surprising because the company has a policy of assigning new college graduates to J1 and quickly move them all up to J2 after one year. Low odds of promotion from the J2/J3 level to the SA/J4 level are not surprising, either, for many production workers and administrative support staff members with high school and 2-year college degrees are stuck at the J2/J3 level with no further promotions. Although talented production workers still have prospects of getting promoted to foremen or plant management positions, such a career track is very limited for female administrative assistants, who, as a result, show very low promotion rates at this level.

Although women have a higher promotion rate at the SA/J4 level than men, this advantage disappears once women reach the SB/JH level, and they continue to lag behind men. For example, although 17% of men at grade G5 get promoted to G4 every year on average, only 8% of women at the same grade get promoted in a similar manner. Since three quarters of women at G5 grade are married, this slow promotion of women may be associated with a constraint on work hours or lack of geographic mobility.

Since there is a rather well-defined and well-established promotion ladder at the firm, we can estimate a logit model of promotion, conditional on the current job level as a function of a number of explanatory variables---a major advantage of an econometric case study as opposed to conventional econometric studies with data gathered from a variety of firms with less precise definitions of promotions. Table 7 reports the logit estimates of the most parsimonious specification with female, age, tenure, and education, and year effects for the full sample as well as for the subsample of college graduates. For the full sample, we find evidence for gender gap in promotion, i.e., the estimated coefficient on Female is negative and statistically significant at the 5 percent level. Note that for the college graduate sample the estimated coefficient on Female is found to be still negative yet not statistically significant.

Table 8 presents a less parsimonious model with additional explanatory variables—maternity experience, lagged hours worked, lagged reduced hours, lagged night hours as well as evaluations. To test whether the effect on promotion of lagged hours worked differ significantly between women and men, we also consider an interaction term involving lagged hours worked and Female (since reduced hours are used almost exclusively by women and night hours by men, they are not interacted with Female). Multiple maternity leaves indicator is not included due to the rarity of promoted women with such multiple maternity leave spells.

We find consistently for all specifications that hours worked in the previous year are positively associated with the odds of promotion. Most important (for the objective of the paper) is that such positive associations between hours worked and promotion are also found (consistently for all specifications) to be significantly stronger for women than for men, supporting our testable hypothesis developed in the previous section.

Using the U.S. National Longitudinal Survey of Youth, Gicheva (2013) finds that the relationship between hours worked and wage growth is non-linear—only workers who put forth more hours than a certain threshold see the positive impact of working additional hours. It is plausible that the relationship between hours worked and the odds of promotion may be also non-linear in our case. To investigate such possible non-linearity, we re-estimate the model, transforming Hours (continuous variable) to a categorical variable Hours Range which takes a value of 1 if hours worked is less than 1800 hours per year; 2 if it is 1800 or more but less than 1900, 3 if it is 1900 or more but less than 2000, 4 if it is 2000 or more but less than 2100, 5 if it is 2100 or more but less than 2200, 6 if it is 2200 or more but less than 2400, and 7 if it is 2400 hours or more.

We calculate the predicted odds of promotion for each categorical value of Hours Range evaluated at means for all other explanatory variables for women and men separately, and plot such predicted promotion odds in Figure 5. As expected, the hours-promotion profiles for all employees as well as for college graduates are indeed steeper for women than for men.

For women, the benefit of working extra hours in the previous year for the worker's promotion prospect is particularly large when hours worked exceed 2200 hours per year.

Note that Figure 5 appears to suggest that the odds of promotion are generally higher for women than for men. However, this is mostly due to the fact that Figure 5 is drawn using mean values calculated separately for women and men. Since women's promotion is more concentrated in lower job levels than men's promotion and the odds of promotion are higher in such lower job levels, women's predicted promotion odds are artificially higher than men's promotion odds. When we use an alternative Marginal Effects at the Means (MEM) approach (or using mean values calculated for all employees including both women and men), reassuringly women's predicted promotion odds appear lower than men's predicted promotion odds.

However, the observed stark difference between men and women in the association between hours and the subsequent promotion rates which support our hypothesis derived from the theory may be simply reflecting job segregation. Many scholars including Blau and Kahn (2000) and Goldin (2014) have reported that women were concentrated in low-paying jobs such as administrative support and service occupations.[11] Some college-educated women may be assigned to jobs with little training and promotion prospects while others join college-educated men for management trainee jobs. If women in the former group have no reasonable promotion prospects, they will not work long hours. Combining members from the two groups may result in a high correlation between the odds of promotion and hours worked.

To rule out this alternative interpretation of job segregation by gender, we further estimate the model with organizational unit fixed effects. In our case firm, a typical organization unit is a section of 3-9 people for white-collar workers and a group of people

[11] Historically in Japan, women were typically assigned to administrative support and clerical jobs called *ippan-shoku* (general job), while college educated men were assigned to management trainee positions called *sogo-shoku* (composite job). Although such differentiation was prohibited by the EEOA, a similar pattern of task assignment may still remain.

working on the same production line or support function (up to 90) for blue-collar workers. The organizational unit fixed effects can account for the gender gaps in promotion caused by such job segregation within the firm, to the extent to which good jobs and bad jobs are separated into different organizational units.

As an efficient way to control for such organizational unit fixed effects in the logit framework, we employ a fixed effects logit model in which organizational unit fixed effects are accounted for by the number of promotion within each unit. Reassuringly the results change little when we use such a fixed effects logit model instead of a standard logit model.[12] The observed high correlation between the odds of promotion and hours worked among women does not appear to be driven by job segregation by gender within the firm.

4. Conclusions

This paper has presented a new model of promotion within the firm which sheds new light on interplay between working hours and the odds of subsequent promotion. The key feature of our model is two different sources of asymmetric information—disutility from working long hours and OJT ability (ability to accumulate valuable human capital on the job through learning by doing). The level of the employee's disutility from working long hours is known to the worker but not to the firm at the beginning of his/her tenure at the firm---the

[12] These results as well as all other unreported results are available upon request from the corresponding author.

level of the employee's disutility from working long hours is his/her private information. The worker's OJT ability is initially unknown to both parties when he/she starts working at the firm, yet it is revealed to the employer earlier than the worker himself/herself at a relatively early stage of his/her tenure. Long hours signal the worker's commitment or low disutility from doing so, which determines the surplus produced when the worker is promoted. Thus, the firm provides the worker with managerial training only after observing the worker's hours worked. The firm's decision to provide training also depends on its private information about the worker's OJT ability, which also affects the second period productivity when the worker gets promoted. Upon completion of training, the firm then promotes the worker.

Key to our result is the firm's decision to reveal or conceal its private information on the worker's OJT ability. Assuming that training and ability are complementary inputs in the production of promotion, on the one hand, information revelation motivates the worker to work long hours if he/she has high OJT ability, for the marginal return to signal his/her commitment becomes greater. On the other hand, those who do not receive positive feedback (or deemed lacking high OJT ability) will be discouraged and choose shorter working hours. In contrast, concealing its private information on the worker's OJT ability helps to retain the minimal incentive, and those with low level of disutility from working long hours will work long hours regardless of their OJT ability.

The firm's optimal choice of information revelation policy crucially depends on three factors. First, the nature of training matters. If the training programs are designed to target high-performers and thus complement worker ability in raising the odds of promotion, information revelation of worker ability motivates workers to work longer. In contrast, if the training programs mainly target the left tail of the ability distribution of workers, aimed at developing uniform skill distribution among workers, training and ability will be substitutable inputs in raising the odds of promotion. It follows that information revelation will discourage workers from working longer.

Second, overtime hourly pay determines both the signaling cost for the worker and the marginal return to information revelation for the firm. If overtime pay is zero, the firm will always want to maximize working hours and signaling becomes more effective for the worker. In contrast, if overtime pay is very high, the firm will try to minimize overtime work hours and the incentive to mimic the higher commitment type becomes greater for the worker.

Thirdly, the distribution of the disutility of working long hours also significantly affect the marginal return to information revelation. Assuming that training complements ability in raising the odds of promotion, if a majority of workers have high disutility of working long hours, information revelation tends to be optimal because it reduces the number of hours worked for low-ability workers while having a positive but relatively limited impact on the number of hours worked of high-ability workers. In contrast, if a majority of workers have relatively low costs, concealing information to ease the rat-race competition tends to be efficient because the complementarity between ability and commitment causes excessively long working hours. Since the late selection (non-information revelation) is more profitable for the firm when a majority of its employees have low cost of working long hours, unequal gender division of household labor and low labor participation of female workers in Japan must have encouraged the adoption of non-information revelation policy in the country. This also means that a recent increase in the number of college-graduate female workers in full-time positions may make the early selection or information revelation efficient. It might also be possible that firms adopt different information revelation policies between men and women. Such a difference in the firm's treatment of men and women, if exists, will potentially lead to a different pattern in the relationship between working hours and promotion for men and women.

Using this model, we have demonstrated that, under a reasonable set of conditions, the correlation between working hours and subsequent promotion will be stronger for women than for men. Our analysis of longitudinal personnel data from a large Japanese manufacturing firm has yielded rigorous econometric evidence that is consistent with this prediction—we have found significantly stronger relationship between hours and promotion rates for women than for men.

Appendix

We will provide the proof of proposition 1. Preparing for the proof, we introduce some notations and provide useful lemmas.

Fix the worker's type k. Consider the set of working hour $H = \{h_1, \ldots, h_m\}$ such that $h_1 < h_2 < \ldots < h_m$ which are chosen by ability-a_k worker in an equilibrium with strictly positive probability and the amount of training $\delta^k(h)$ that the firm provides to the worker who choses $h \in H$. For $h, h' \in H$, it have to be satisfied that if $h' < h$ then $\delta^k(h') < \delta^k(h)$ (otherwise no one chooses h).

We say an equilibrium is a partition equilibrium if both type-b' and type-b'' worker choose the same working hour h and $b'' > b'$ then any type-b worker such that $b' < b < b''$ also chooses h. The following lemma says any equilibrium is either completely separating equilibrium or partition equilibrium.

Lemma A1. Any pooling equilibrium is the partition equilibrium.

proof. Consider equilibrium working hours h, h' and h'' such as $h' < h < h''$. Because $\frac{\partial^2 u}{\partial \delta \partial b} > 0$ and $\frac{\partial^2 u}{\partial h \partial b} > 0$, if type-$b'$ prefers $(h, \delta^k(h))$ to $(h', \delta^k(h'))$, for $b > b'$ type-b also prefer $(h, \delta^k(h))$ to $(h', \delta^k(h'))$. Also that, if type-b'' prefers $(h, \delta^k(h))$ to $(h'', \delta^k(h''))$, for $b < b''$ type-b also prefer $(h, \delta^k(h))$ to $(h'', \delta^k(h''))$. Thus, if type-b' and type-b'' choose h, type-b chooses h. □

Consider an off-path working hour h_d. Let x_i be the equilibrium working hour which type-b_i worker chooses. Because $\frac{\partial u}{\partial \delta} > 0$ and $\frac{\partial u}{\partial h} < 0$, there exist an unique training $\delta_i^{id}(h_d)$ such that type-b_i worker is indifferent between his/her equilibrium outcome $(x_i, \delta(x_i))$ and $(h_d, \delta_i^{id}(h_d))$. The following lemma is useful in applying D1 criterion.

Lemma A2. (i) For $h < h_d < h'$, $\delta_i^{id}(h_d) < \delta_j^{id}(h_d)$ for $i, j \in (l|x(l) \le h)$ and $i > j$, and $\delta_j^{id}(h_d) < \delta_i^{id}(h_d)$ for $i, j \in (l|x(l) \ge h')$ and $i > j$, (ii) for $h_d < h_1$, $\delta_1^{id}(h_d) < \delta_i^{id}(h_d)$ for any $i \ne 1$, and (iii) for $h_m < h_d$, $\delta_n^{id}(h_d) < \delta_i^{id}(h_d)$ for any $i \ne n$.

proof. The former part of (i) holds from the following; for $i, j \in \{l|h(l) \le h\}$ and $i > j$,

$$0 = u(a_k, b_i, h_d, \delta_i^{id}(h_d)) - u(a_k, b_i, x_i, \delta^k(x_i))$$

$$> u(a_k, b_j, h_d, \delta_i^{id}(h_d)) - u(a_k, b_j, x_i, \delta^k(x_i))$$

$$\ge u(a_k, b_j, h_d, \delta_i^{id}(h_d)) - u(a_k, b_j, x_j, \delta^k(x_j))$$

$$= u(a_k, b_j, h_d, \delta_i^{id}(h_d)) - u(a_k, b_j, h_d, \delta_j^{id}(h_d)).$$

The first inequality follows from $\delta_i^{id}(h_d) > \delta(x_i)$, $\frac{\partial^2 u}{\partial \delta \partial b} > 0$ and $\frac{\partial^2 u}{\partial h \partial b} > 0$. Because u is strictly increasing in δ, we obtain $\delta_j^{id}(h_d) > \delta_i^{id}(h_d)$. (iii) also hold from above.

The later part of (i) holds from the following; for $i, j \in \{l|h(l) \ge h'\}$ and $i > j$,

$$0 = u(a_k, b_j, h_d, \delta_j^{id}(h_d)) - u(a_k, b_j, x_j, \delta^k(x_j))$$

$$> u(a_k, b_i, h_d, \delta_j^{id}(h_d)) - u(a_k, b_i, x_j, \delta^k(x_j))$$

$$\ge u(a_k, b_i, h_d, \delta_j^{id}(h_d)) - u(a_k, b_i, x_i, \delta^k(x_i))$$

$$= u(a_k, b_i, h_d, \delta_j^{id}(h_d)) - u(a_k, b_i, h_d, \delta_i^{id}(h_d)).$$

The first inequality follows from $\delta_j^{id}(h_d) < \delta^k(x_j)$, $\frac{\partial^2 u}{\partial \delta \partial b} > 0$ and $\frac{\partial^2 u}{\partial h \partial b} > 0$. Then, we obtain $\delta_i^{id}(h_d) > \delta_j^{id}(h_d)$. (ii) also hold from above. □

We check an equilibrium whether or not to survive D1 criterion as the following two steps. First, we specify how the firm makes a belief when the firm observes an off-path working hour. Let $MBR_k(\lambda_k, h)$ be the set of the mixed best-response training strategy to the worker whose working hour is h given the belief λ_k. Abusing notation, $\lambda_k(T|h)$ also represents the posterior probability with which the firm believes the worker is in set T. Applying D1 criterion, the firm makes the belief that the deviator is NOT type-b_i worker on off-path working hour h_d if there exist $j \neq i$ such that

$$\{D_k(b_i, B, h_d) \cup D_k^0(b_i, B, h_d)\} \subset D_k\left(b_j, B, h_d\right)$$

where

$$D_k(b_i, B, h_d) = \bigcup_{\{\lambda_k | \lambda_k(B|h)=1\}} \{\delta \in MBR_k(\lambda_k, h_d) | u(a_k, b_i, x_i, \delta^k(x_i)) < u(a_k, b_i, h_d, \delta)\},$$

which represents the set of mixed best-response training strategy to working hour h_d and beliefs concentrated on B that make type-b_i worker strictly to prefer to the equilibrium strategy in the sense of expectation and

$$D_k(b_i, B, h_d) = \bigcup_{\{\lambda_k | \lambda_k(B|h)=1\}} \{\delta \in MBR_k(\lambda_k, h_d) | u(a_k, b_i, x_i, \delta^k(x_i)) = u(a_k, b_i, h_d, \delta)\},$$

which represent the set of expected mixed-strategy best-response training strategy that make type- b_i worker exactly indifferent. Note that $\{D_k(b_i, B, h_d) \cup D_k^0(b_i, B, h_d)\} = [\delta_i^{id}(h_d), \delta^*(a_k, b_n)\ ]$, then $\{D_k(b_i, B, h_d) \cup D_k^0(b_i, B, h_d)\} \subset D_k(b_j, B, h_d)$ holds if $\delta_i^{id}(h_d) > \delta_j^{id}(h_d)$.

Second, we check the type of the worker who is considered as the deviator whether prefers the deviation to the equilibrium outcome. We define,

$$B^*(h_d) = \{i | \{D_k(b_i, B, h_d) \cup D_0^k(b_i, B, h_d)\} \not\subset D_k(b_j, B, h_d) \forall j \neq i\}$$

as the set of the type which the firm consider as the deviators and

$$\Delta^*(B^*(h_d), h_d) = \bigcup_{\{\lambda_k | \lambda_k(B^*(h_d)|h_d)=1\}} \{\delta \in BR_k(\lambda_k, h_d)\}$$

as the set of expected best-response training strategy to h_d for belief $\lambda_k(\cdot\,|h_d)$ such that $\lambda_k(B^*(h_d)|h_d) = 1$. The equilibrium does not survive D1 criterion if there exist a type of worker b_i such that, for some $h_d \notin H$,

$$\min_{\in \Delta^*(B^*(h_d), h_d)} u\,(a_k, b_i, h_d, \delta) > u(a_k, b_i, x_i, \delta^k(x_i)).$$

Proof of Proposition 1

proof. We show that the equilibrium characterized in Proposition 1 is the only equilibrium that survive D1 criterion under $s = R$.

We first show that, in the equilibrium that survive D1 criterion, the longest hour chosen in the equilibrium, denoted by h_m, is chosen by only type-b_n worker. Suppose not. If more than two types of worker choose h_m, then $\delta^k(h_m) < \delta^*(a_k, b_n)$. Consider a deviation strategy $h_m + \epsilon$, $\epsilon > 0$. From Lemma A2(iii), $B^*(h_m + \epsilon) = \{b_n\}$ then $\Delta^*(B^*(h_m + \epsilon), h_m + \epsilon) = \{\delta^*(a_k, b_n)\}$. There is small ϵ such that $u(a_k, b_n, h_m + \epsilon, \delta^*(a_k, b_n)) >$

$u(a_k, b_n, h_m, \delta^k(h_m))$ then type-b_n worker deviates from the equilibrium. This is contradiction.

Next, we show that, in the equilibrium that survive D1 criterion, the second longest hour chosen in the equilibrium, denoted by h_{m-1}, is chosen by only type-b_{n-1} worker and that worker is indifferent between h_m and h_{m-1}. Suppose he/she is not indifferent, that is, $u(a_k, b_{n-1}, h_m, \delta^k(h_m)) < u(a_k, b_{n-1}, h_{m-1}, \delta^k(h_{m-1}))$. Then, there exist small $\epsilon' > 0$ such that $u(a_k, b_{n-1}, h_m - \epsilon', \delta^k(h_m)) < u(a_k, b_{n-1}, h_{m-1}, \delta^k(h_{m-1}))$ and $u(a_k, b_n, h_m - \epsilon', \delta^k(h_m)) > u(a_k, b_n, h_m, \delta^k(h_m))$. This implies $\delta_n^{id}(h_m - \epsilon') < \delta_{n-1}^{id}(h_m - \epsilon')$. Together with Lemma A2(i), we obtain $B^*(h_m - \epsilon') = \{b_n\}$ and $\Delta^*(B^*(h_m - \epsilon'), h_m - \epsilon') = \{\delta^*(a_k, b_n)\}$, then $u(a_k, b_n, h_m - \epsilon', \delta^*(a_k, b_n)) > u(a_k, b_n, h_m, \delta^k(h_m))$. Thus, type-$b_n$ worker deviates from the equilibrium, this is contradiction.

Suppose he/she is indifferent but h_{m-1} is chosen by more than two types. Since type-b_n chooses h_m, if more than two types of worker choose h_{m-1}, $\delta^k(h_{m-1}) < \delta^*(a_k, b_{n-1})$. Consider a deviation strategy $h_{m-1} + \epsilon'' < h_m$, $\epsilon'' > 0$. Comparing $\delta_n^{id}(h_{m-1} + \epsilon'')$ and $\delta_{n-1}^{id}(h_{m-1} + \epsilon'')$,

$$0 = u(a_k, b_{n-1}, h_m, \delta^k(h_m)) - u(a_k, b_{n-1}, h_{m-1}, \delta^k(h_{m-1}))$$

$$= u(a_k, b_{n-1}, h_m, \delta^k(h_m)) - u(a_k, b_{n-1}, h_{m-1} + \epsilon'', \delta_{n-1}^{id}(h_{m-1} + \epsilon''))$$

$$< u(a_k, b_n, h_m, \delta^k(h_m)) - u(a_k, b_n, h_{m-1} + \epsilon'', \delta_{n-1}^{id}(h_{m-1} + \epsilon''))$$

$$= u(a_k, b_n, h_{m-1} + \epsilon'', \delta_n^{id}(h_{m-1} + \epsilon'')) - u(a_k, b_n, h_{m-1} + \epsilon'', \delta_{n-1}^{id}(h_{m-1} + \epsilon''))$$

where the first inequality follows from $\delta^k(h_m) > \delta_{n-1}^{id}(h_{m-1} + \epsilon'')$, $\frac{\partial^2 u}{\partial \delta \partial b} > 0$ and $\frac{\partial^2 u}{\partial h \partial b} > 0$, then we obtain $\delta_n^{id}(h_{m-1} + \epsilon'') > \delta_{n-1}^{id}(h_{m-1} + \epsilon'')$. Together with Lemma A2(i), $B^*(h_{m-1} + \epsilon'') = \{b_{n-1}\}$ and $\Delta^*(B^*(h_{m-1} + \epsilon''), h_{m-1} + \epsilon'') = \{\delta^*(a_k, b_{n-1})\}$. There is small ϵ'' such that $u(a_k, b_{n-1}, h_{m-1} + \epsilon'', \delta^*(a_k, b_{n-1})) > u(a_k, b_{n-1}, h_{m-1}, \delta^k(h_{m-1}))$ then type-b_{n-1} worker deviates from the equilibrium. This is contradiction. Applying the same manner downward, we can show that any equilibrium hour is chosen by only one type of worker and that type is indifferent between his/her equilibrium outcome and the one-rank higher worker'outcome. Finally, since the worker's commitment type is completely separated in the equilibrium, the lowest commitment worker does not need to signal his/her type to the firm and chooses his/her optimal working hour $h = 0$. Therefore, the equilibrium survive D1 criterion is only the equilibrium characterized in the proposition. □

Since it is straightforward to prove Proposition 2 by applying almost the same manner, we omit the proof of Proposition 2. The only difference from the proof of Proposition 1 is that the worker's utility is expected utility with regard to his/her ability. The firm makes belief on off-path hours depending on the range of expected promotion probability $p\mu(a_H, \delta^H) + (1 - p)\mu(a_H, \delta^H)$ which can improve the worker's utility, that is, the deviator the firm believes is the worker whose equilibrium utility can be improved with the lowest promotion probability.

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Table 1. Summary of the results

	w^{OT} sufficiently low	w^{OT} sufficiently high
$\mu_{a\delta} > 0$	Revelation is optimal. $h_i^L < h_i^N < h_i^H$ (ex. US, UK)	Non-revelation is optimal. $h_i^L < h_i^N < h_i^H$
$\mu_{a\delta} < 0$ & $f(a_H) - f(a_L)$ is small	Non-revelation is optimal. $h_i^H < h_i^N < h_i^L$ (ex. Japan before 1990)	Revelation is optimal. $h_i^H < h_i^N < h_i^L$

Table 2 Employee Composition by Gender and Marital Status

Fiscal Year	Single Men	Married Men	Single Women	Married Women without Small Children	Married Women with Small Children*	Total
2004	18.6%	70.6%	5.9%	4.4%	0.6%	100%
2005	19.3%	69.8%	5.5%	4.2%	1.2%	100%
2006	21.6%	67.5%	5.5%	3.8%	1.6%	100%
2007	23.2%	65.6%	5.8%	3.6%	1.8%	100%
2008	25.5%	63.4%	5.5%	3.5%	2.0%	100%
2009	25.8%	63.0%	5.5%	3.5%	2.2%	100%

Source: Personnel data provided by a large manufacturing firm in Japan
Note: Includes only regular workers. * shows the number of female workers who have taken parental leave after FY1998. This group also includes those who got divorced after having children.

Table 3 Annual Wage, Average Age, Hours Worked by Gender and Marital Status

Average Annual Wage

Fiscal Year	Single Men	Married Men	Single Women	Married Women without Small Children	Married Women with Small Children*
2005	5,900,233	8,087,088	5,222,444	5,157,902	4,403,632
2006	5,961,231	8,198,714	5,402,587	5,405,735	4,471,967
2007	5,922,937	8,265,332	5,582,436	5,763,785	4,839,741
2008	5,803,538	8,186,499	5,469,831	5,811,252	4,825,612
2009	5,275,211	7,570,200	5,057,443	5,437,273	4,560,014
Average	5,772,630	8,061,567	5,346,948	5,515,189	4,620,193

Average Age

Fiscal Year	Single Men	Married Men	Single Women	Married Women without Small Children	Married Women with Small Children*
2005	34.9	44.4	37.3	36.7	34.8
2006	34.7	44.3	37.9	37.6	35.0
2007	34.0	43.9	38.0	38.9	36.2
2008	33.3	43.4	37.7	39.9	36.5
2009	32.9	43.1	38.2	40.4	37.4
Average	33.9	43.8	37.8	38.7	36.0

Average Hours Worked per Year

Fiscal Year	Single Men	Married Men	Single Women	Married Women without Small Children	Married Women with Small Children*
2005	2,072	2,060	1,922	1,794	1,667
2006	2,090	2,073	1,945	1,821	1,640
2007	2,095	2,091	1,950	1,838	1,588
2008	2,112	2,089	1,919	1,821	1,613
2009	2,059	2,034	1,854	1,782	1,588
Average	2,086	2,069	1,918	1,811	1,619

Source: Personnel data provided by a large manufacturing firm in Japan

Note: The figures in the table only include those who work for twelve months in each fiscal year. Hence, women who took a parental leave in the fiscal year are not included.

Table 4 Distribution of Men and Women by Education levels

Men

Year of Hiring	Ph.D.	Master	BS/BA	Tech. College	2-yr. college	Vocatio-nal Sch.	High School	Middle School	UNK	Total
1990-99	1.8%	18.5%	23.0%	7.2%	0.7%	3.7%	44.2%	0.8%	0.1%	100.0%
2000-09	3.8%	19.7%	28.5%	3.2%	0.9%	5.0%	30.6%	0.2%	8.0%	100.0%

Women

Year of Hiring	Ph.D.	Master	BS/BA	College of Tech.	2-y college	Vocational Sch.	High School	Middle School	UNK	Total
1990-99	0.3%	3.3%	14.8%	1.3%	37.2%	9.5%	33.4%	0.0%	0.3%	100.0%
2000-09	4.2%	26.7%	28.3%	3.3%	3.6%	20.2%	5.5%	0.0%	8.1%	100.0%

Source: Personnel data provided by a large manufacturing firm in Japan

Note: Employees hired before 2004 include only those who were still employed in 2004. UNK stands for unknown.

Table 5 Distribution of Men and Women in Hierarchy

As of 2004

Job Grades	Single Men	Married Men	Single Women	Married Women without Small Children	Married Women with Small Children*	Total
J1	3.09%	1.77%	0.30%	0.08%	0.00%	5.24%
J2, J3	8.88%	27.73%	4.89%	3.63%	0.57%	45.68%
SA, J4	2.29%	8.64%	0.31%	0.11%	0.01%	11.37%
SB, JH	1.54%	4.56%	0.11%	0.11%	0.00%	6.33%
G6	1.10%	4.04%	0.13%	0.25%	0.03%	5.55%
G5	1.22%	10.61%	0.14%	0.17%	0.00%	12.14%
G4	0.44%	8.71%	0.03%	0.08%	0.00%	9.26%
G3	0.08%	3.53%	0.01%	0.00%	0.00%	3.63%
G1,G2	0.01%	0.79%	0.00%	0.00%	0.00%	0.81%
Total	18.66%	70.36%	5.92%	4.45%	0.61%	100.00%
Managers	202	1,954	22	36	2	2,216
(G6 or higher)	9.1%	88.2%	1.0%	1.6%	0.1%	100.0%
Senior Managers	38	920	3	6	0	967
(G4 or higher)	3.9%	95.1%	0.3%	0.6%	0.0%	100.0%

As of 2009

Job Level	Single Men	Married Men	Single Women	Married Women without Small Children	Married Women with Small Children*	Total
J1	6.91%	3.04%	0.59%	0.11%	0.01%	10.63%
J2, J3	8.77%	20.65%	3.36%	2.32%	1.78%	36.85%
SA, J4	4.94%	8.17%	0.93%	0.37%	0.10%	14.52%
SB, JH	2.45%	4.84%	0.32%	0.17%	0.15%	7.93%
G6	0.92%	4.06%	0.13%	0.15%	0.15%	5.42%
G5	1.15%	8.07%	0.14%	0.18%	0.04%	9.58%
G4	0.64%	9.51%	0.08%	0.13%	0.00%	10.34%
G3	0.11%	3.81%	0.00%	0.04%	0.00%	3.96%
G1,G2	0.01%	0.77%	0.00%	0.00%	0.00%	0.78%
Total	25.91%	62.92%	5.54%	3.47%	2.23%	100.00%
Managers	222	2,053	27	39	15	2,355
(G6 or higher)	9.4%	87.2%	1.1%	1.7%	0.6%	100.0%
Senior Managers	60	1,103	6	13	0	1,181
(G4 or higher)	5.1%	93.4%	0.5%	1.1%	0.0%	100.0%

Source: Personnel data provided by a large manufacturing firm in Japan

Table 6 Frequency of Promotion by job level, gender, and marital status (2004-2009)

	Single Men			Married Men			Men Total		
Job Grades	# of employees	Freq. of promotions	Promotion rate	# of employees	Freq. of promotions	Promotion rate	# of employees	Freq. of promotions	Promotion rate
J1	2646	696	26.3%	1241	277	22.3%	3887	973	25.0%
J2, J3	3746	136	3.6%	10495	515	4.9%	14241	651	4.6%
SA, J4	1483	227	15.3%	3721	242	6.5%	5204	469	9.0%
SB, JH	830	103	12.4%	2024	265	13.1%	2854	368	12.9%
G6	436	65	14.9%	1669	298	17.9%	2105	363	17.2%
G5	559	41	7.3%	4146	485	11.7%	4705	526	11.2%
G4	238	12	5.0%	4069	280	6.9%	4307	292	6.8%
G3	51	2	3.9%	1659	106	6.4%	1710	108	6.3%

	Single Women			Married Women without Small Children			Married Women with Small Children*			Women Total		
Job Grades	# of employees	Freq. of promotions	Promotion rate	# of employees	Freq. of promotions	Promotion rate	# of employees	Freq. of promotions	Promotion rate	# of employees	Freq. of promotions	Promotion rate
J1	215	130	60.5%	40	18	45.0%	6	2	33.3%	261	150	57.5%
J2, J3	1782	38	2.1%	1281	15	1.2%	606	2	0.3%	3669	55	1.5%
SA, J4	280	35	12.5%	96	14	14.6%	24	0	0.0%	400	49	12.3%
SB, JH	83	7	8.4%	57	10	17.5%	31	1	3.2%	171	18	10.5%
G6	54	6	11.1%	93	9	9.7%	43	1	2.3%	190	16	8.4%
G5	69	4	5.8%	80	4	5.0%	11	0	0.0%	160	8	5.0%
G4	18	0	0.0%	37	2	5.4%	0	0	0.0%	55	2	3.6%
G3	5	0	0.0%	15	0	0.0%	0	0	0.0%	20	0	0.0%

Source: Personnel data provided by a large manufacturing firm in Japan

Table 7: Gender Gaps in Promotion: Logit Model
Dependent variable=probability of promotion conditional on the current job level

	All employees		College graduates	
Marriage	0.2664	***	0.1690	
	(0.0598)		(0.1174)	
Female	-0.2634	**	-0.0871	
	(0.1203)		(0.2236)	
Marriage × Female	-0.1578		-0.4036	
	(0.1751)		(0.3428)	
Maternity	-0.0709		-0.2793	
	(0.3346)		(0.8581)	
Leave Length	-0.0941	***	-0.0645	*
	(0.0278)		(0.0378)	
Working in the HQ	0.65101	***	0.4387	***
	(0.0835)		(0.1193)	
Pseudo R^2	0.1544		0.1482	
Number of observations	31711		5824	

Source: Personnel data provided by a large manufacturing firm in Japan
Note: Age, tenure, education, job grade, and fiscal year are all controlled for but their coefficients are omitted from the table.
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Career Interruptions, Hours and Promotion: Logit Model
Dependent variable=probability of promotion conditional on the current job level

	All employees		College graduates	
	w/ hours worked	w/ evaluation	w/ hours worked	w/ evaluation
Marriage	0.2744 ***	0.1038	0.1880	0.0851
	(0.0723)	(0.0752)	(0.1467)	(0.1513)
Female	-19.2762 ***	-20.1029 ***	-17.9351 **	-18.5391 **
	(4.2414)	(4.3792)	(8.7044)	(8.7111)
Marriage × Female	0.1718	0.2165	-0.2429	-0.3038
	(0.2053)	(0.2098)	(0.4195)	(0.4327)
Maternity	-0.2194	-0.1879	-0.0405	-0.1909
	(0.4582)	(0.4715)	(0.8956)	(0.8922)
Leave Length	-0.0376	-0.0317	0.0488	0.0696
	(0.0298)	(0.0329)	(0.0430)	(0.0471)
Lagged hours worked (log)	2.0406 ***	1.3570 ***	1.9729 ***	1.5790 **
	(0.3261)	(0.3347)	(0.6711)	(0.6946)
Female × Lagged hours worked	3.6746 ***	3.8002 ***	3.4400 **	3.5370 **
	(0.8174)	(0.8451)	(1.6796)	(1.6838)
Lagged reduced hours (log)	0.1039	0.1604	(omitted)	
	(0.2937)	(0.2851)		
Lagged late night hours (log)	-0.2438 ***	-0.2207 ***	-0.2594 ***	-0.2521 ***
	(0.0269)	(0.0271)	(0.0676)	(0.0690)
Evaluation : A1 or better		0.8657 ***		0.6303 ***
		(0.0702)		(0.1464)
Evaluation : A3 or worse		-0.8389 ***		-0.4439 *
		(0.1389)		(0.2280)
A1 or better × Female		0.3576 *		0.2255
		(0.2016)		(0.4715)
A3 or worse × Female		0.3244		0.5213
		(0.4200)		(0.6777)
Working in the HQ	0.7437 ***	0.7877 ***	0.6263 ***	0.6445 ***
	(0.0985)	(0.1019)	(0.1563)	(0.1597)
Pseudo R^2	0.1607	0.1893	0.1567	0.1709
Number of observations	21562	21293	3919	3905

Source: Personnel data provided by a large manufacturing firm in Japan
Note: Age, tenure, education, job grade, and fiscal year are all controlled for but their coefficients are omitted from the tab
*** p<0.01, ** p<0.05, * p<0.1

Figure 1. Timing of the game

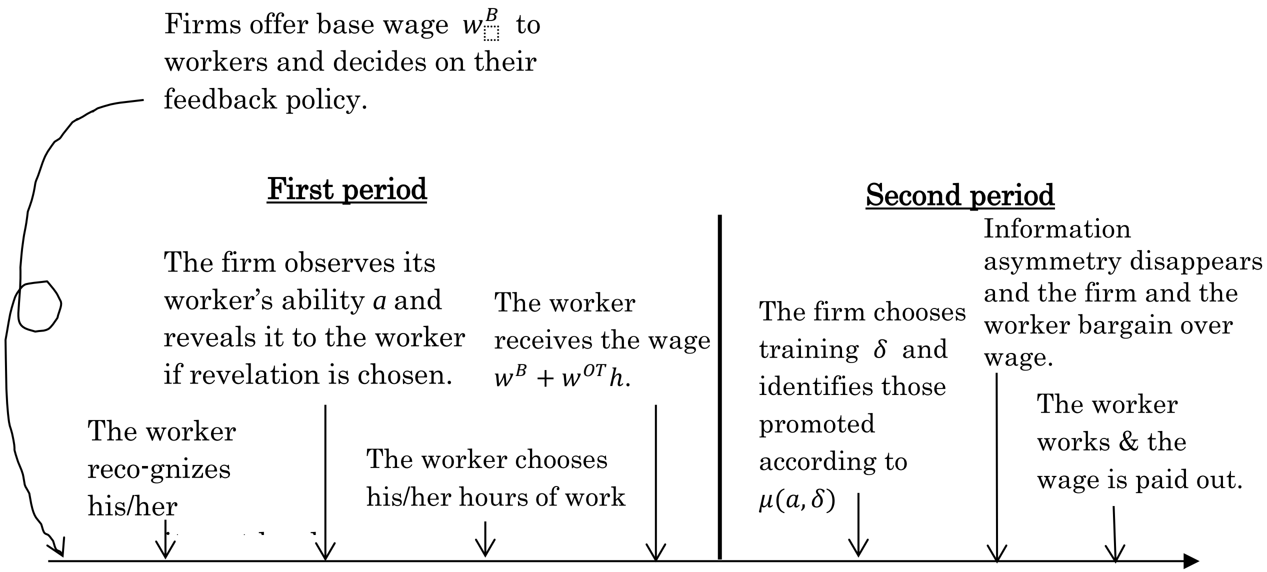


Figure 2. Do our equilibrium survive D1 criterion?

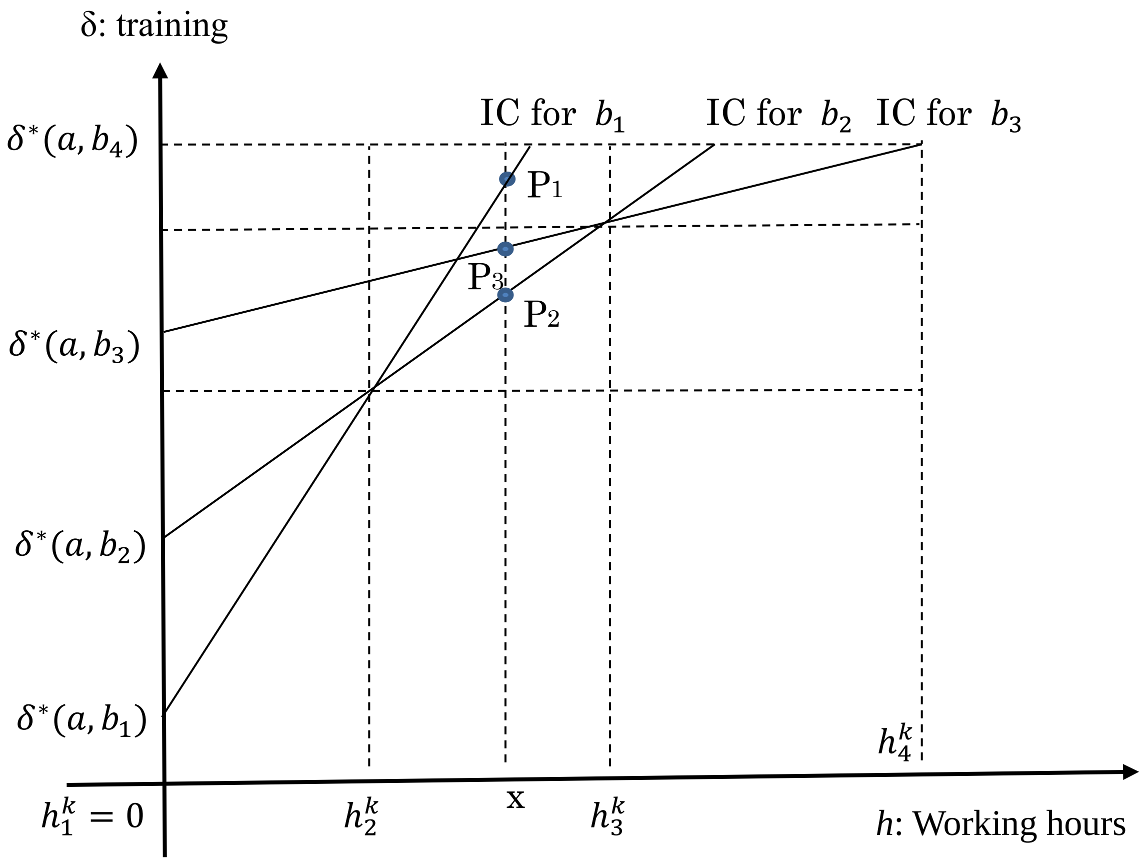


Figure 3 Expected Profit as a Function of b when $\mu_{a\delta} > 0$

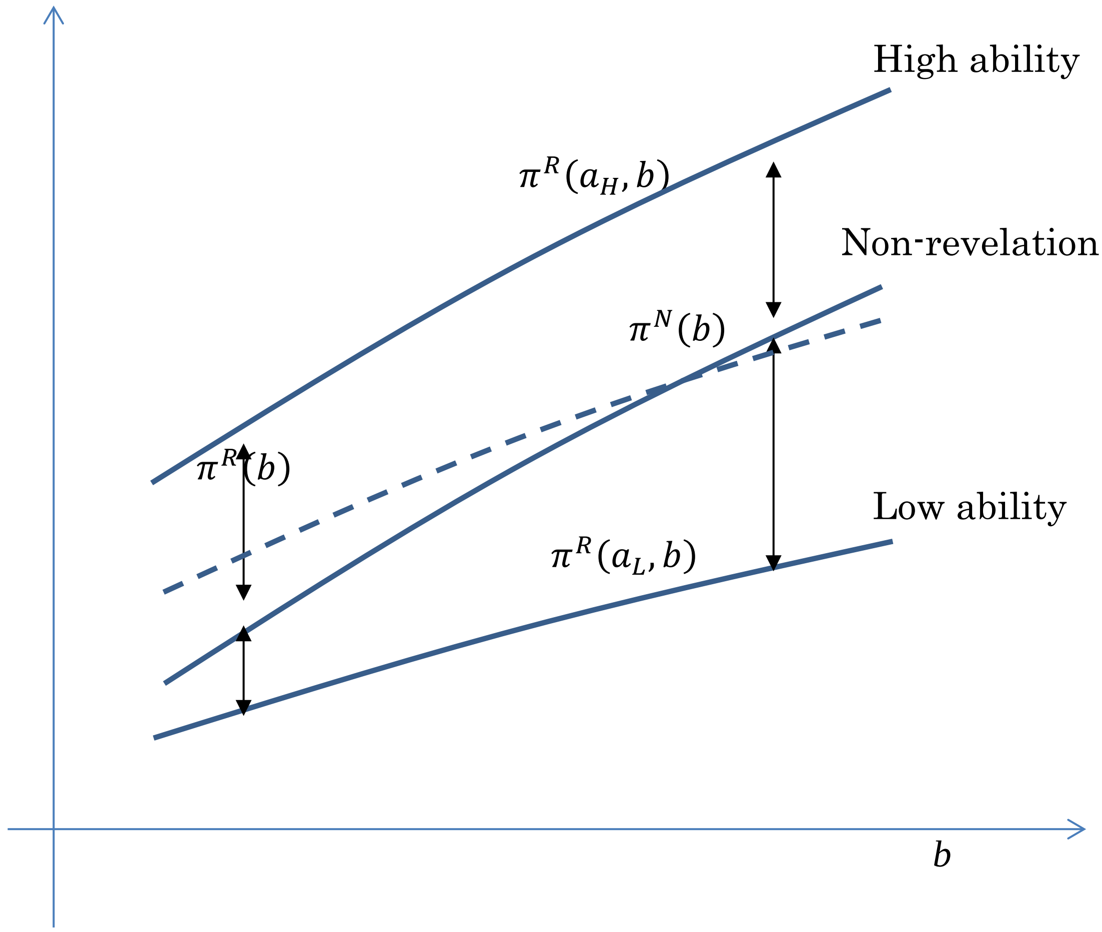


Figure 4. Gender Difference in Promotion Pattern

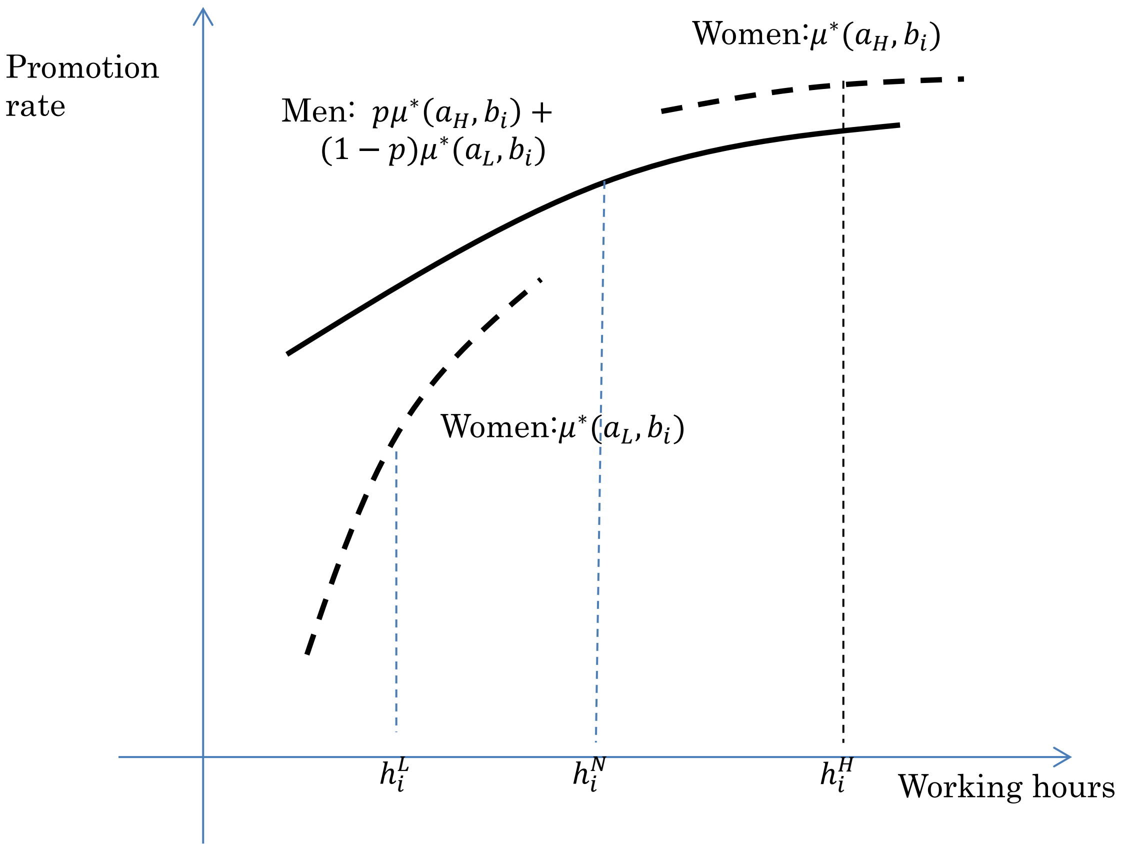


Figure 5 Promotion Path Chart

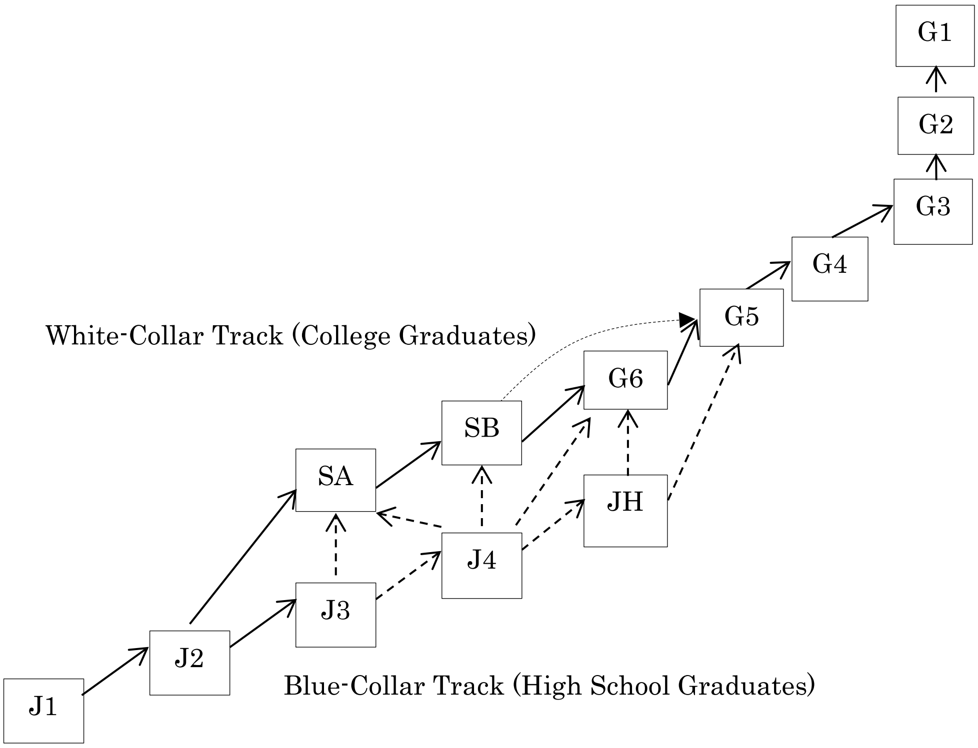
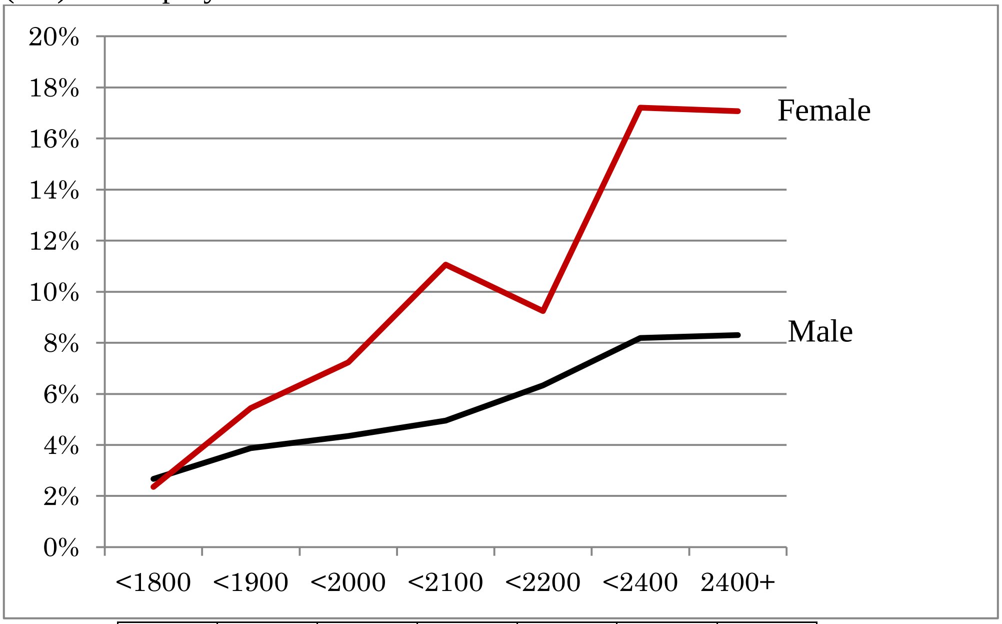


Figure 5 Predicted Odds of Promotion, conditional on the current job level

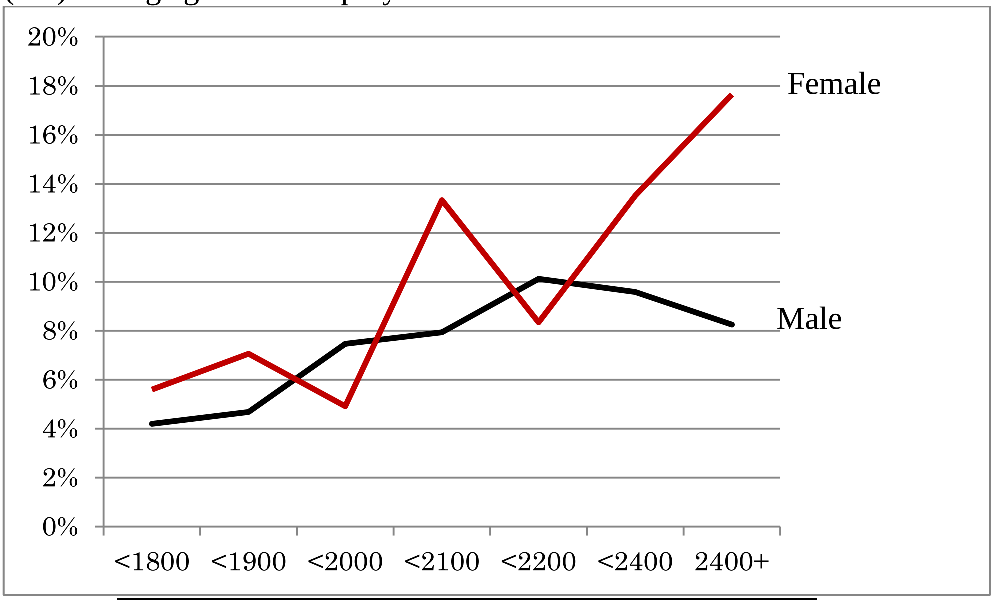
– Figures in the tables show distribution by hours worked

(5-1) All employees



Female	43.3%	22.6%	12.7%	9.1%	5.3%	5.3%	1.8%
Male	6.8%	15.0%	15.2%	21.2%	16.9%	15.1%	9.9%

(5-2) College graduate employees



Female	30.2%	20.9%	15.4%	14.5%	6.2%	8.8%	4.0%
Male	7.2%	20.9%	12.6%	18.1%	15.2%	14.8%	11.3%