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Learning, favoritism and incentive provision within organizations

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LEARNING, FAVORITISM AND INCENTIVE PROVISION WITHIN ORGANIZATIONS

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YAO SHU

B.S., National University of Singapore, 2010

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Approved by

First Reader

Andrew F. Newman, PhD
Professor of Economics

Second Reader

Kevin Lang, PhD
Professor of Economics

Third Reader

Michael Manove, PhD
Professor of Economics

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Yao Shu

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YAO SHU

Boston University, Graduate School of Arts and Sciences, 2016

Major Professor: Andrew F. Newman, PhD
Professor of Economics

ABSTRACT

This doctoral dissertation provides new theoretical and empirical analysis on employer learning and its impact on employees' incentive provisions within organizations.

In the first chapter, we show with 20 years of personnel data from a large U.S. firm, that employee performance displays a unique pattern that cannot be explained by human capital or incentive theories under the classical principal-agent framework. To explain the observed pattern, we propose an enriched principal-manager-employee framework that captures real life complications such as favoritism and influence activities. We show that supervisors are disciplined to give less biased subjective evaluations under promotion-based incentive schemes compared to bonus-based incentive schemes and the costs of wasteful influence activities could constrain the firm's ability to optimize employees effort in a way that generates equilibrium performance patterns we observe in the data.

In the second chapter, we study the credibility of the firing threat, which is widely used as a disciplinary device in the workplace. Despite its prevalence, theoretical foundations on the credibility of firing threats are not well studied. When firing is costly to the employer, it is not credible to carry out a firing threat unless a decrease in expected future return is associated with the employees misbehavior. We explore the role of learning in ensuring the credibility of firing threats and how a certain level of uncertainty is necessary to effectively induce compliance. Peter Principle arises as an outcome of the model, as workers who are known to be competent almost certainly can no longer be disciplined and need to be promoted to more difficult tasks, even though they may be less productive at those tasks.

In the third chapter, we propose a new method to test asymmetric learning in a multi-period framework and derive testable implications based on easily observable dynamic wage patterns. We test our model predictions using the NLSY97 data. The empirical results are consistent with symmetric learning and show no evidence of asymmetric learning.

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List of Abbreviations

NLSY79	....	National Longitudinal Survey of Youth 1979
NLSY97	....	National Longitudinal Survey of Youth 1997

Chapter 1

Favoritism, Influence and Employee Incentives in Large Organizations

1.1 Introduction

Optimal incentive provision is an essential aspect of firm management. Despite the abundance of economic studies on this topic, most previous studies focus on the design of incentive contracts when worker outputs are easily observed and measured. Although contracts and performances of CEOs and mutual fund managers shed important light on how incentives operate, most people do not work in positions like this. Compared to the large body of literature on managers, the incentives and performances of ordinary employees, especially those in white collar positions with hard to measure output, receive relatively little attention. In this chapter, we look into the performances of ordinary white-collar employees in large organizations and discuss the optimal design of their incentives under real-life complications of favoritism and influence activities.

With 20 years of personnel data from a large U.S. firm in the financial industry, we find that performance ratings of employees at the studied firm display a unique non-monotonic pattern. Firstly, with fixed effect panel data analysis, there is a significant negative correlation between performance ratings and position specific tenure. That is, as an employee stays in one position for longer, his performance rating scores decrease. Secondly, the level of position has a significant positive effect on performance ratings. That is, an employee's performance rating increases when he is promoted to a higher level. The general pattern of performance ratings of an employee who has moved through several job levels in the firm is thus non-monotonic. Performance gradually decreases as an employee stays in the same position, but jumps back up when he is promoted to a higher level. This pattern of performance ratings decreasing with position-specific tenure and jumping back up with promotion to a higher level is worth noting because it is incompatible with human capital theories. Intuitively, as an employee stays in one position longer, he should have gained more experience and skills for that position, making him able to perform better. Upon promotion to a higher level, facing new tasks that he may not be familiar with, the employee should be less likely to perform well. However, our data suggest the exact opposite of what human capital theories predict.

Before our study, the negative relationship between performance and general firm tenure has been reported in several previous studies. With personnel data from three different firms, Medoff and Abraham (1980, 1981) first showed that there was a negative relationship between within level performance ratings and employees' tenure at the firm. This negative relationship was later confirmed in several other studies with different data sets, including Bakers, Gibbs and Holmstrom (1994), Flabbi and Ichino (2001) and Gibbs and Hendricks (2004). Despite the consistent evidence of the negative relationship between performance rating scores and tenure, little discussion is made on why performance would fall with tenure. The main reason is that there exist plausible alternative explanations of these empirical results other than that performance indeed decreases with tenure. For cross-sectional results, the selection effect of better performers being promoted out of the position alone could explain the negative relationship. However, the selection effect could not explain the still existing negative effect in longitudinal results, when decreasing performance is observed for the same set of employees. Harris and Holmstrom (1982) and Gibbons and Waldman (1999) suggest that supervisors may evaluate individuals relative to others with similar experience and that rating scores reflect believed innate ability rather than absolute performance. With relative performance ratings and on-the-job learning, slow learners would stay in the same position for longer and also experience gradual decreases in performance ratings, as they are gradually learned to be of low ability or fall further behind their peers.

Our empirical analysis adds on to this line of research, firstly, by showing that position-specific tenure is the main driving force of the general negative relationship between performance and tenure. Secondly, we provide additional empirical analysis addressing alternative explanations, making a stronger case that performance indeed decreases with tenure. In particular, with the relative performance rating explanation, only employees with below average innate ability should receive decreasing ratings with tenure. For those who are of higher than average ability, additional years in the position should reveal that they are better than others and increase their ratings. We, therefore, separated employees into different ability groups based on how fast they are promoted and we show that the negative relationship persists regardless of employees' ability group.

With multiple studies showing the evidence of the general negative relationship between performance ratings and tenure, and our analysis that such a negative relationship cannot be explained by previously believed alternative explanations, we believe it is worth considering that decreasing employee performance with tenure may be a real phenomenon and discussing why it happens, especially with position-specific tenure.

Possible theories related to decreasing performance with tenure include the deferred compensation theory in Lazear (1979, 1981) and the career concerns theory in Holmstrom (1982, 1999). In the deferred compensation theory, the deferred compensation and the possibility of losing it act as an incentive device. As the amount of deferred compensation decreases when employees approach retirement, their performance could fall due to reduced incentives. This theory could potentially explain the decrease of performance with tenure; however, it could not explain why performance falls with position-specific tenure, which in fact is the main driving force of the general decrease in our empirical results. Another possible theory could explain the fall with position-specific tenure by applying the underlying mechanism of the career concerns, which was originally formulated for managers, to ordinary employees. If supervisors learn about employees' ability and make decisions such as promotions based on their belief about employees' ability, the same falling of implicit incentives could happen with ordinary employees within organizations as well. If the learning restarts as employees change positions, the falling incentives would be associated with position-specific tenure.

Although the falling implicit incentives from promotion concerns seems like a plausible story, we would like to argue that this story alone cannot satisfactorily explain the decreasing performance we observe in the data. The reason is that promotion is only one of the many devices that firms could use to motivate employees. In a follow-up study of Holmstrom (1982), Gibbons and Murphy (1991) show that a firm's optimal incentive scheme should optimize the overall incentives and neutralize decreasing career concerns with increasing explicit incentives. They also find support for that with data on CEO compensations. Gibbons and Murphy's result explains why, despite the decreasing career concerns, we do not observe a negative correlation between CEO performance and tenure. If we believe that, similar to the optimization of incentives for CEOs, firms also optimize the total incentives for ordinary employees, it is then less clear why the decreasing implicit incentives alone would result in the decreasing equilibrium performance which we are able to observe in the data. We then move forward to explore what might be special about the incentive provision of ordinary employees such that their performances fall with tenure, even when the optimal combination of explicit and implicit incentives is deployed.

One special aspect of the incentive provision for ordinary white-collar employees is that, most of the time, their output cannot be easily measured, and assessments of their performance often depend on manager's subjective evaluations. The subjective evaluation by managers, who are self-interested agents themselves in large organizations, adds another layer to the usual principal-agent framework for the analysis of the incentive provision of ordinary employees in large organizations. Managers, as human beings with personal likes and dislikes, are not invulnerable to personal favoritism and influence activities as discussed in Prendergast and Topel (1996) and Milgrom and Roberts (1988). The fact that managers may derive private benefit from rewarding their favored employees opens up the possibility that subjective evaluations are distorted by favoritism, and such favoritism furthermore induces employees to engage in interpersonal influence activities to gain the manager's favor. Such complications not only introduce additional influence cost for incentive provisions but also affect the firm's choice of different incentive instruments.

In our theoretical analysis, we propose an enriched principal-manager-employee framework to study the optimal incentive provision for ordinary employees under real-life complications such as favoritism and influence. Our model is different from the usual principal-agent framework in that, instead of assuming that the setting of incentive schemes, monitoring of employees and the execution of incentive schemes are all done by the principal, we assume the monitoring and execution are delegated to managers. Furthermore, managers are not always impartial. They derive private benefit from exercising their own preferences over employees and must be disciplined away from doing so.

One important result arising from the possible existence of manager's favoritism is that certain incentive instruments are less prone to the problem of favoritism than others, and would be preferred by the firm. In particular, the difference lies in whether the reward for performance has only distributional consequences or would have a direct impact on the firm's future output. To illustrate the point, take for example a tournament with monetary bonuses vs. promotion as the reward. For now, let us move away from relational contracts and long-term reputations and consider a two-period case. When the reward is monetary, who wins the reward in the first period has no direct consequence on the production in the second period. On the other hand, if the reward is promotion, it matters whether those who win are those who would be most productive at the higher level. If better performance is associated with better suitability for promotion and manager's compensations are tied to the firm's output, using promotion as the incentive instrument would give managers the implicit incentive to reward those who performed well, rather than those they favor, while using monetary bonuses would not. Given the different subjectivity to favoritism, firms would rely more heavily on promotion incentives compared to monetary bonuses than they would in the absence of such complications.

Besides the weakened desirability of using monetary bonus rewards under concerns of favoritism, the possibility of influence activities further limits the firm's ability to induce effort through optimal promotion rewards. If there is no concern for influence activities, although additional effort does have a smaller impact on promotion probability as position-specific seniority increases, the firm could optimally respond to that by making the rewards larger. In the case when employees are risk neutral, it is not hard to show that the optimal promotion reward scheme would induce the same level of effort for employees with different position-specific seniority. Although risk aversion may change the result towards lower effort levels for more senior employees, it would not change the prediction that the firm should increase the reward associated with promotion for those with higher position-specific seniority. On whether firms actually do that in real practice, both casual observations and our data suggest otherwise. If there is the concern for influence activities, however, the reason firms do not raise the reward on promotion to counter the decreased learning effect can be easily explained. Under the possibility of influencing the manager, employees basically have two ways to increase their chance of promotion. They can either invest in higher productive effort to achieve better performance or invest in wasteful influence activities to gain the manager's favor. As employees get more senior in a position, the benefit of better performance decreases as the learning completes, so the benefit of influence activities can be reasonably assumed to remain roughly the same. As a result, more senior employees would direct more attention on influence activities compared to productive activities, making it more costly for the firm to induce productive effort from them.

With the complications of favoritism and influence activities, firms are both constrained to use heavy monetary bonus rewards as well as optimize the promotion rewards for employees with higher position-specific seniority. The combined effect generates equilibrium employee effort that is consistent with our empirical observations: effort decreases with position-specific seniority and also reverts higher upon promotion as the learning re-initiates.

The rest of our paper is organized as follows. We present the general description of the data and show our empirical findings in section 2. Section 3 provides the setup of the principal-manager-employee framework and the analysis of firms' optimal incentive schemes under favoritism and influence. In section 4, we conclude the paper and discuss implications of our empirical and theoretical results.

1.2 Empirical Findings

The data set we use for our empirical findings contains the personnel records of a large U.S. firm in the service industry over the years 1969-1988. The data set is constructed by Baker, Gibbs, and Holmstrom from the firm's personnel tapes and detailed records of the data and the firm can be found in Baker, Gibbs and Holmstrom (1994a). There are a total of 74,071 employee-year observations. Each observation contains information on employees' ID, age, sex, education, job title, salary, bonus, and performance rating.

The firm under investigation is a typical hierarchical firm with multi-layers and white-collar jobs. There are a total of eight job levels from the entry positions to the CEO.[1] The bottom 4 levels contain 97.5% of the total employees and 95% of the employees in levels 1-4 are in product creation/selling positions or staff positions such as accounting, finance, and human resources. Within levels 1-4, the size of each higher level is only slightly smaller than the lower level. At level 5, the size of the level shrinks significantly to only about 10% of level 4 and remains small in levels 6-8. In higher levels, jobs are mostly associated with planning and general management. In levels 1-4, the average bonus is less than 7% of the base salary. The average bonus size jumps to around 14% in levels 5-6 and 22% in levels 7-8.

According to position characteristics, we consider those in levels 1-4 in the data as "the employees" and those in levels 5-8 as "the managers" in our model. Since we are interested in investigating the effort dynamics of the ordinary white-collar employees, we shall conduct our empirical analysis on the 97.5% of employees in levels 1-4. Summary statistics of key variables for the sample of employees in levels 1-4 are shown below in Table 1.1.

[1] The hierarchy of the firm is back constructed from moves between jobs. The details on the construction of the hierarchy can be found in Baker, Gibbs and Holmstrom (1994a).

	Min	Max	Mean	Std. Dev.	Median
Performance Rating	1	5	4.10	0.53	4
Level of Position	1	4	2.42	1.08	2
Year at Position	1	19	2.90	2.52	2
Tenure	1	19	4.52	3.55	3
Years taken to get promoted	2	17	4.64	2.51	4

Table 1.1: Summary statistics of key variables for the sample of employees in levels 1-4.

General Pattern of Employee Performance

We shall use the performance rating score as our primary measure of employees' performance. The performance rating of employees is administrated once a year and is given on the 1-5 scales. In the original data set, the ratings are coded in descending order, with 1 being the highest rating and 5 being the worst. For easier interpretation, we recode the ratings in ascending order, with 1 as the worst performance and 5 as the best. Observations of performance ratings show the leniency bias: scores are concentrated on the higher end, with those receiving rating 1-2 accounting for only about 1% of the data. The overall percentage of observations with ratings 3, 4 and 5 are 18%, 50%, and 31% respectively.

A general picture of the dynamics of employee performance is illustrated in Figure 1.2.1. Figure 1.2.1 shows the distribution performance rating scores of a fixed set of employees through the first 5 years in levels 1-4. To avoid selection bias from promotion or exit, we included only employees who have stayed more than 5 years before promotion or exit for each of the levels shown.

We can see from Figure 1.2.1 that there is a clear pattern of decreasing performance ratings with position-specific seniority. The percentage of employees receiving the best

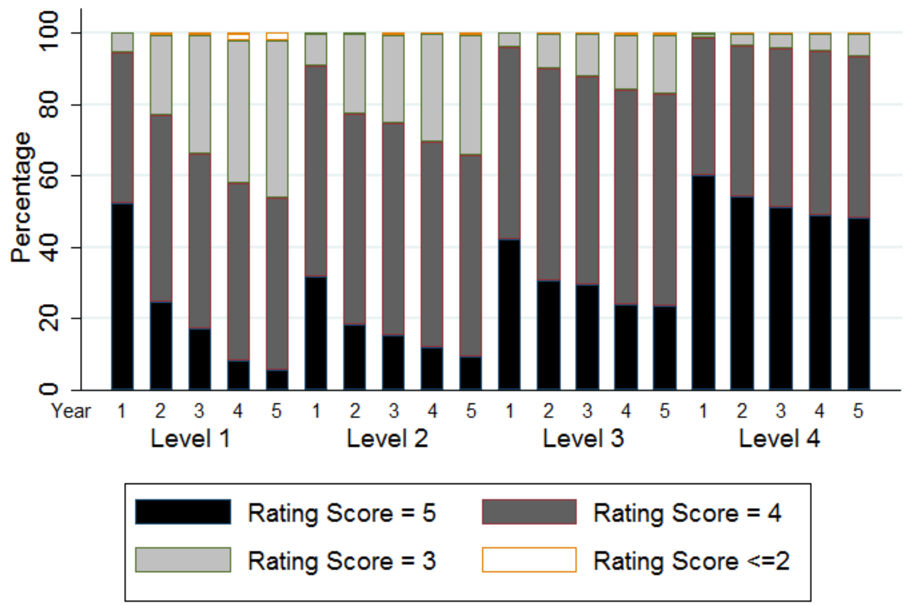

Figure 1.2.1: Distribution of ratings scores for employees who have stayed more than 5 years at each level.

rating, 5, is around 60% in the first year at level 1. That quickly drops to less than 20% in the third year at level 1, and to around 10% in the 5th year. The percentage of employees receiving rating 4 remains roughly stable, while the percentage receiving rating 3 greatly increases. The cases of ratings 1-2 are rare and are notable only in the fourth and fifth year at level 1. The pattern is similar at all other levels.

Fixed Effect Regression Analysis

Since the pattern illustrated in Figure 1.2.1 is based on a restricted sample, we shall next examine whether the illustrated pattern holds for the general population of employees through regression analysis. To avoid selection bias due to unobserved innate ability, we investigate the relationship with fixed-effect models.

The results from the fixed-effect linear and ordered logit regressions of employees' performance ratings on position-specific seniority, tenure and level of position are presented in Table 1.2. Columns (1) and (2) show the result from the fixed-effect linear regression with level of position not included in (1) and included in (2). Columns (3) and (4) show the result from fixed-effect ordered logit estimation with level of position not included in (3) and included in (4). The estimation method we used is the BUC estimation proposed in Baetschmann, Staub and Winkelmann (2011).[2]

	Dependent Variable: Performance Rating			
	Fixed Effect Linear Regression		Fixed Effect Ordered Logit	
Independent Variable	(1)	(2)	(3)	(4)
Year at Position	-0.062***	- 0.049***	-0.19***	-0.17***
	(0.0035)	(0.0046)	(0.027)	(0.034)
Tenure	- 0.012***	-0.027***	-0.052***	- 0.078***
	(0.0022)	(0.0042)	(0.016)	(0.029)
Level of Position		0.062***		0.14
		(0.013)		(0.12)
Constant	4.36***	4.25***		
	(0.0092)	(0.022)		
Observations	34,574	34,574	34,574	34,574
No. Employees	8,863	8,863	8,863	8,863

Table 1.2: Fixed effect linear and ordered logit regression of performance ratings on position specific seniority, tenure and level of position.

The results represented in Table 1.2 are consistent with the pattern shown in Figure 1.2.1. There is a consistent and significant negative relationship between position-specific seniority and performance ratings across all specifications. The result in column (2) suggests that an extra year at the position decreases performance rating by approximately 0.05, which gives a decrease of a quarter grade with 5 extra

[2]The estimation method we used is the BUC estimation proposed in Baetschmann, Staub and Winkelmann (2011).

years. Since most of the performance ratings are between 3 and 5, the estimate suggests a quite notable effect of decreasing performance as employees' position-specific seniority increases. Employees' overall tenure at the firm also has a negative effect on employees' performance. However, the magnitude of the effect is much smaller compared to that of position-specific seniority in all specifications.

The fact that the main driving force behind decreasing employee performance is position-specific seniority rather than overall tenure is important and predicts that performance not only decreases with years when employees stay at one level, but also jumps up at promotion as the position-specific seniority reverts back to zero.

What's more, the estimated effect of the level of position is positive. The level effect adds further to the jump in performance upon promotion and may negate the negative effect of tenure for promoted employees. With specification 2, the magnitude of the positive effect of level is more than two times larger than the negative effect of tenure. If an employee is promoted after two years at level 1, the estimated result would predict that the expected rating that the employee would receive is actually higher in his first year at level 2 compared to his first year at level 1.

If level is not controlled for, the positive effect of level could severely bias the estimated effect of tenure on performance, as evidenced by the difference of the estimated coefficient on tenure between specifications (1) and (2). If the level effect is large enough, it is possible that an uncontrolled regression of performance on tenure would show no relationship between performance and tenure, as some of the previous studies have found.

Addressing Alternative Explanations

Since performance ratings are subjectively evaluated, it is reasonable to question whether the changes in performance ratings are indeed caused by changes in performances rather than other reasons, such as supervisors' bias or changes of standards in ratings.

One well-accepted hypothesis, raised by Harris and Holmstrom, reconciles the empirical evidence of decreasing performance ratings and the human capital theory prediction of increasing experience and skills. Their hypothesis is that supervisors rate employees relative to others with similar experience and tenure. In other words, the standard of the performance rating is rising with tenure as the expected level of performance rises. In that case, what the performance rating reveals is more about an employee's ability relative to others, rather than his absolute level of productivity. Then, since those who have stayed in a position for a long time are likely of lower ability, it is not surprising to see their performance ratings falling with tenure, as they are gradually learned to be of low ability, or as they fall further behind due to slow learning.

Next, we shall show empirical evidence that the decreasing performance ratings we observed in our data are not driven by the above hypothesis. To address the concern, we selected out the sample of employees who eventually get promoted to the next level within our observations. Then, we separated them into high ability and low ability groups according to how long it takes for them to get promoted. For the whole sample, the median years taken to get promoted is 4 years for the first three levels, and 8 years for level 4. We group employees into those who took less than or equal to 4 years to get promoted and those who took more than 4 years. If the relative rating hypothesis is at force in our data, we should expect the performance ratings to increase for the high ability group and decrease for the low ability group.

The results of the regression using the sample of employees who get promoted are shown in Table 1.3. For all three regressions, we use the fixed effect linear regression model, as in specification (2) in Table 1.2. Comparing (1) in Table 1.3 with (2) in Table 1.2, we can see that the estimated coefficients on both position-specific tenure

Independent Variable	Dependent Variable: Performance Rating		
	All Employees who get promoted	Time to get promoted <= 4 years	Time to get promoted >=5 years
	(1)	(2)	(3)
Year at Position	-0.0528***	-0.0497***	-0.0560***
	(0.00652)	(0.0159)	(0.0113)
Tenure	-0.0217***	-0.0850***	-0.00458
	(0.00585)	(0.0142)	(0.0109)
Level of Position	0.0210	0.151***	-0.0187
	(0.0169)	(0.0286)	(0.0561)
Constant	4.412***	4.397***	4.341***
	(0.0247)	(0.0366)	(0.0964)
Observations	12,839	5,322	7,517
No. Employees	4,128	2,815	2,010

Table 1.3: Fixed effect lineaer regression over the sample of employees who get promoted.

and tenure at the firm are consistent across samples. Excluding the observations of employees who left the firm before getting promoted, or had not been promoted at the end of our observed years has little effect on our estimated coefficients, except that the effect of the level of position becomes much smaller and more insignificant.

Comparing across (1), (2) and (3) in Table 1.3, we can see that estimated coefficients on the position-specific tenure is quite consistent across specifications. However, for firm tenure and level of position, the estimated results are quite different for the high ability and low ability groups. Estimated coefficients on both tenure and level of position are very small and insignificant for the low ability group.

From the results represented in Table 1.3, we can see that for both the high ability and the low ability group, there is a consistent decrease of performance rating scores with position-specific tenure. This means that the relative rating standard story cannot explain the decreasing performance scores, as the performance ratings are decreasing across samples, regardless of the employees' relative ability.

Interpretation of the Empirical Result

The empirical result we have shown above is interesting, as it shows the opposite of what general human capital theories would predict. As employees stay in one position longer, they acquire skills and become more efficient at their tasks, and we would expect increases rather than decreases in the level of performance they are capable of. Even if performances are rated relative to expected level of performance, we should not observe the consistent decrease of performance ratings regardless of employees' relative ability within the group.

If we believe that the performance ratings are not just randomly biased against more senior employees, there must be something going on that is driving the decreasing ratings. Since it is unlikely such decrease is due to decreasing ability to perform, it is reasonable to believe it is due to the decrease in employees' willingness to perform. In the next section, we shall provide theoretical analysis on how this odd pattern of employee effort could arise as equilibrium outcome even after the firm has optimized the incentives for employees.

1.3 Model and Analysis

3.1 The Model Setup

We shall consider here a firm with three groups of actors: the principal, the manager and the employees. The firm is owned by the principal. The manager monitors the employees and makes management decisions. Production is carried out by employees. Tasks that each employee carries out are complex and multi-dimensional. We assume that while the aggregate output of the firm is measurable and contractible, each individual employee's contribution to output is hard to measure and not contractible.

We assume that at least some aspects of employees' performance cannot be objectively measured but can be subjectively evaluated by managers. In each period t, the manager privately observes a signal η_{jt} on employee j's performance:

$$\eta_{jt} = a_j + e_{jt} + \epsilon_{jt}. \tag{1.3.1}$$

The performance signal η_{it} is influenced by the employee's ability a_j, effort e_{jt} and a random noise term ϵ_{jt}. We assume that an employee's ability a_j is job-specific and initially unknown to either the firm or the employee. The prior of a_j is normally distributed as $N(a_0, \sigma_0^2)$ and the observational noise ϵ_{jt} follows $N(0, \sigma_\epsilon^2)$.

Besides observing employees' performance, the manager also forms personal preferences for employees. Let f_{jt} measure the manager's preference of employee j in period t. We assume that f_{jt} is influenced by both the manager's previous preference $f_{j,t-1}$ and the employee's effort in interpersonal influence activities i_{jt}. We would like to interpret f as a comparative measure and normalize the impact of i_{jt} as $i_{jt} - E(i_{jt})$ keep the mean of f_{jt} zero. Let $f_{j0} \sim N(0, \sigma_f^2)$ denote the manager's initial preference; the manager's preference f_{jt} can be expressed as:

$$f_{jt} = f_{j,t-1} + [i_{jt} - E(i_{jt})] = f_{j0} + \sum_{s=1}^{t} [i_{js} - E(i_{js})]. \tag{1.3.2}$$

The Employee's Incentives

Employees privately choose their effort e_{jt} in productive activities and i_{jt} in influence activities in each period. Let the employee's cost function be $c(e_{jt}, i_{jt}) = c_e e_{jt}^2 + c_i i_{jt}^2$. To focus on the impact of favoritism and influence activities on employees' incentive provision, we abstract away from the well-studied insurance vs. incentive trade-off and assume that employees are risk-neutral .

Let the incentive scheme for employees take a simple two step form: a certain number of employees receives an extra reward, R, while all the others receive only the base wage, w.[3] Let $p(e_{jt}, i_{jt})$ be the probability of receiving the reward; the utility of an employee in period t is then:

$$u^E(e_{jt}, i_{jt}) = p(e_{jt}, i_{jt})R + w - c(e_{jt}, i_{jt}). \tag{1.3.3}$$

The Manager's Incentive

In contrast to usual models of incentive provision that take managers as the principal, in our model, managers are also self-interested agents who take actions to maximize their own utility.

Let the manager be risk-neutral and care about his compensation, as well as his personal preferences towards employees. There are two central assumptions we would like to make about the manager's incentives. First, we assume that the manager's compensation is tied to the output of the team he monitors and that the aggregate output the the team can be better measured and contracted on than individual output. Second, we assume that the manager prefers for employees that he likes better to receive performance rewards.

Let y_{jt} be employee j's output and the team's output be $Y_t = \sum_j y_{jt}$. Let θ be the sensitivity of the manager's compensation to the team's output. The manager's compensation is specified as:

$$w(Y_t) = \theta Y_t + \underline{w} = \theta \sum_j y_{jt} + \underline{w}. \tag{1.3.4}$$

Let B_t be the set of employees who receive the performance reward in period t and let u_f measure the utility that the manager derives from favoritism. We assume

[3] It suffices to study this simple form of incentive scheme, as the shape of the reward function does not matter under the risk neutrality assumption.

that u_f increases with f_{jt} of the rewarded employees:

$$u_f(B_t) = \sum_{j \in B_t} f_{jt}. \tag{1.3.5}$$

Combining (1.3.4) and (1.3.5), the manager's overall utility in period t is then:

$$u(Y_t, B_t) = \theta \sum_{j} y_{jt} + \underline{w} + \sum_{j \in B_t} f_{jt}. \tag{1.3.6}$$

3.2 Choice of Incentive Schemes under Favoritism and Influence

With the model basics specified above, let us first examine the effect of favoritism and influence on incentive provision in a simple two-period context.

Let both the employees and the manager live for two periods and there be no discounting. At the beginning of the first period, the firm commits to the manager's compensation, the number and the size of employees' performance reward. In the first period, the manager privately observes employees' performance and determines the set of employees to receive the performance reward. The performance reward is then distributed at the beginning of the second period.

Incentives under Monetary Reward

Depending on whether the distribution of reward has any effect on the team's expected future output, performance rewards can be divided into two types. In the first type, rewards have distributional consequences only, with bonus payments being the most common example. We shall refer to this type of reward as "monetary reward."

With monetary reward, the team's output in the second period is unrelated to the distribution of rewards. At the end of the first period, the manager chooses the set of reward-winning employees to maximize his own expected second-period utility.

The maximization problem of the manager is:

$$\max_B \theta \sum_j E(y_{j2}) + \underline{w} + \sum_{j \in B} E(f_{j2})$$

$$\Leftrightarrow \max_B \sum_{j \in B} E(f_{j2})$$

It is then easy to see that, under the monetary reward scheme, the manager's maximization problem reduces to the maximization of the utility derived from favoritism. As the distribution of rewards has no effect on the second period output, and thus the manager's compensation, the manager will choose the set of employees to be promoted based on his personal preference only.

Result 1. *Under the monetary reward scheme, the manager chooses the set of employees to be rewarded based on his personal preference only. Employees exert positive effort in influence activities and zero effort in productive activities.*

Incentives under Promotion-Based Reward

With the second type of reward, who gets the reward does not only have distributional consequences, but also affects future production of the team. The most common example is promotion, in which the receipt of higher wage is accompanied with reassignment of the employee's job. We shall refer to this type of reward scheme as the "promotion-based reward."

Let there be two job levels, and the expected output of employees for the higher and lower levels be $E(y_j^H) = \rho^H a_j + e_j + b_H$ and $E(y_j^L) = \rho^L a_j + e_j + b_L$ respectively. We assume $\rho^H > \rho^L$, that high-ability workers are more suited for the higher position, and $E(y_j^L|a_0) > E(y_j^H|a_0)$, that employees are better suited for the lower position when they enter the firm.

After observing an employee's performance, the manager learns about the ability and updates the expected output of the employee in both levels of jobs. Given the linear form of η_{jt} and the normality of a_j and ϵ_{jt}, the manager's learning follows the normal updating rule:

$$E(a_j|\eta_{j1}) = \frac{h_0}{h_0 + h_\epsilon} a_0 + \frac{h_\epsilon}{h_0 + h_\epsilon}(\eta_{j1} - e^*_{j1}), \tag{1.3.7}$$

where $h_0 = \frac{1}{\sigma_0^2}$ and $h_0 = \frac{1}{\sigma_\epsilon^2}$.

Let $\beta_1 = \frac{h_\epsilon}{h_0+h_\epsilon}$, we can rewrite (1.3.7) as:

$$E(a_j|\eta_{j1}) = (1 - \beta_1)a_0 + \beta_1(\eta_{j1} - e^*_{j1}). \tag{1.3.8}$$

We can see from (1.3.8) that better first period performance increases the manager's belief about an employee's ability, which in turn increases the manager's belief about the employee's suitability for the higher level job. The manager's maximization problem under the promotion-based reward scheme is:

$$\max_B \theta \sum_j E(y_{j2}) + \underline{w} + \sum_{j \in B_1} E(f_{j2})$$

$$\Leftrightarrow \max_B \theta \sum_j E(y^L_{j2}) + \theta \sum_{j \in B} E(y^H_{j2}) - E(y^L_{j2}) + + \sum_{j \in B} E(f_{j2})$$

$$\Leftrightarrow \max_B \sum_{j \in B} \theta(\rho^H - \rho^L) E(a_j|\eta_{j1}) + f_{j1}$$

$$\Leftrightarrow \max_B \sum_{j \in B} \theta(\rho^H - \rho^L)\beta_1 \eta_{j1} + f_{j1} \tag{1.3.9}$$

We can see from (1.3.9) that the manager's utility maximization problem can be expressed as the maximization of a weighted combination of the employee's performance and the manager's personal preference term.

Result 2. *Under the promotion-based reward scheme, the manager chooses the set of employees to be rewarded based on both the employee's performance and his personal preference towards the employee.*

Let $p(e_{j1}, i_{j1})$ be the probability of being promoted as a function of the employee's effort. Given the manager's decision rule, it is obvious that $p(e_{j1}, i_{j1})$ is increasing in both e_{j1} and i_{j1}. Substituting the expression of η_{jt} and f_{jt} into (3.9), we can derive that:

$$p(e_{j1}, i_{j1}) = G(\theta(\rho^H - \rho^L)\beta_1 e_{j1} + i_{j1}), \tag{1.3.10}$$

where G is a cumulative density function jointly determined by the distribution of a_j, ϵ_{jt} and f_{j0}.

The maximization problem of the employees is then:

$$\max_{e_{j1}, i_{j1}} p(e_{j1}, i_{j1})R - c(e_{j1}, i_{j1}) \tag{1.3.11}$$

Given (1.3.10) and (1.3.11), it is easy to derive from the first order condition that:

$$\frac{\partial c}{\partial e_{j1}} / \frac{\partial c}{\partial i_{j1}} = \theta(\rho^H - \rho^L)\beta_1 \tag{1.3.12}$$

Result 3. *Employees exert positive effort in both productive and influence activities under the promotion-based reward scheme. The relative level of effort spend on the productive activities compared to influence activities increases with the manager's compensation sensitivity to output θ, the productivity difference parameter $(\rho^H - \rho^L)$, and the learning update parameter β_1.*

The Firm's Optimal Reward Scheme

Given the choice rules of the manager and the employees, the firm sets the manager's compensation and the reward scheme to maximize the expected joint surplus.

Proposition 1. *Under favoritism and influence, the firm chooses the promotion-based reward scheme over the monetary reward scheme to induce employee effort. Employees exert effort in both productive and influence activities. Under the firm's optimal reward scheme, the level of productive effort induced is lower than the first-best.*

With Results 1-3 in previous analysis, the derivation of Proposition 1 is straightforward. When managers are subject to favoritism and influence, the promotion-based reward scheme is preferred over the monetary reward scheme, as assignment efficiency provides managers the implicit incentive to limit their practice of favoritism. However, as favoritism and influence activities are still present, the optimal productive effort induced is lower than the first-best.

Note that the uncertainty and learning about an employee's ability play an important role in creating the implicit incentive to limit favoritism. The manager cares about an employee's performance only because it changes his assessment of the employee's ability. When there are more periods, the learning process completes over time, which may well affect the effectiveness of the promotion-based scheme. In the next subsection, we shall extend the model to more periods and examine the dynamics of incentive provision under the promotion-based reward scheme.

3.3 Dynamics of Employee Effort

Now, let both the employees and the manager live for T periods and the discounting factor be δ. At the beginning of the first period, the firm commits to the wage profiles and the number of employees to promoted in each period. In each period, the manager privately observes employees' performance and determines the set of employees to be promoted. Once promoted, employees stay in the higher level.

Let P_n be the set of employees to be promoted at the end of period n. The manager's maximization problem at the end of period n is now:

$$\max_{P_n} \sum_{j\in P_n} \sum_{s=n+1}^{T} \delta^{s-n}[E(y_{js}^H) - E(y_{js}^L) + E(f_{js})]$$

$$\Leftrightarrow \max_{P_n} \sum_{j\in P_n} E(y_{j,n+1}^H) - E(y_{j,n+1}^L) + E(f_{j,n+1})$$

$$\Leftrightarrow \max_{P_n} \sum_{j\in P_n} \theta(\rho^H - \rho^L)E(a_j|\eta_j^n) + f_{j,n}$$

$$\Leftrightarrow \max_{P_n} \sum_{j\in P_n} \theta(\rho^H - \rho^L)\beta_n \sum_{s=1}^{n} \eta_{js} + f_{jn}, \tag{1.3.13}$$

where $\beta_n = \frac{h_\epsilon}{h_0 + nh_\epsilon}$.

Let $p_n(e_j^n, i_j^n)$be probability of an employee being promoted at the end of period n, given his effort history e_j^n and i_j^n. Substituting the expression of η_{js} and f_{jn} into (1.3.13), we have:

$$\frac{\partial p_n}{\partial e_{js}} / \frac{\partial p_n}{\partial i_{js}} = \theta(\rho^H - \rho^L)\beta_n \ \forall s \leq n. \tag{1.3.14}$$

Let V_n and V_n^P be the present value of an employee working at the lower and higher levels in period n. We can express employee j's present value in period n recursively as:

$$V_n(e_j^n, i_j^n) = w_n^L + \delta[p_n(e_j^n, i_j^n)V_{n+1}^P + (1 - p_n(e_j^n, i_j^n))V_{n+1}(e_j^n, i_j^n)] \tag{1.3.15}$$

The employee's maximization problem in period n is then:

$$max\ V(e_j^n, i_j^n) - c(e_{jn}, i_{jn}). \tag{1.3.16}$$

Lemma 2. *In the T-period model, employees' effort choices in period n satisfies the following condition:*

$$\frac{\partial c}{\partial e_{jn}} / \frac{\partial c}{\partial i_{jn}} < \frac{\partial c}{\partial e_{jn'}} / \frac{\partial c}{\partial i_{jn'}}\ \forall n' < n \leq T.$$

Given the maximization problem derived in (1.3.16), the result in the above lemma follows directly from the first order condition of (1.3.16). What the lemma states is that the relative level of effort employees put on productive activities compared to influence activities decreases as they stay in the same position for longer. With this result, we are ready to derive the general characterization of equilibrium employee effort under our model.

Proposition 3. *Let the e_{jn}^* be employee's effort choice under the firm's optimal promotion-based incentive scheme and e^E be the first-best employee effort. Then, the following hold:*

1) $e_{jn}^* < e^E\ \forall n$;
2) $e_{jn}^* < e_{jn'}^*$ if $n > n'$;
3) $e_n^* \to 0$ as $n \to \infty$.

Proposition 3 states that, not only are effort levels lower than the first-best under favoritism and influence, the distortion away from the first-best gets worse as employees' position-specific tenure increases. What's more, if an employee stays in the same position for a very long time, he would almost devote all his effort to influence rather than productive activities, resulting in the firm choosing to induce very little effort from him.

monetary reward scheme and that employees' productive effort decreases as they stay longer in the same position. Note that these results are derived under the simplifying assumption that there exists no external force that disciplines the manager's practice of favoritism, be it the possible punishment from the firm or its negative effect on the manager's reputation. In this section, we would like to discuss the implication of favoritism and influence on incentive design and employee effort in a more general context where objective performance measures and monitoring on subjective evaluations are allowed to exist.

Consider a firm in which tasks to be performed at each job are complex and multidimensional. Let $(t_1, t_2, .., t_n)$ be the set of tasks relevant for production, and $\overrightarrow{e} = (e_1, e_2, .., e_n)$ be the vector of efforts spent in the set of tasks. Let $f(\overrightarrow{e}) = \overrightarrow{\alpha} \cdot \overrightarrow{e} = \alpha_1 e_1 + \alpha_2 e_2 + .. + \alpha_n e_n$ be the value of output produced as a function of the efforts.

Let there exist a contractible performance measure $m(\overrightarrow{e}) = \overrightarrow{\beta} \cdot \overrightarrow{e}$. The contractible measure is imperfect in the sense that there exists no multiplier r such that $r\overrightarrow{\beta} = \overrightarrow{\alpha}$. The most common example of imperfection is that $\beta_x = 0$ for some x, which means some aspect of the tasks to be performed is not covered by the contractible measure.

On the other hand, subjective evaluations can be formed over any specific task t_x. We denote the subjective evaluation of task x by $s_x(\overrightarrow{e}) = \psi_x e_x$.

Incentive Provision under No Favoritism or Influence

When managers are not subject to favoritism and are expected to carry out performance evaluations honestly, the firm can base its incentive scheme on subjective evaluations without any additional cost. In such cases, subjective evaluations can be used as if they are objective measures.

It is then easy to see that it is possible to construct a perfect measure of performance based on subjective evaluations by choosing an appropriate weight on each s_x according to $\overrightarrow{\alpha}$. When there exists no favoritism or influence, imperfection in objective measures posts no constraint on the incentive provision for employees. The problem of incentive provision goes back to the classical insurance-incentive tradeoff, and first-best effort can be achieved if employees are risk-neutral.

Incentive Provision under Favoritism and Influence

In the presence of favoritism and influence, use of subjective evaluations carries the associated cost of influence activities. Influence costs associated with promotion-based incentives may be lower than those associated with monetary incentives, depending on employees' position-specific seniority and how well external punishment mechanisms such as reputation work. However, monetary incentive is more flexible, as it can be based the firm's choice of any combination of s_x. Objective measures, although may not be perfect, are not susceptible to the problem of favoritism and influence cost.

As a result, the firm's optimal incentive scheme may be a combination of monetary reward based on objective measures, monetary reward based on subjective evaluations and reward associated with promotion.

Note that, for monetary reward based on objective and subjective measures of performance, there is no obvious reason why its effectiveness should change over time. On the other hand, the effectiveness of promotion-based reward decreases with employees' position-specific seniority.

Proposition 4. *When managers are not subject to favoritism and influence, the effort of employees under the firm's optimal incentive scheme does not vary with employees' position-specific seniority. When managers are subject to favoritism and influence, if there exists some aspect of effort e_x that is better induced through promotion compared to other options, e_x decreases as the employees' position-specific seniority increases.*

Proposition 4 states that, even under relaxed assumptions about the firm's available incentive instruments, the existence of favoritism and influence would result in decreasing employee effort with position-specific seniority as long as there is some aspect of employees' performance that is either not well measured, or not easily observable to other employees for the reputation mechanism to work.

1.4 Conclusion

Economic literature has traditionally studied too little about the incentive provision of the group of employees whose output is hard to measure and subjectively evaluated by managers. With 20 years of personnel data from a large firm, we show that employee effort is not optimized in the way that classical incentive theories would predict. With the insight from our empirical work, we set out to explain in theory why the firm's optimization of employee effort would be constrained in such a way that it produces the pattern of employee effort we observe in the data. We show with an enriched principal-manager-employee framework that real life complications such as favoritism and influence could result in decreasing equilibrium effort with seniority even after the firm has optimized its incentive schemes. The empirical observation that an employee's effort decreases as he stays in the same position for longer and the theoretical result that such decreasing effort could be more than just poor incentive management, but a result of real life constraints, has several important implications. First, in contrast to most human capital theories, decreasing effort means that it is possible for an employee's productivity to decrease as he stays longer in his position. Second, if an employee's effort decreases as position-specific tenure increases, firms would face higher pressure to promote employees with higher position-specific seniority. This gives a rational explanation of why seniority is usually taken into account in promotion decisions. Third, decreasing effort with position-specific seniority points to the importance of designing career paths with appropriate step lengths. A career path with fewer expected years to progress to the next level is preferred to one with longer expected years, as the cost of decreasing effort becomes larger as employees stay longer in the same position.

Chapter 2

Employer Learning, Firing Threat and the Peter Principle

2.1 Introduction

When a boss asks his employee to prepare a set of important documents, the employee usually does it to the best of his effort, even when the quality of the prepared documents is never written into the employment contract, can never be verified in court and does not directly affect the employee's wage. In typical employment relationships, as depicted in Simon (1951), contracts are usually vague, but employers possess the power of asking employees for specific tasks to be performed later according to their needs.

In the large body of literature on the theory of the firm pioneered by Coase (1937) and Williamson (1975), the power of employers to make employees perform tasks beyond what can be contracted on is often viewed as central to the functioning of the firm and counted as one important advantage of transacting within firms. In most of these works, however, the reason why employers possess such power is often assumed rather than carefully discussed. Among others, the threat of firing is often quoted as the reason why employers are able to command employees beyond what is written in contracts. Although the threat of firing is widely accepted as a disciplining device in efficiency wage models, such as in Shapiro and Stiglitz (1984), those models adopt a fully contractible framework which ensures the credibility of the firing threat. In a framework with incomplete contracts, where the believed authority power of employers matters, the credibility of the firing threat becomes problematic. In particular, if the firing policy is non-contractible, after an employee is observed with low effort, would it indeed be optimal for the employer to fire the employee? By the time the employer considers whether to fire or not, the damage of low effort is already sunk. If there is any small cost of firing, the act of firing the worker could well not be optimal ex-post. Without ex-post optimality, the threat of firing would just be an empty threat.

Regarding the empty threat problem, previous literature often takes the view that it can be solved through repeated interactions, with the reputation mechanism, as in Kreps and Wilson (1982), or through relational contracts, as in Levin (2003). The limitation of relying on such repeated game models is that, firstly, in many situations where the power of employers matters, the time horizon is not long enough for reputation or relational contracts to form. Secondly, the working of the reputation mechanism relies on the public observability of performances, which may not be the case in real life. In many cases, especially when employees directly provide service to their bosses, actions taken by employees are privately observed by the boss only. It is then hard for any reputation concern to have an effect on employer's firing decisions.

Despite these theoretical difficulties, the threat of firing is widely believed to be effective in a wide range of employment relationships. In particular, the credibility of the firing threat seems unaffected by privately observed effort or short employment horizons in real life. We therefore believe that there exists a more general mechanism ensuring the credibility of the firing threat besides the repeated games theories.

In this paper, we propose that an employer's learning could be the mechanism ensuring the credibility of the firing threat, and it works even under the harshest possible environment - when neither output nor effort is contractible, when effort is only privately observed and when the time horizon is short. When there are different types of employees with different propensities to provide consummate effort, the effort choice of an employee does not only affect his output for that period, but also affects the employer's belief about his type. As employment continues, employers learn about an employee's type and adjust their assessment of the employee's value each period. It would then be optimal for the employer to carry out the firing threat after observing low effort, whenever the low effort reduces the employer's valuation of the employee by more than the cost of firing.

With the credibility of the firing threat ensured by employer learning and appropriate wage setting, it is then possible for the employer to achieve positive discipline power over employees even under the setting with privately observed and not contractible output and effort. However, as the credibility of the firing threat depends on employer learning and adjustment of beliefs, it is natural to wonder what happens when uncertainty about the employee's type resolves with time.

Under the extended multi-period framework, we show that, when there exists noise in a firm's valuation of employees, no matter how small the noise is, the threat of firing loses its effectiveness as learning completes. Intuitively, when an employee is learned with near certainty to be competent, his further actions will have very little impact on the employer's assessment of his future value; thus, the possible effect of discipline through the firing threat is very small. At the same time, firing a worker becomes more and more costly as the probability of the employee being competent increases. Therefore, when the employer's belief of an employee's probability of being competent passes a certain level, the threat of firing will no longer be optimal and thus, loses its credibility. Given that no more effective discipline can be achieved through the firing threat when the learning over an employee's type completes, it would be optimal for employers to maintain some uncertainty about employees' types if possible. If promoting a worker into a higher level can introduce additional uncertainty when an employee is known to be competent at the current level with near certainty, optimal promotion policy resembling the Peter Principle could arise out of our model.

The Peter Principle, as discussed in Peter and Hull (1969), describes the promotion policy that employees are promoted based on their performance in their current position, rather than on abilities relevant to the higher position. Under such a promotion policy, employees are promoted to the next level once they are shown to be competent in the current level, and will eventually be promoted to a level of incompetency. Eventually, all positions would be occupied by employees who are incompetent.

From the perspective of assignment only, the Peter Principle is clearly inefficient. In the management literature, it is widely criticized and often regarded as bad management practice. In the economic literature, Fairburn and Malcomson (2001) show that when performance is unverifiable and managers can be bribed by employees, the optimal promotion rule may involve promoting too many workers than is efficient, which they refer to as the Peter Principle effect. Lazear (2004) takes a different perspective and describes the Peter Principle effect as the decrease in the performance of employees after they are promoted. Lazear (2004) referred to the negative correlation between job and tenure found in Medoff and Abraham (1980) and between wage and job tenure in Lazear (1992) as the Peter Principle and argues that it could simply be a result of the regression-to-the-mean effect. What our model explains, however, is not the consequences of the Peter Principle that too many are promoted, or that performance drops after promotion. Rather, our model concerns the rationality of the Peter Principle as a supposedly inefficient practice of promoting workers based on their performance in current positions rather than suitability for the positions to be promoted into.

With our model of employer learning, we show that the Peter Principle could be driven by the firm's concern to maintain effective discipline through the firing threat. As an employee is shown to be competent at his current level, he reaches a stage when the firing threat is no longer credible and there is no more incentive to provide consummate effort. The competent worker thus enters into a stage of complacency and the effort level decreases. To avoid the decreased effort, the firm has the incentive to promote the worker into a higher level with more difficult tasks, such that the learning restarts and it is possible to discipline the worker again.

The rest of this chapter is organized as follows. In section 2, we show formally with a simple two-period model that, with employer learning, it is always possible for employers to establish positive discipline power through a credible firing threat and it is optimal for them to do so. In section 3, we extend the model to multi-periods and explore the function of the firing threat when learning approaches completion. In section 4, we explore the implications of our model on firms' promotion policy. In particular, we show that delete comma the completion of learning and the loss of effective discipline provide a rational explanation of the Peter Principle. In section 5, we conclude this chapter.

2.2 A Model of Employer Learning and Credible Firing Threat

2.2.1 The Model Setup

Let there be many firms and many workers. Let the labor market be competitive, and the cost of firing and job searching be positive but infinitely close to 0. Firms are profit maximizers and workers are risk-neutral utility maximizers. For the base model, let there be two periods and the discounting factor be δ.

Types of Workers Let there be two types of workers for each job position. A worker can either be *competent* or *incompetent* for a given job. We assume that the competency of a worker is job-specific and the prior of a worker being competent for a given job is α.

Effort Levels Let there be two possible effort levels. The lower effort level, which we refer to as the perfunctory effort, is always contractible and denoted by e_L. The higher effort level, which we refer to as consummate effort, is not contractible and denoted by e_H. We assume that during production, the effort levels of workers are observed by their employers.

Cost of Effort Let c be cost of providing consummate effort. Since perfunctory effort can always be enforced, we normalize its cost to 0. Let $c \sim G_H$ when the worker is competent and $c \sim G_L$ when the worker is incompetent, where G_H and G_L are continuous distributions with support $(0, \infty)$. Assume that incompetent workers find it more costly to provide consummate effort in the first order stochastic dominant sense, i.e. $G_L(c) \geq G_H(c)\ \forall c \in (0, \infty)$.

Productivity We assume that due to team work or task complexity, a worker's output y is not contractible or immediately observable. However, employers understand that the expected output of a worker varies with his competency and effort. Let $y^H_{e_L}$, $y^H_{e_H}$,$y^L_{e_L}$,$y^L_{e_H}$ be the expected output levels of competent and incompetent workers when they provide perfunctory and consummate effort respectively. We assume that $y^H_e > y^L_e$ for both $e = e_L$ and $e = e_H$, $y^a_{e_H} > y^a_{e_L}$ for both $a = H$ and $a = L$.

2.2.2 Existence of Employment Equilibrium with Credible Firing Threat

The Employment Contract

Since neither output nor effort is contractible, the employment contract in a two-period setting is simply a pair of wages (w_1, w_2), with the option to terminate by any party at the end of period 1.

At the end of period 1, the only information available to the firm, and that the continuation of employment could be made contingent upon, is the employee's observed effort level. Let a *firing threat* be the firm's conditional continuation policy that the original employment contract will be continued if consummate effort is observed, and terminated otherwise. Let T be the reduction in the worker's payoff if the original contract is terminated; T then measures the effective disciplining power from the firing threat.

Firms' Learning and Updating of Beliefs

For the firm to optimally decide whether to carry out the firing threat or not, it must correctly update a worker's expected continuation value according to available information, which is the worker's first period effort choice here.

For a given T, a worker will choose consummate effort with probability $G_H(T)$ if he is competent and $G_L(T)$ if he is incompetent. Let α^H and α^L be the updated probability of a worker being competent after consummate effort and perfunctory effort are observed respectively. Then, according to the Beyes' Rule:

$$\alpha^H(T) = \frac{\alpha G_H(T)}{\alpha G_H(T) + (1-\alpha)G_L(T)};$$

$$\alpha^L(T) = \frac{\alpha(1 - G_H(T))}{\alpha(1 - G_H(T)) + (1-\alpha)(1 - G_L(T))}.$$

Since we know that $G_H(c) \leq G_L(c)\ \forall c \in (0, \infty)$, it follows that, for any given T, $G_H(T) < G_L(T)$ and $(1 - G_H(T)) > (1 - G_L(T))$. It is then easy to see from here that$\alpha^L(T) \leq \alpha \leq \alpha^H(T)$ for any T.

Credibility of the Firing Threat

For employees to be disciplined by the firing threat, it must be credible. In other words, the conditional employment policy contingent upon observed effort levels must be ex-post optimal. To determine the conditions for the firing threat to be credible, we need to compute a worker's second period expected output based on his first period effort choice.

Since period 2 is the last period, workers will only provide perfunctory effort because there is no more future to keep them disciplined. Then, according to the updated beliefs, the second period expected output of a worker is $E(y|e_H) = \alpha^H(T)(y_{e_L}^H - y_{e_L}^L) + y_{e_L}^L$ if consummate effort is observed and $E(y|e_L) = \alpha^L(T)(y_{e_L}^H - y_{e_L}^L) + y_{e_L}^L$ if perfunctory effort is observed.

In a competitive labor market, the expected payoff of hiring a new employee is always 0. Given the infinitely small firing cost, the firm's decision on keeping or replacing a continuing employee is then: keep if $E(y|e_i) \geq w_2$ or fire if $E(y|e_i) < w_2$. Given the previously computed expected second period output, with wage contract (w_1, w_2), the firm's firing threat is credible if:

$$\alpha^L(T)(y_{e_L}^H - y_{e_L}^L) + y_{e_L}^L < w_2 \leq \alpha^H(T)(y_{e_L}^H - y_{e_L}^L) + y_{e_L}^L. \tag{2.2.1}$$

Employment Equilibrium

Throughout the previous analysis, we have taken the discipline power T as given. In equilibrium, however, the discipline power T used in belief updating must be consistent with the actual cost of getting fired for workers.

Since we assumed that competency is job-specific, the worst a worker can do after getting fired is start a new career with the prior competency probability α. In a competitive labor market, workers' second period outside option is then $w_2^o =$

$\alpha(y^H_{e_L} - y^L_{e_L}) + y^L_{e_L}$. With contracted continuation wage w_2 and infinitely small search cost, the value of staying at a worker's current job is then:

$$T = w_2 - w_2^o = w_2 - [\alpha(y^H_{e_L} - y^L_{e_L}) + y^L_{e_L}]. \tag{2.2.2}$$

Let $((w_1,w_2),T)$ be an employment relationship with contracted wage (w_1, w_2) and expected discipline power T. We say that $((w_1,w_2),T)$ is an employment equilibrium if: *1) the firing threat is credible if $T > 0$, i.e. condition 2.2.1 is satisfied if $T > 0$; 2) the expectation of the discipline power is consistent, i.e. condition 2.2.2 is satisfied; and 3) the firm's expected profit is 0.*

Proposition 5. *If G_H and G_L are continuous and $\frac{g_H(T)}{g_L(T)} \nrightarrow 1$ as $T \to 0$, then there always exist $T > 0$ and (w_1, w_2) such that $((w_1,w_2),T)$ is an employment equilibrium.*

The significance of Proposition 5 is that, even under the situations when neither output nor effort is contractible, employees would still be willing to provide more than perfunctory effort due to the fear of getting fired. Note that our model does not require the output or effort choices to be observable by the outside market. Thus, this model is a step forward from the Holmstrom (1999) career concerns model, in which the incentive to exert effort comes from the adjustment of market wages with observed performance.

Moreover, the two-period nature of this model demonstrates that the discipline power of firing threats can be effective, even under extremely a short time horizon. Thus, our model is applicable to a wider range of employment situations and compliments the relational contract literature that builds on infinitely repeated interactions.

Lastly, the discipline power from the threat of firing in our model is unaffected even if the worker's effort choice is privately observed by his employer only. With publicly observed effort, it is possible to establish a credible firing threat based on the reputation concern of the firm. In such reputation models, learning happens in the opposite direction - employees learn whether an employer is strict with discipline by observing his actions toward other employees. Thus, employers are motivated to carry out the firing threat even with ex-post cost in order to maintain their reputation on discipline. The reputation model is widely applicable to many employment situations, but has its limitations due to its reliance on public observability of performance or effort. In the white collar workplace, employees often perform tasks in individual settings and the quality of an employee's work is usually overseen by the supervisor only. Since our model of employer learning does not require publicly observed performance or effort, it covers an even wider range of employment situations than the reputation model.

2.2.3 Optimality of the use of the Firing Threat

In the previous section, we developed the existence of employment equilibrium in which positive discipline power is achieved through credible firing threat. Given the possibility of achieving discipline power through the threat of firing, firms still face the choice of whether to establish the firing threat and the choice of equilibrium under multiple equilibria possibilities.

In the two-period setting, the employer's optimal choice is straightforward. After observing the effort choice in period 1,, a continuation worker's updated prior is either $\alpha^H(T)$ or $a^L(T)$. From previous analysis, we know that $\alpha^L(T) \leq \alpha \leq \alpha^H(T)$ for any T. Since the worker can always exit and start a new career with prior α and we've assumed infinitely small labor market frictions, it is always *socially optimal* for workers who have chosen perfunctory effort in the first period to leave the firm, and for those who have chosen consummate effort to stay. In other words, there is no efficiency loss of setting up and carrying out the firing threat. At the same time, there is efficiency gain in achieving more efficient effort by setting up the firing threat.

Let $S(T)$ be the set of all T's such that $((w_1, w_2), T)$ is an employment equilibrium, and $\alpha(T)$ be the updated prior given an observed effort cost of T.

Proposition 6. *In the two-period model, it is always efficient for the firm to choose an equilibrium with $T > 0$. If G_H and G_L are continuous $\frac{g_H(T)}{g_L(T)}$ is monotone decreasing in T, the firm's optimal choice of equilibrium is $T^* = max\{S(T)|T \leq V(T)\}$, where $V(T) = \alpha(T)(y^H_{e_H} - y^H_{e_L}) + (1 - \alpha(T))(y^L_{e_H} - y^L_{e_L})$.*

Proposition 6 establishes that, in the base two-period model, it is always efficient for the firm to establish the firing threat. With the regularity condition of monotone decreasing $\frac{g_H(T)}{g_L(T)}$, which is satisfied by most families of distribution functions such as normally distributed G_H and G_L, the firm would choose the largest possible T, as long as T is not greater than the expected value gain from consummate effort.

2.3 Model Extension and Limitations of the Firing Threat

In the previous section, we showed with the two-period model that, even when neither output nor effort is contractible, it is possible for the employer to establish positive discipline power through credible firing threat and it is optimal for the employer to do so. In this section, we extend the model to discuss the use and limitations of firing threats in multi-period settings.

In the two-period setting, the effectiveness and optimality of the firing threat are greatly simplified by the fact that there is only one stage of learning and that the starting prior of learning within the firm is the same as the prior that a worker would restart his career with after getting fired. However, this is no longer the case when there are more periods.

The Completion of Learning

When an employment relationship continues for multi-periods, the learning of the employee's competency also continues. Since an employee is either competent or incompetent, when learning periods are long enough, the learning would eventually reach a point where the employer is almost sure about the employee's type. Since it is always optimal for the firm to fire an employee once his expected probability of competency falls below the average outside level, the eventual completion of learning will only happen in one direction - the expectation of almost certain competency.

Let everything be same as in the base model, except, now, allow the employment relationship to continue for $N > 2$ periods. Let α_t denote the prior of a worker's believed probability of being competent at the end of period t.

Lemma 7. *Consider an employee who has stayed in the same firm for t periods. If in all t periods, the discipline power from the firing threat T is positive and* $\frac{g_H(T)}{g_L(T)} \nrightarrow 1$ *as* $T \to 0$*, then* $a_t \to 1$ *as* $t \to \infty$.

Lemma 7 states that, if the firing threat is effective for all periods during an employee's tenure, then eventually the learning over the employee's type would reach a point when the employer is almost sure that he is competent.

Since it is not unusual to have long-lasting employment relationships in real life, given that the learning will eventually approach almost certain competency, it is important to discuss the effectiveness of the firing threat under such conditions.

The Effectiveness of the Firing Threat

As we have discussed in our previous analysis, the credibility of the firing threat depends on the ex-post optimality condition: the expected net value of a worker to the firm should be positive if he is to be retained, and negative if he is to be fired. In the two-period case, this is the optimality equation 2.2.1.

Consider the same optimality condition as in 2.2.1, but now, allow the starting prior to be α_t instead of α. In the two period case, if there is scope of learning to start with - in other words, if the market prior α is not close to 0 or 1 - there should be some distance between α^H and α^L. In the multi-period case, however, since we are starting with α_t, and we know from Lemma 7 that α_t could be very close to 1 if t is large enough, there could be very little scope of learning left. The result of the almost certain starting prior is that, after effort is observed, whether the effort choice is consummate or perfunctory would have very little effect on α_{t+1}, and thus, very little effect on the worker's continuation value to the firm. Although it is still possible to set the continuation wages such that the optimality condition is satisfied, the function of the firing threat would require extremely accurate setting of wages and absolutely zero noise, which is unrealistic in real life.

Since a worker's continuation value after consummate or perfunctory effort would be extremely close when α_t is very close to 1, when we allow random noise in the employer's ex-post decision, setting the continuation wage in between the two values would result in the worker being retained or fired almost solely due to the noise.

Let there be a random noise to a worker's expected value at the end of each period, and let the noise ϵ be normally distributed in $[-\varepsilon, \varepsilon]$, where ε is a small number.

Lemma 8. *Given any positive ε, if there exist employment equilibria with positive T_t, then the maximum possible equilibrium discipline power $max\{T_t|T_t \in S_t\} \to 0$ as $\alpha_{t-1} \to 1$.*

Lemma 8 states that, if there exists some noise in the firm's valuation of employees, no matter how small that noise is, as learning completes, the maximum discipline power that can be achieved through credible firing threat would approach zero.

The Cost of Using the Firing Threat

At the same time, the cost of using the threat of firing is no longer always zero as in the two-period case. In the two-period case, the updated prior of a worker always falls below the market level after perfunctory effort is observed in the first period; thus, firing such workers would result in no efficiency loss. This is no longer the case in the multi-period setting, as the starting prior before update is now α_{t-1} instead of α. The execution of the firing threat would result in inefficient separation whenever

$a_t(a_{t-1}, L)$ is greater than α.

Let $L_t(a_{t-1})$ be the expected total surplus of the next period of employment when not firing anyone at the end of t, minus that of firing a worker after observing perfunctory performance. $L_t(a_{t-1})$ thus measures the loss of surplus due to inefficient separation.

Lemma 9. *As $\alpha_{t-1} \to 1$, there exist $L > 0$ such that the loss of efficiency from separation $L_t(a_{t-1}) \to L$.*

Lemma 9 states that, as learning completes, the expected loss resulting from inefficient separation approaches a positive level.

With the previous three Lemmas, we've established that *1) the learning approaches almost certain competency as an employee stays longer in the firm; 2) the maximum discipline power that can be achieved through the firing threat approaches zero as learning completes; 3) the efficiency loss of using the firing threat approaches a positive level as learning completes.*

Given the above, we can derive the following result:

Proposition 10. *When N is large enough, there exist t and $\widetilde{a_t}$ such that, if $a_t > \widetilde{a_t}$, then no discipline power can be achieved through the threat of firing after period t, and the learning process stops.*

Proposition 10 establishes that, in multi-period settings, as long as there are long enough periods, the learning would eventually reach a point when no more discipline power can be achieved through the threat of firing. Intuitively, as we discussed before, when there is no learning, and no output nor effort can be contracted on, there is a credibility problem with the use of the firing threat. When we introduce employees' competency types and learning into the model in the previous section, the difference in ex-post expected values of employees makes it possible to establish credible threat of firing. In the multi-period case, as learning completes and the uncertainty over employees' competency disappears, we are again approaching the initial case where there is no learning. The approaching zero benefit and positive cost of using the firing threat again makes it not credible for the firm to use the threat of firing. Therefore, what we've established here is that the use of the firing threat has a finite life and it ends when there is too little uncertainty about an employee's competency.

2.4 Discipline through the Firing Threat and the Peter Principle

In the previous two sections, we've shown that, when neither output nor effort is contractible, employers could establish discipline power over employees through the firing threat and that such discipline loses its effectiveness as the learning over employees' competency completes. In this section, we shall discuss the implications of such changes on the firm's promotion policy. In particular, we will show that the completion of learning and the loss of effective discipline could provide a rational explanation of the Peter Principle.

The Model with Promotion

In order to discuss the implications of our model on job assignment, let us first extend the structure of the model to allow for more job levels.

Let there be two different job levels in the firm, the lower and the higher level. Let there be two tasks a and b. The productivity of a worker at the lower level depends on his performance in task a only while the productivity of a worker in the higher level depends on his performance in both task a and task b.

Let y_{L1}, y_{L2} be the worker's productivity in the lower level and higher level respectively, and y_a and y_b be the productivity of the worker associated with performing task a and task b respectively. Let $y_{L1} = y_a + B$, where B is some constant and

$y_{L2} = y_a + y_b$.

A worker could either be competent or incompetent in task a and in task b. Let the market prior of a worker being competent in task a be α and in task b be β. Assume that competency in task a is independent from competency in task b.

Let the cost of providing consummate effort in the lower level be G_H when the worker is competent in task a and G_L if incompetent in task a. In the higher level, the cost of providing consummate effort is G_H if the worker is competent in both task a and task b, and G_L otherwise.

Let the learning update and the rest of the model setup be the same as in the base model.

Optimal Promotion Policy without Considering Employee Effort

Consider first the situation that there is no productivity difference between consummate and perfunctory effort and consider only the efficient assignment of job positions.

Let α_t and β_t be the expected probability of a worker being competent in tasks a and b in period t respectively. Since $y_{L1} = y_a + B$ and $y_{L2} = y_a + y_b$, it is clear that, without considering the effect of effort, promotion should always be made based on β_t and the level of α_t should not affect the firm's assignment decision.

Optimal Promotion Policy with Changing Discipline Power

Now, consider the situation where effort makes a difference on productivity and when neither output nor effort is contractible. We are therefore in a situation where employers can establish effective discipline over employees through the firing threat in early periods but they lose such power as the learning completes.

As we have shown previously that the effectiveness of discipline through the firing threat depends crucially on the uncertainty about the employee's competency. For a worker who is learned to be competent almost certainly in task a, promoting him to the higher level or not now has another effect beyond assignment efficiency - the promotion to the higher level will reintroduce uncertainty into the employee's competency.

After a worker is learned to be competent in task a and the firing threat loses its discipline power in the lower position, the learning can start again with respect to the employee's competency in task b if he is promoted to the higher level. Since the restart of learning will again make it possible to increase employee effort through the firing threat, the firm has the incentive to promote competent workers into the higher level to achieve higher employee effort.

Proposition 11. *Let$\hat{\beta}_t$ be the efficient threshold of β_t for promotion in terms of assignment only. When employee effort is taken into account, there exist $\widetilde{a}_t$ and $\hat{\beta}'_t < \hat{\beta}_t$ such that it is optimal to promote employees with $\hat{\beta}'_t \leq \beta_t < \hat{\beta}_t$ if $a_t > \widetilde{a}_t$. Furthermore, if no learning over β happens in the first level, employees will be promoted based solely on a_t.*

Proposition 11 states that, when we take into account the need to sustain employees' effort through credible firing threat, it is no longer inefficient to decide promotion based on current level competency. In particular, when employers could somehow observe signals on the employee's competency in task b, being competent in task a lowers the required belief of β_t for an employee to be promoted. In this case, even if the employee's productivity would decrease from the pure assignment perspective, he could still be promoted to the higher level in order for consummate effort to be sustained. Furthermore, if employers could not effectively determine an employee's probability of competency in task b based on his performances in the lower level, promotions would be made purely based on concerns of sustaining effort, thus determined purely by a_t. In that case, we would have an optimal promotion policy exactly the same as that the Peter Principle describes.

2.5 Conclusion

In this paper, we propose an employment model with employer learning to provide the foundation of credible firing threat in an employment relationship when neither output nor effort is contractible. With a two-period model, we show that credible firing threat can be achieved even when the time horizon is extremely short. When the employer is not sure about an employee's type, the employee's actions acts as signals to the employer and change the employer's belief about the employee's future productivity, which ensures the ex-post credibility of firing threats. As the ex-post credibility of firing threat is dependent on the learning and uncertainty over the employee, the use of firing threat as a disciplinary device becomes problematic when the employer is almost sure about the employee's competence at the job. To sustain the employee's incentives, the employer may find it optimal to promote him into more difficult tasks, even though this results in an immediate decrease in expected base output. Our model thus provides a rational explanation for the Peter Principle: employees who are known to be competent at the current level are promoted to higher levels in order to sustain their incentives to provide consummate effort.

Chapter 3

Testing Asymmetric Learning Using Wage Data

3.1 Introduction

When a firm hires a new graduate, it tries to assess as correctly as possible the productivity of the potential hire from all information available - education, background, interviews and so on. Firms form their beliefs about a worker and make offers corresponding to their beliefs. This assessment, however, is never perfect. Due to imperfect information, employers' starting beliefs of a worker's productivity often reflect statistical averages rather than true individual productivity. As the employment relationship goes on, however, the employing firm observes the worker's performance and more information on the worker's productivity is revealed. Firms are then able to update their beliefs and make more precise assessments of the worker's productivity. In other words, employers learn about a worker's productivity over time.

One important question about this learning process is whether firms observe the same performance signals. Early works like Freeman (1977) and Harris and Holmstrom (1982) primarily adopted the symmetric learning hypothesis due to its simple structure. In their models, all firms receive the same signals and the learning process is identical for incumbent and outside firms. Later works, such as Waldman (1984, 1996), Greenwald (1986) and Acemoglu and Pischke (1998) consider the case when incumbent firms hold information not known to outside firms and explore the implication of such information asymmetry. Since incumbent firms are likely to be able to observe employee performance more closely, most models with asymmetric learning assume that incumbent firms hold more precise information. Lazear (1984) takes a different approach and assumes that each firm receives different signals; however, incumbent firms' signals are not better than outside firms.' In other words, the learning processes are different for each firm, but the incumbent firms do not possess a unique information advantage when compared to outsiders. Here, we shall refer to the asymmetric learning hypothesis as the case when incumbent firms hold superior information compared to outsiders.

The major implication of the asymmetric learning hypothesis is that, with informational advantage on wage setting, the incumbent firm is able to extract rent from the worker and takes actions to maximize that rent. In Waldman (1984), firms are reluctant to promote workers when learning is asymmetric, as promotion reveals part of the incumbent-knows-only information to the market. Asymmetric learning thus leads to inefficient job assignment in Waldman (1984). In Acemoglu and Pischke (1998), however, asymmetric learning makes firms willing to invest in general training. As firms are able to pay below the marginal productivity of the worker, they extract partial benefits of general trainings, and thus would be willing to invest in them.

Gibbons and Katz (1991) first proposed a test of asymmetric learning and the resulting adverse selection using layoffs. The main idea is that if the learning is asymmetric, being laid off is a bad signal to the outside market, while losing a job on a plant closure is not. Laid-off workers are then expected to experience a larger decrease in wage compared to movers due to plant closure. Using data from the Current Population Survey, Gibbons and Katz find support for asymmetric learning. Doiron (1995) and Grund (1999) used the same testing method with data from Canada and Germany, and found mixed support for asymmetric learning. Acemoglu and Pischke (1998) adopted a similar idea, that quitters of the apprentice programs due to military service receive higher wages than those who are laid off or quit voluntarily, because they do not suffer from adverse selection. Moreover, military quitters could even receive higher wages than stayers, as stayers are paid less than their marginal productivity due to incumbent firms' information monopoly, while military quitters receive competitive wage offers. With data on Germany apprentices, they found support for asymmetric learning.

In a more recent paper, Schonberg (2007) proposes a new test of asymmetric learning using AFQT scores. The main idea is determining whether the incumbent and the outsider have the same information from whether AFQT score's impact on wages changes differently with tenure and experience. If information is symmetric, the learning process should not be affected by the change of firms; thus, the AFQT score's impact on wages should not vary with tenure after controlling for experience. If information is asymmetric, the AFQT score's impact on wages should increase with tenure. Using data from NLSY79, Schonberg (2007) found no evidence of asymmetric learning in general, except some weak evidence when workers are college graduates.

In this paper, we propose a new test of asymmetric learning using wage data. The central innovation of our method is that it does not depend on variables such as reasons of displacement or AFQT scores, and only requires the observation of wage and employment histories of workers. Due to the minimal requirement of key variables, our testing method opens up the possibility of using the much larger and more precise administrative data sets to test asymmetric learning instead of depending on survey data. The central idea of our testing method is that, under either the symmetric or asymmetric hypothesis, employer's learning over a worker's productivity is reflected in the changes in the worker's wages. Since individual wages are unlikely to be fully transparent to the market, the changes in past wages reflect a worker's ability, not observed by later employers, but observed by econometricians, just like AFQT scores.

Intuitively, a worker is more likely to get a better wage adjustment if his performance reveals favorable information about his productivity beyond the employer's initial expectation. No matter what wage setting mechanism we assume, it is safe to expect that a worker's wage increases with his employer's belief about his productivity. Under asymmetric learning, past wage increase of a worker positively correlates with the worker's ability and is information that later employers cannot take into account in their wage offers. Conditional on a worker's employment history, in a pool of workers who look the same to a new employer, a worker who is revealed to be productive to his prior employer is more likely to be of high productivity, and thus, more likely to be productive later, and receive higher wage raises later on. Under symmetric learning, however, all the information revealed to econometricians through past wage changes is already available to later employers. When workers changes firms, there is no pooling that happens. All the available information, including past performances, has already been taken into account and reflected in the new firm's offering wages. Thus, conditional on the new firm's offering wage, past wage changes should add no new information and should not predict future wage changes. Thus, given workers' employment and wage histories, we can test whether the learning is asymmetric or symmetric by testing whether past wage changes predict future wage changes, conditional on observable characteristics, employment history and current wage levels.

Given the above idea, we develop a two-step testing strategy as follows. Consider the set of workers who have just switched to a new firm. First, we regress future wage on current wage and all the other observable characteristics. Given the estimated parameters, we predict the residual of the fitted regression. The residual term then measures how much the actual future wage deviates from what we would expect from his current wage and other characteristics. Then, we take the residual of the first stage regression and regress the residual on past wage increase. If learning is symmetric, past wage increase should not predict future wage conditional on current wage; thus, we should observe the estimated parameter on past wage increase in the second stage regression to be close to zero. On the other hand, if learning is symmetric, past wage increase should reveal positive signal about the employee's productivity, which has not been taken into account into the current wage. Therefore, we should expect the estimated parameter on past wage increase in the second stage regression to be positive.

Due to data accessibility, at this stage, we are not able to implement our test on an administrative data set, which is the type of data that our testing method is most suitable for. Instead, we have implemented our testing strategy with the publicly available National Longitudinal Survey of Youth 1997 (NLSY97). With data from NLSY97, our empirical result gives a close to zero and insignificant estimated parameter of past wage increase in the second stage regression, and thus, is consistent with symmetric rather than asymmetric learning.

The rest of this chapter is organized as follows. In section 2, we set up a model of learning with multi-periods and analyze the model predictions on wage patterns under both symmetric and asymmetric learning hypotheses. We also explore the robustness of our model predictions under alternative model specifications. In section 3, we discuss the strategy of empirical implementation based on our theoretical predictions. In section 4, we describe the data set and discuss our empirical results. In section 5, we conclude and discuss the limitations of our testing strategy.

3.2 The Model

3.2.1 Model Setup

Let there be many workers and many firms. Workers live for N periods while firms are infinitely lived. Workers maximize expected utility and firms maximize profits. The discount factor is $\delta < 1$.

Productivity Signals

Let η_i be a worker's productivity and X_i be the set of characteristics that employers can observe when the worker enters into the labor market. Let $\eta_i^0 = E(\eta_i|X_i)$ be the initial expectation of the worker's productivity based on observable characteristics, and $e_i = \eta_i - \eta_i^0$ be the difference between a worker's real productivity and the expectation. Assume the error term e_i is normally distributed with mean 0 and variance σ_0^2.

In each period, the incumbent firm observes a signal $s_{it} = \eta_i + \epsilon_{it}$ of the employee's productivity. Assume that the noise term ϵ_{it} is independent each period and normally distributed with mean 0 and variance σ_ϵ^2.

For outside firms, we consider two hypotheses, the symmetric learning hypothesis and the asymmetric learning hypothesis. Under the symmetric learning hypothesis, outside firms also observe s_{it}, thus have exactly the same information as incumbent firms. Under the asymmetric learning hypothesis, s_{it} is observed by the incumbent firm only.

The Labor Market

Let the labor market be competitive. When a new worker enters the labor market, all firms make simultaneous wage offers based on $(\eta_i|X_i)$, the worker's believed productivity η_i given X_i. The worker always chooses the firm with the highest wage offer.

When there is a tie, he picks randomly from firms with highest wage offers.

At the end of each period, an employed worker has the option to switch to another firm. Under the asymmetric hypothesis, outside firms make offers according to $(\eta_i|X_i, H_i^t)$, where H_i^t is the worker's employment history. Under the symmetric learning hypothesis, outside firms also take into accoun the productivity signals S_i^t and make offers according to $(\eta_i|X_i, H_i^t, S_i^t)$. The incumbent firm then makes the continuation wage offer based on the worker's best outside wage offer w_{it}^o and the firm's belief $(\eta_i|X_i, H_i^t, S_i^t)$ about the worker's productivity.

Before the worker decides whether to switch, he privately observes a random switching cost $\theta_{it} \sim G(\cdot)$. Let PV denote the expected present value of the worker's future income stream. The worker makes the switch if $PV_{it}^{switch} - PV_{it}^{stay} > \theta_{it}$.

3.2.2 Model Analysis

Learning Update of Employers

The Symmetric Learning Case Under the symmetric learning hypothesis, outside firms observe the productivity signals and have the same information as the incumbent firm. The process of employers' learning about a worker's ability is thus the same for all employers.

Given the normally distributed error term e_i and the signal noise term ϵ_{it}, the learning update of a worker's productivity follows the normal update rule. Let t_i be the period at which worker i enters the labor market. Let $h_0 = \frac{1}{\sigma_0^2}$ and $h_\epsilon = \frac{1}{\sigma_\epsilon^2}$, the updating process is:

$$\eta_{it_i} = \eta_i^0, \; h_{t_i} = \frac{1}{\sigma_0^2};$$

$$\eta_{it} = \frac{h_{t-1}\eta_{i,t-1} + h_\epsilon s_{it}}{h_t}, \; h_t = h_{t-1} + h_\epsilon \; \forall t > t_{i1}. \qquad (3.2.1)$$

At the end of each period, employers update the worker's expected productivity according to new signal s_{it}. The updated conditional distribution of the worker's productivity is still normally distributed, with the mean η_{it} and variance $1/h_t$.

Lemma 12. *Under the symmetric learning hypothesis, taking* X_i, H_i^t, S_i^t as given, *a worker's updated productivity distribution* $(\eta_i|X_i, H_i^t, S_i^t)$ *is normally distributed with* $N(\eta_{it}, h_t)$, *where* η_{it} *and* h_t *are given by 3.2.1.*

The Asymmetric Learning Case Under the asymmetric learning hypothesis, outside firms no longer have the same information as the incumbent firm. The process of employers' learning about a worker's ability is now dependent on the worker's working history H_i^t.

At period t, for a worker who has never switched firms since he entered the labor market, his current employer has complete information on all the productivity signals S_i^t. It is easy to see that, in this case, the employer's learning update about the worker's productivity is exactly the same as the normal updating process 3.2.1 under the symmetric case.

However, if a worker has ever switched firms, his current employer does not observe the complete history of S_i^t. Let t_s be the period when the worker switches to his current firm. The firm now makes expectations about the worker's productivity based on his working history H_i^t and partial signals after switch $S_i^{t_s,t}$.

Due to information asymmetry and adverse selection upon switching, the believed distribution of η_i, conditional on a history with switches is no longer normal. The learning update by the worker's second and later firms thus no longer follows the normal updating rule.

Although the distribution of $(\eta_i|H_i^t, S_i^{t_s,t})$ is complex and dependent on the equilibrium wages, the belief updating still satisfies some tractable properties. Intuitively, even though the starting conditional distribution of η_i is no longer normal, higher later signals still suggest that the worker is more likely to be of higher η_i. This intuition is formally established in the following Lemma.

Lemma 13. *Under the asymmetric learning hypothesis, consider a worker with working history H_i^t and partially observed productivity signals $S_i^{t_s,t}$. Then, for any $t > t_s$, if $s_{it} > s'_{it}$, the conditional distribution $D(\eta_i|H_i^t, S_i^{t_s,t-1}, s_{it})$ first order stochastic dominate $D(\eta_i|H_i^t, S_i^{t_s,t-1}, s'_{it})$.*

Wage Determination and Model Implications

The Symmetric Learning Case Let y_{it} denote output and PR_{it} denote the present value of the profit that the incumbent firm expects to earn from an employed worker. Given the outside wage offer w_{it}^o, the incumbent firm chooses w_{it} to maximize:

$$Pr(stay)(E(y_{it}|\eta_{i,t-1}, h_{t-1}) - w_{it} + \delta E(PR_{it+1}|\eta_{i,t-1}, h_{t-1})). \tag{3.2.2}$$

Note that, under the symmetric learning case, an outside firm becomes an incumbent firm one period after a worker's switching. And since the learning update is the same whether the worker makes the switch or not, we know that $PV_{i,t+1}^{switch} = PV_{i,t+1}^{stay}$. Therefore, it is easy to see that:

$$Pr(stay) = 1 - G(PV_{it}^{switch} - PV_{it}^{stay}) = 1 - G(w_{it}^o - w_{it}). \tag{3.2.3}$$

.

Also, since outside firms make competitive offers, we know:

$$w_{it}^o = E(y_{it}|\eta_{i,t-1}, h_{t-1}) + \delta E(PR_{it+1}|\eta_{i,t-1}, h_{t-1}). \tag{3.2.4}$$

Combining 3.2.3 and 3.2.4 with 3.2.2, we can simplify the maximization problem as:

$$(1 - G(w_{it}^o - w_{it}))(w_{it}^o - w_{it}). \tag{3.2.5}$$

Let d be the solution to $G(d) + g(d)d = 1$. The wage process under symmetric learning are then:

$$w^o_{it} = E(y_{it}|\eta_{i,t-1}, h_{t-1}) + \delta d,$$

$$w_{it} = E(y_{it}|\eta_{i,t-1}, h_{t-1}) - (1-\delta)d \ \forall t < t_i + N;$$

$$w^o_{it} = E(y_{it}|\eta_{i,t-1}, h_{t-1})$$

$$w_{it} = E(y_{it}|\eta_{i,t-1}, h_{t-1}) - d \ \forall t = t_i + N.$$

Now that we have the expression for wages, we can derive the theoretical prediction of wage patterns under symmetric learning.

Proposition 14. *Under the symmetric learning hypothesis, if y_{it} is increasing in η_i, a worker's next period wage conditional on his current wage and experience is independent of his past wages. In particular, we have*

$$Pr(w_{i,t+1}|w_{i,t}, t, w_{i,t'}) = Pr(w_{i,t+1}|w_{i,t}, t) \ \forall t' < t.$$

Proposition 14 states that, with symmetric learning, a worker's current wage and experience is sufficient statistics for the prediction of his next period wage. Conditional on current wage and experience, workers' past wages have no additional effect on future wages, as any effect of past wages would have been taken into account in the current wage.

The Asymmetric Learning Case In the symmetric learning case, the derivation of the wages is greatly simplified, as the probability of a worker staying $(1 - G(PV^{switch}_{it} - PV^{stay}_{it}))$ can be reduced to $1 - G(w^o_{it} - w_{it})$ and is independent of the worker's employment and performance history. The simplification is possible because, one period after a switch, a worker's new employer becomes an incumbent and the wage setting and information of this new incumbent would be exactly the same as if the worker has not switched.

Under asymmetric learning, this is no longer the case. One period after a worker's switch, due to asymmetric learning, the expected future payoff from the new firm would not be the same as if he had stayed with his old employer. What's more, a worker's expectation of the future payoffs depends not only on his employment history, but also on his own assessment of his productivity η_i and his expectation of firm's wage functions. As a result of the complexity, it is impossible to derive a closed form expression of wages under the asymmetric learning case.

However, with the properties of the learning update as stated in Lemma 13, we can still derive implications of wage patterns under some weak assumptions on equilibrium wages.

Definition 15. Let D_{it} be the conditional distribution of η_i in period t given all the observable information to worker i's current employer. We say that the wage function w is increasing in D_{it} if $w(H_i^t, D_{it}) \geq w(H_i^t, D_{it}^{'})$ whenever D_{it} first order stochastic dominate $D_{it}^{'}$.

Consider a worker who switched firms in period t_s and stayed in the same firm in period $t_s + 1$. Let $t_{s'}$ be the period when the worker started working for his previous firm.

Proposition 16. *Under the asymmetric learning hypothesis, if the equilibrium wage is increasing in D_{it}, then* $E(w_{i,t_s+1}|w_{i,t_s}, H_i^{t_s}, w_{i,t'})$ is increasing in $w_{i,t'}$ for all $t_{s'} < t' < t_s$.

Proposition 16 states that, under asymmetric learning, a worker's future wage conditional on current wage and employment history is no longer independent of past wages, as in the symmetric case. In particular, past wage information with the worker's previous employers is not available to the current employer and is not taken into account in the switching wage offer. Furthermore, given what we've established in Lemma 13, and the assumption that wages are increasing in the employer's belief as defined in Definition 15, we can show that the expected future wage after switch, conditional on current wage and employment history, is increasing from past wages.

Robustness of the Model Prediction

In the previous subsection, we've shown in Proposition 14 and Proposition 16 that, conditional on current wage and employment history, past wage is independent of future wage changes in the symmetric case, but not in the asymmetric case.

Intuitively, the prediction that past wages positively predict future wages in the asymmetric learning case is easy to understand. Under asymmetric learning, past wages contain information that reveals the employee's ability, but is not taken into account by the current employer. Even if we relax the asymmetric learning assumptions to allow outside firms to also observe partial performance signals, as long as outside firms are not as well informed as inside firms, and wages contain information not available to outside firms, the model prediction remains unaffected.

Given the intuitive robustness of the prediction under the asymmetric hypothesis, if the data shows zero correlation between past wage and future wage conditional on current wages, we could be relatively confident that there is no significant asymmetric learning happening, at least to the point that revealing wage histories would have no significant effect on wage settings.

On the other hand, the prediction that future wages should be independent of past wages conditional on current wage and experience with symmetric learning seems more subtle. In particular, it is not intuitively clear whether this prediction will remain robust under situations beyond the setting of our model. To make sure we could correctly interpret the empirical result in the case when the data shows significant positive correlation between past and future wages conditional on current wages, we shall now consider some common alternative assumptions and their effect on our model prediction under symmetric learning.

Human Capital Accumulation Throughout our previous analysis, we have not explicitly specified the term of human capital accumulation. In our previous model setting, the productivity term η_i is chosen by nature at period 0 and fixed throughout the worker's life. In real life, as workers acquire human capital, their productivity is likely increasing with experience. Next, we shall show that, as long as there exists a single variable, such as ability, which determines both the starting productivity and the speed of learning, the result in Proposition 14 would still hold.

Let a_i be the worker's ability, which is chosen by nature at period 0 and fixed throughout the worker's life. Let both the starting productivity and the speed of learning be determined by a_i. Then the productivity function can be expressed as $\eta_i(t) = f(t)a_i$, where $f(t)$ is a function of t that describes the learning curve of workers. With this setting, our previous model without human capital accumulation is just a special case when $f(t)$ is constant.

Let the employer's information structure be the same as before; i.e., the firm still receives signals $s_{it} = \eta_i(t) + \epsilon_{it}$ on the worker's productivity each period. Since $\eta_i(t)$ is basically a function of a_i, the employer's learning process is similar to before, except that now, the learning happens over a_i rather than over η_i. The learning update over a_i is still normal as before. The only difference now is that later signals will receive higher weight compared to early signals if we assume ϵ_{it} is still distributed with the same variance ϵ_{it} in each period. Then, with the normal updating, we would still have the result that, the state of the learning can be summarized by the current state mean a_{it} and experience t. And since wages are set according to the employer's belief on $\eta_i(t)$, which is essentially determined by a_{it}, the result in Proposition 14 would still hold after including the term of human capital accumulation.

Alternative Wage-Setting Mechanisms In our previous analysis, we've assumed that firms set wages to maximize expected profit under a moving mechanism with a random per period moving cost of θ_{it}. With this specification, we were able to derive functional forms of the wage function under the symmetric learning case. Now, we shall show that our model prediction in Proposition 14 does not depend on these details of the model and is robust with a wide range of alternative wage-setting mechanism.

In particular, suppose the wages are set according to wage bargaining between the employer and employees instead of by wage posting. Let the bargaining power of the employee be β and the reservation wage be R. The employee's wage under the simple Nash bargaining would be $w_{it} = \beta E(y_{it}|\eta_{i,t-1}, h_{t-1}) + (1-\beta)R$. It is easy to see from the functional form that the result of Proposition 14 still holds. Moreover, the result of Proposition 14 does not even require any specific form of the wage function. As long as w_{it} is *strictly* increasing in $E(y_{it}|\eta_{i,t-1}, h_{t-1})$, combined with the properties of the learning, the independence of future wages from past wages conditional on current wage and experience still holds.

3.3 Empirical Implementation

With our model predictions specified in the previous section, we shall now move on to the strategy of empirical implementation.

Let t be the period when a worker has just switched to a new firm. Let X_i be the set of observable characteristics when the worker enters the market and Z_{it} be the set of characteristics that is observable and is changing with time, such as the worker's employment history. Expressing the wage function in terms of current wage and other observable characteristics, we have:

$$w_{i,t+1} = \beta_0 + \beta_1 w_{i,t} + \beta_2 Z_{i,t+1} + \beta_3 X_i + u_{i,t+1}. \tag{3.3.1}$$

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Given our result in Proposition 14, the residual term $u_{i,t+1}$ in 3.3.1 should be independent with $w_{i,t-1}$ if learning is symmetric and positively correlated with $w_{i,t-1}$ if learning is asymmetric.

If we, the cliometricians can observe the complete set of X_i as the employers observe, our testing strategy would simply involve running the regression as in 3.3.1 and then running a second stage regression of $u_{i,t+1}$ on $w_{i,t-1}$ and testing whether the coefficient on $w_{i,t-1}$ is positive.

However, due to limitation of the data, it is unlikely that the characteristics included in the data cover the full set of X_i. Let X_{1i} be the set of characteristics in X_i that can be observed in the data and X_{2i} be those that we cannot observe; the wage expression is now:

$$w_{i,t+1} = \beta_0 + \beta_1 w_{i,t} + \beta_2 Z_{i,t+1} + \beta_3 X_{1i} + \beta_4 X_{2i} + u_{i,t+1}. \tag{3.3.2}$$

Since we can not observe X_{2i}, running the regression with only what we can observe will give biased estimates, and more importantly, X_{2i} will still show up in the estimated residual $\hat{u}_{i,t+1}$. Since X_{2i} also determines $w_{i,t-1}$, our prediction will fail as there would always be a positive correlation between $\hat{u}_{i,t+1}$ and $w_{i,t-1}$. To resolve this problem, in our second stage testing, we use $(w_{i,t-1} - w_{i,t-2})$ instead of $w_{i,t-1}$ to cancel out the X_{2i} term.

Therefore, our testing strategy is as follows. In the first step, we estimate:

$$w_{i,t+1} = \hat{\beta}_0 + \hat{\beta}_1 w_{i,t} + \hat{\beta}_2 Z_{i,t+1} + \hat{\beta}_2 X_{1i} + \hat{u}_{i,t+1}. \tag{3.3.3}$$

In the second step, we estimate:

$$\hat{u}_{i,t+1} = \hat{\gamma}_0 + \hat{\gamma}_1(w_{i,t-1} - w_{i,t-2}) + \mu. \tag{3.3.4}$$

Here, $\hat{u}_{it}$ measures how much $w_{i,t+1}$ is higher than expected given $w_{i,t}$ and other observable characteristics, and $(w_{i,t-1} - w_{i,t-2})$ is the wage increase in period $t-1$, when the employee is still working for the previous employer. If learning is symmetric, since the information on an employee's productivity associated with the previous wage increase is already known to the current employer and shown in $w_{i,t}$, whether the employee performs out of expectation in the next period should be independent of past wage increase. Therefore, we would expect $\hat{\gamma}_1 = 0$. On the other hand, if learning is asymmetric, higher past wage increase reveals positive information about the employee's productivity that has not been taken into account in $w_{i,t}$, and we would expect $\hat{\gamma}_1 > 0$.

3.4 Empirical Test

3.4.1 Description of Data and Variables

In this section, we shall implement our testing strategy using the National Longitudinal Survey of Youth 1997 (NLSY97), which traces information from the same set of individuals from 1997 to 2011. The advantage of using the National Longitudinal Survey of Youth is that it contains information on individuals' early careers when learning is the most important. Previous tests of learning by Farber and Gibbons (1996), Altonji and Pierret (2001) and Schonberg (2007) use the early NLSY79 version of the same survey.

Since our test is about employers' learning, we include only observations when the individual is working at a regular employee job. We consider a period as one year and take an individual's wage at the first job during year t as w_{it}. To avoid the result being driven by outliers, we exclude the observation if wage is lower than 1 or higher than 6000. Our two-step test requires the observation of wages during four consecutive periods w_{t-2}, w_{t-1}, w_t and w_{t+1}, and that the worker is working for one firm in period t and $t+1$ and a different firm in period $t-2$ and $t-1$. Without considering the possible missing values in other control variables, the number of observations satisfying the above requirement is 4898. The average wage in this sample is 1317 with a standard deviation of 761.

For control variables, we include basic employment information on experience, tenure and tenure at the previous job, all of which are measured in weeks. We also include firm-specific information on industry, occupation and firm size. Individual characteristics include education, age, sex and race. Education is given in seven different levels of degrees. The summary statistics of key variables are shown below in Table 3.1.

	Min	Max	Mean	Std. Dev.	No. Observations
Wage	194	6000	1317	760.9	4898
Experience in weeks	0	839	301	150.2	5257
Tenure in weeks	0	622	82	47.5	5197
Degree	0	7	2.32	1.18	5227
Age	17	31	24.67	3.07	5257

Table 3.1: Summary statistics of key variables.

3.4.2 Empirical Results

With the data from NLSY97, we implement our test with the two-step empirical strategy discussed in the previous section. The result of the test is shown in Table 3.1. The first stage regression predicts future wage based on current wage and other observable characteristics. In specification (1), we included experience, tenure at current job, tenure at previous job, education, age, sex, race and year dummies. In specification (2), we included additional control of firm-specific characteristics, including employer size, industry and occupation.

The results are similar across specifications. In both specifications, in the first stage regression, the parameter on current wage, experience, education and age are significantly positive. The parameter on being female is significantly negative. Under both specifications, the parameters on tenure and tenure at previous job are small and insignificant. From specification (1) to specification (2), the magnitude of all significant parameters decreases. This is consistent with the inclusion of additional controls, which are likely correlated with those previous controls because of sorting.

Our key parameter of concern, the estimated parameter on past wage increase in the second stage regression, is very close to zero and insignificant in both specifications. In specification (1), the estimated parameter is 0.0141 with a standard error of 0.0167. In specification (2), the estimated parameter is further reduced to 0.00681 and the standard error is 0.0138. Since the estimates are close to zero and insignificant, our result is consistent with the prediction under the symmetric learning hypothesis and shows no support of asymmetric learning.

3.5 Discussion and Conclusion

In this paper, we proposed a new method of testing asymmetric learning using wage data. This method takes advantage of the fact that employers adjust wages according to their learning and updated belief about an employee's productivity. Thus, past wage changes reveal information about an employee's performance, which are not observed by later employers under the asymmetric learning hypothesis. On the other hand, if the learning is symmetric, any information revealed by past wages should have already been observed by current employers. With the difference between the two learning hypotheses, we are able to test asymmetric learning based on whether past wages positively predict future wage conditional on current wage and other observable characteristics. With NLSY97, we find the data is consistent with symmetric rather than asymmetric learning.

The key advantage of our model is that our testing strategy requires only the observation of wages and employment histories, making it possible for our test to be used with an administrative data set. The advantage of an administrative data set is that it is usually much larger and very precise; thus, we would have very accurate testing results. The disadvantage of our model is, as we use wage patterns for prediction, we require four consecutive observations of wages and require a particular employment pattern across the four periods. If our method is used with survey data sets, our sample size can be greatly reduced by missing value problems. Combined with the rough recordings of wage information in survey data sets, the accuracy of the test can be greatly reduced. Given the advantages and disadvantages of our testing method, it would be ideal to use our testing method with administrative rather than survey data, and we hope to be able to implement our test on administrative data in the future.

	Two Stage OLS Regression			
	(1)		(2)	
Independent Variable	First Stage: $\ln(w_{i,t+1})$	Second Stage: $\hat{u}_{i,t+1}$	First Stage: $\ln(w_{i,t+1})$	Second Stage: $\hat{u}_{i,t+1}$
$\ln(w_{i,t})$	0.802***		0.688***	
	(0.00880)		(0.0118)	
Experience	0.000103**		9.49e-05**	
	(4.23e-05)		(4.45e-05)	
Tenure at Current Job	8.14e-05		0.000146	
	(9.18e-05)		(9.45e-05)	
Tenure at Previous Job	4.59e-05		6.63e-05	
	(5.35e-05)		(5.39e-05)	
Education	0.0288***		0.0174***	
	(0.00365)		(0.00437)	
Age	0.00754**		0.00567*	
	(0.00316)		(0.00323)	
Female	-0.0433***		-0.0343***	
	(0.00788)		(0.00947)	
$\ln(w_{i,t-1}) - \ln(w_{i,t-2})$		0.0220		0.00415
		(0.0158)		(0.0136)
Observations	4,596	4,248	3,861	3,587

*** p<0.01, ** p<0.05, * p<0.1

Race and Year Dummies included in Specification (1). Race, Year, Employer Size, Industry and Occupation Dummies included in Specification (2).

Table 3.2: Results of the two stage OLS regression

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CURRICULUM VITAE

YAO SHU
270 Bay State Road
Boston MA 02215 USA
Cell: (914) 414-2820
Fax: (617) 353-4449
Email: dianashu@bu.edu

EDUCATION

Ph.D., Economics, Boston University, Boston MA, May 2016 (expected)
Dissertation Title: Learning, Favoritism and Incentive Provision within Organizations
Main advisor: Andrew Newman

B.S., Applied Mathematics (First Class Honors), National University of Singapore, Singapore, 2010

FIELDS OF INTEREST

Organizational Economics, Labor Economics, Microeconomic Theory

TEACHING EXPERIENCE

Teaching Fellow, Microeconomic Theory (Masters Level), Department of Economics, Boston University, Fall 2014

Teaching Assistant, Advanced Microeconomic Theory I: Decision Theory and General Equilibrium (Ph.D. Level), Department of Economics, Boston University, Fall 2013, Fall 2012

Teaching Assistant, Advanced Microeconomic Theory II: Game Theory and Information Economics (Ph.D. Level), Department of Economics, Boston University, Spring 2014, Spring 2013

WORK EXPERIENCE

Research Assistant, Professor Kevin Lang, Department of Economics, Boston University, Summer 2013

Research Assistant, Professor Larry G. Epstein, Department of Economics, Boston University, Summer 2012

FELLOWSHIPS AND AWARDS

Deans Fellow, Boston University, Fall 2010-Spring 2015

Deans List, National University of Singapore, Fall 2006-Fall 2010

WORKING PAPERS

Favoritism, Influence and Employee Incentives in Large Organizations, November 2015.

Testing Asymmetric Learning with Wage Data, November 2015.

Employer Learning, Firing Threat and the Peter Principle, November 2015.

WORK IN PROGRESS

Multi-lateral Relational Contracts and the Efficiency of Long Term Relationships

A Human Capital Based Theory of the Firm