The Optimal Policy to Reward the Value Added by Educators: Theory and Evidence from China

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Abstract

Over the last thirty years, education reform has been a constant topic of debate for both policy makers and social scientists. Recent reform proposals have suggested policies to be built on what students actually accomplish and reward instructors who induce good performance by students. In this paper we demonstrate that incentive contracts combining objective and subjective performance evaluations can mitigate incentive distortions caused by imperfect objective measure (i.e.teaching towards test). Moreover, when we combine the explicit contract based on an objective performance measure and the implicit contract based on a subjective performance measure, the joint incentive bonus provided is increasing with the variation of the objective performance measure. We further examine China's teacher evaluation system as it has many desirable features, in particular the use of objective and subjective performance incentives to reward teachers. Our preliminary estimates indicate that teacher salaries are indeed positively related to objective performance and subjective performance measures; increases in salary are greater for higher ranked instructors; and instructors who are more educated, married, male, experienced and who encounter fewer students within a week are more likely to be higher ranked.

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1 Introduction

A common thread runs through many recent proposals for the reform of American K-12 education system: the notion of using students' performance on achievement tests or assessments as a basis for rewarding educators and school systems. The logic behind these proposals is simple and compelling: since student achievement is the primary goal of education then providing teachers with incentives tied to the amount of learning they induce would focus and intensify their efforts. The proposal of the Panel on the Economics of Education Reform (PEER) (Hanushek et al. 1994) is an example of a reform approach that would rely heavily on holding educators accountable for improving student's performance. The PEER proposal focuses on three elements: the efficient use of resources, continuous adaptation and performance incentives for educators based on assessments of student performance. The proposal asserts that effective management requires a system take into account the many sources of educational performance, some of which are not the responsibility of the school, and maintains that schools should therefore be held accountable only for their value added.

In the United States teacher compensation has typically been tied to extrinsic measures of quality, such as highest degree attained. However, the many studies find little correlation between such extrinsic measures and student performance[1]. The lack of a relationship between resources and performance surprises many people but perhaps should not. Schools are easily distinguished from other more successful institutions in that rewards to their employees are only vaguely associated with performance. A teacher who produces exceptionally large gains in her students performance generally sees little difference in compensation, career advancement or job status when compared with a teacher who produces exceptionally small gains. With few incentives to obtain improved performance, it should not be surprising that resources have not been systematically used.

Since it is student achievement that matters, there is a growing interest in the United States in tying the

[1]See Hanushek (1986) for a survey of studies that have attempted to account for teacher skill differences. Measures include indicators if the teacher is teaching the subject in which she was granted a degree, principals' evaluations, teaching techniques and as discussed in the text the highest degree obtained.

compensation of teachers to measures of their performance. One might measure a teacher's performance by the performance of that teacher's students, factoring out the contributions that are attributable to other influences, such as prior achievement and peer group effects. This approach presumes that whatever variations in the average of student test performance from class to class that cannot be accounted for by measured differences must be attributed to differences in the quality of instruction across classrooms. This approach is not feasible since it relies on the presumption that accurate measures of peer and family effects exist. Yet this presumption may not be warranted. There is some limited evidence that the subjective evaluation of principals and school administrators of the effectiveness of the teachers can be highly correlated with achievements of students[2]. If such subjective valuations are good predictors of student achievement then they might be used as a basis for a performance based payment system.

Performance contracts typically involve developing explicit contracts that base rewards on meeting various performance goals. There exists a great fear that such contracts could distort the behavior of educators and students. For example, tying pay to performance on specific tests may lead to narrowing of instruction within subject areas as instructors reduce their emphasis on untested subject areas. Instructors further may increase the use of in class drills and test preparation sessions.

Furthermore, since there is no single agreed upon best approach to performing specific educational tasks, it is simply not possible to design policies that are based on full descriptions of what is to be done and how it is done in the classroom[3]. An additional complication is that there are other desired outcomes of schooling. Much of what many individuals need to learn will arise after they leave public schools in later education, in the workplace and in civic life. The extent to which they are successful in this later learning may depend in a substantial part on the body of knowledge and skills that students have at graduation, much of which can be tested. But is also likely to depend

[2]Munrane (1975) found that students taught by effective teachers learn much more in school than students who are taught by ineffective teachers.

[3]There are many equally effective approaches to learning various subjects and skills, differentiated by how individual students and teachers adapt to specific tactics and techniques.

on attitudes and habits that are not typically measured by achievement tests. Thus an accountability system that produces high test scores at the price of poor performance on unmeasured outcomes may be a poor bargain[4].

Currently, in the United States several states and a few local districts have introduced school based performance incentive programs. Unfortunately there has not been many evaluations of these programs. Ladd (1999) evaluates the program introduced in Dallas which rewards members of the school staff based on estimated value added and finds some limited evidence of positive impacts on student's performance[5]. Lavy (1999) uses a regression discontinuity design to identify the causal effect of teachers' performance incentives on student performance in Israel and again finds evidence of positive impacts[6].

School based performance incentive programs typically divide the total incentive payment among individuals within the school regardless of individual performance. However group incentives may be less effective than individual incentives due to the free rider problem[7]. In China, administrators and distinguished teachers evaluate the performance of each teacher. This evaluation along with other factors are used to determine a significant component of teachers' compensation. We have collected a unique data set from east China that allows us to measure the contribution of the quality of the teachers a student has had access to during the course of her secondary school education to that student's academic achievement, as measured by scores on college admission examinations. The goal of this paper is to demonstrate that an incentive compensation scheme composed of both objective and subjective

[4]See Haney and Raczek (1994) for a discussion. In the economics literatue, Holmstrom and Milgrom (1991) point out that if incentive pay is only linked with some outcome measures, multitask agents perform strategically and moral hazard issues arise.

[5]These results should be interpreted with caution since a variety of selection issues are not dealt with including i) controlling for students who transfer betwen schools, ii) parents choice of neighborhood affect school enrollment decisions and iii) the fact that schools exercised discretion in who wrote these exams. In addition, Ladd and Walsh (1999) argue value added measures of school effectiveness that are based on test scores alone do not measure school efficiency, distort incentives and are likely to discourage good teachers from working in schools seving primariliy disadvantaged students.

[6]The appropriateness of this identification strategy depends crucially on the assumption that schools in his treatment and control groups do not differ on observable factors and unobservable factors.

[7]Despite the potential free rider problem, group incentives are fairly widespread based on standard arguments that individuals who share a common goal are likely to help and monitor each other. However, temwork requires substitutuion among inputs which is not perfect within schools (a math teacher can not teach music at the same level). In addition, Gaynor and Pauly (1990) provide empirical evidence suggesting that group incentives are more efficient the smaller the group. Schools are relatively large organizations and it is difficult for teachers to monitor each other when they do not regularly observe their colleague's performance in the classroom.

performance evaluations of student performance and evaluation of teacher quality can be superior to one which is predicated on objective evaluation of students alone. The idea underlying the model is that subjective performance evaluations (i.e. principal's evaluations) can be used to correct any possible distortions in teacher incentives generated by an objective performance evaluation (i.e. students' test scores) first design a contract between the school boards and teachers which includes incentives for both objective and subjective performance to motivate and increase teachers' effort. The Chinese system demonstrates the feasibility of such a system and may hold lessons for other systems. We examine China's teacher compensation scheme in detail and demonstrate that there are strong financial systems to achieve high performance evaluations and that promotions reward teaching quality effectively.

This paper is organized as follows. In the next section we introduce our model and demonstrate how an incentive scheme composed of objective and subjective performance evaluations can increase teacher effort. In section 3, we describe the secondary education system in China and discuss the data that we utilize to estimate our model. This is to the best of our knowledge the first study to employ individual level data on students and school inputs from China. We empirically examine China's salary schedule in detail in Section 4. We find that the system in China is indeed rewarding teachers based on the criteria upon which it is designed and that there are strong financial incentives for teachers to improve their performance. In section 5, we discuss the econometric methodology that we use to estimate the promotion history of China's teachers. Estimates of the factors that affect promotion are found in section 6. Promotions are found to reward teaching quality effectively quality effectively. Our concluding thoughts and directions for future work are provided in section 7.

2 Theory

2.1 The economic environment

We consider a repeated game between a school and its teachers. The school does not know the quality of a newly hired teacher[8]. There are two types of teachers, who differ only in their teaching abilities. With probability α, the school meets with a teacher of type H (high teaching ability); and with probability $1-\alpha$, the teacher is of type L (low teaching ability). The school's objective in a labor contract is to maximize teachers' contribution to the students' human capital (hc) each period less the wage payment ($wage$) to teachers. For simplicity, we assume hc takes the value of either zero or one.

Each period, the teacher chooses an unobservable effort level e, which stochastically determines her contribution to the school's objective $hc - wage$. When the teacher is of type H and chooses her effort level to be e, hc equals one with probability ε : $prob\{hc = 1|\ e, H\} = \varepsilon$. When the teacher is of type L and chooses her effort level to be e, hc equals one with probability $p\varepsilon$: $prob\{hc = 1|\ e, L\} = p\varepsilon$, where $e \in [0,1]$ *and* $p \in (0,1)$. Thus p is the productivity difference between high and low ability teachers. We assume that a teacher's contribution to the students' human capital is too complicated and subtle to be included in any explicit contract but otherwise can be subjectively evaluated.

The teacher's effort also contributes to a second variable t, which can be objectively evaluated. An example of t in the real world would be students' test scores. We assume t to be either zero or one as hc. Let μ define the difference between the effect of a teacher's effort on school's objective hc and that on objective performance measure t. Each period a teacher observes μ prior to exerting effort but after accepting the contract. Thus the probability that $t = 1$ is $\mu \cdot \varepsilon$.[9] μ is private information to the teacher. This private information can be interpreted as the state of the students she faces in each period. If the students she has are disruptive, then high effort increases hc but not t since she has to devote effort teaching discipline and less in knowledge — μ is close to zero; if the students

[8] Our model extends the benchmark model discussed in Baker, Gibbons and Murphy (1994). There are two major differences between our model and that of Baker, Gibbons and Murphy (1994). First, we introduce teacher's type as hidden information. Second, a teacher cannot be fired once hired by assumption while in their paper, a firm can decide to fire a worker after any period even though in equilibrium, the worker is never fired.

[9] We assume that the support of μ and the shape of the disutility function introduced later are such that $\mu \cdot \varepsilon < 1$. It is easier to think of μ as a ratio of effort.

are well disciplined, high effort increases both hc and t — μ is close to one; if the students are well disciplined and well-equipped in test skills, small effort can increase t but not hc since students can be taught to memorize knowledge without really understanding — μ is greater than one. We assume $E\{\mu\} = 1$: on average t is an unbiased measure of hc.

The school can offer a contract based on a fixed salary s, a bonus β_1 paid to the teacher when $t = 1$ is realized and a bonus β_2 paid to the teacher when $hc = 1$ is realized. For simplicity and the purpose of static comparison we consider the optimal linear incentive contracts. We restrict our attention to the institutional environment where only one contract can be offered to either type of teacher to accord with the data. This means that teachers cannot be differentiated by different contracts offered up-front.

The timing of the events in each period is as follows: First, the school offers the contract (s, β_1, β_2) to the teacher. Second, the teacher decides whether to accept this contract. Her reservation payoff (utility) from an alternative employment opportunity is W_H if her type is H and W_L if her type is L. After she accepts the contract, she will observe the state μ and decides her effort level e. At the end of the period, hc and t are realized and the school pays the teacher s and β_1 according to the contract but will decide whether to honor β_2 since it's non-verifiable by a third party.

Upon receiving a contract, H type teacher decides her effort level e_H such that

$$\max_{e_H} s + \mu e_H \beta_1 + e_H \beta_2 - \gamma e_H^2 \tag{IC1}$$

and L type teacher decides her effort level e_L such that

$$\max_{e_L} s + \mu p e_L \beta_1 + p e_L \beta_2 - \gamma e_L^2 \tag{IC2}$$

Solving the first order conditions, we derive the optimal effort levels

$$e_H(\mu, \beta_1, \beta_2) = \frac{\mu\beta_1 + \beta_2}{2\gamma},$$

$$e_L(\mu, \beta_1, \beta_2) = \frac{\mu\beta_1 + \beta_2}{2\gamma} p$$

2.2 The optimal contract with no incentive compensation

From the first order conditions it is easy to see that the effort level of both teacher types would be zero[10] if no incentive compensation is offered. The school's expected payoff is $-W_i$ depending on which type of teacher they would hire. It is obvious that the school would only want to hire a L type teacher since it costs them less. This yields the first proposition of the model.

Proposition 1 *The optimal fixed salary contract is ($s = W_L$). Only the low ability teacher would accept this contract and zero effort is exerted regardless of the realization of the state (μ).*

2.3 The optimal explicit contract based on the objective performance measurement

If an explicit contract (s, β_1) is accepted, the high ability teacher would choose effort level $e_H(\mu, \beta_1) = \frac{\mu\beta_1}{2\gamma}$ and the low ability teacher would choose effort level $e_L(\mu, \beta_1) = \frac{\mu\beta_1}{2\gamma} p$ for each realization of μ. Thus high ability teacher will accept the contract if the expected utility from this contract is at least as large as her outside options:

$$E_\mu \left\{ s_H + \mu e_H \cdot \beta_1 - \gamma e_H^2 \right\} \geq W_H \text{ for } e_H \text{ derived as above;} \tag{IR$_1$}$$

[10] or some minimum effort level the school has to and can observe from its teacher in order to continue the employment relationship with its teacher. That is under the assumption that the least able teacher can be detected by the school and be dismissed as a result.

and low ability teacher accepts the contract if it's no worse than her outside options

$$E_\mu \left\{ s_L + \mu p e_L \cdot \beta_1 - \gamma e_L^2 \right\} \geq W_L \text{ for } e_L \text{ derived as above.} \tag{IR$_2$}$$

The minimum base salary for each teacher type to accept the contract would be

$$\begin{aligned} s_H(\beta_1) &= W_H - E_\mu \left\{ \mu e_H \cdot \beta_1 - \gamma e_H^2 \right\} \\ &= W_H - [1 + var(\mu)] \frac{\beta_1^2}{4\gamma} \end{aligned}$$

$$\begin{aligned} s_L(\beta_1) &= W_L - E_\mu \left\{ \mu p e_L \cdot \beta_1 - \gamma e_L^2 \right\} \\ &= W_L - p^2 [1 + var(\mu)] \frac{\beta_1^2}{4\gamma} \end{aligned}$$

When the minimum base salary for the high ability teacher is greater than the minimum base salary for the low ability teacher, the school has two choices[11]:

1. Set $s = s_H(\beta_1)$ so that both types of teachers accept the contract. In this case the school's expected payoff would be

$$\begin{aligned} V(\beta_1) &= E_\mu \{ [\alpha e_H + (1-\alpha) p e_L] - s - \alpha \mu e_H \beta_1 - (1-\alpha)\mu \cdot p e_L \beta_1 \} \\ &= \frac{A}{2\gamma}\beta_1 - \frac{2A-1}{4\gamma}[1 + var(\mu)]\beta_1^2 - W_H \qquad \text{where } A \equiv [\alpha + (1-\alpha)p^2] \in (0,1) \end{aligned}$$

the optimal explicit contract derived from the first order condition is

[11]

$$If \ s_H > s_L, ie, \ W_H - W_L > (1-p^2)[1 + var(\mu)] \frac{\beta_1^2}{4\gamma}, \tag{case 1}$$

$$\beta_1^* = \frac{E_\mu\{\mu\}[\alpha+(1-\alpha)p^2]}{E_\mu\{\mu^2\}[2\alpha+2(1-\alpha)p^2-1]}$$

$$= \frac{1}{[1+var(\mu)]}\cdot\frac{A}{(2A-1)} \qquad > 0\ if\ A \equiv [\alpha+(1-\alpha)p^2] > \frac{1}{2}$$

The school's expected payoff by offering $(s = s_H(\beta_1^*)\ ,\ \beta_1 = \beta_1^*)$ is

$$V(\beta_1^*|s = s_H) = \frac{1}{4\gamma[1+var\{\mu\}]}\cdot\frac{A^2}{2A-1} - W_H$$

That is valid if $W_H - W_L > (1-p^2)[1+var(\mu)]\frac{\beta_1^2}{4\gamma} = \frac{1}{4\gamma[1+var\{\mu\}]}\cdot\frac{A^2}{(2A-1)^2}\cdot(1-p^2).$

2. Set $s = s_L(\beta_1)$ such that only the low ability teacher would accept the contract. The school's expected payoff is

$$V(\beta_1) = E_\mu\{pe_L - s - \mu\cdot pe_L\beta_1\}$$

the optimal explicit contract derived from the first order condition is

$$\beta_1^* = \frac{1}{1+var(\mu)}p^2 > 0$$

with school's expected payoff to be

$$V(\beta_1^*|s = s_L) = \frac{1}{4\gamma[1+var\{\mu\}]}\cdot p^2 - W_L$$

The second case is valid with only L type accepts the contract at $W_H - W_L > \frac{1}{4\gamma[1+var(\mu)]}\cdot(1-p^2)p^4$.

As the variance of μ increases, t becomes a much noisier measure of hc. It's intuitive to see the bonus attached to the objective performance measure β_1^* becomes smaller since the school doesn't want to provide a distortionary incentive. The school decides to hire both type of teachers if[12]

$$\frac{1}{4\gamma[1+var\{\mu\}]}\left(\frac{A^2}{2A-1}-p^2\right) > W_H - W_L > \frac{1}{4\gamma[1+var\{\mu\}]}\frac{A^2}{(2A-1)^2}\cdot(1-p^2) \tag{V1}$$

The gap between the LHS of (V1) and the RHS of (V1) becomes wider as the variation of μ decreases. This implies that (V1) is more likely to be the case if the objective performance measure is a better signal for the school's goal. Somewhat "controversial" is that as α increases, the school is less willing to attract high ability teacher (s $=s_L$ is more likely) since the gap becomes narrower as the fraction of high ability teachers in population increases. The intuition behind this is that the school is more likely to pay β_1 if the teacher is more likely to be of high ability, which increases the school's wage cost if both type of teachers are attached.

Proposition 2 *If the minimum base salary for a high ability teacher is higher than the minimum base salary for a low ability teacher, it's possible for the school to offer an explicit contract to both type of teachers (V1). The bonus attached to the objective performance measure is close to zero if $var\mu$ is a very noisy assessment of the teacher's value added. Moreover, this explicit contract yields higher value for the school than a contract with no incentive compensation.*

Since the explicit contract is based on the quality of the objective performance measure, the variance of the measure decides the power of the incentive in any optimal contract, otherwise distortionary performance will be generated. When the measure is a very noisy assessment of a teacher's real contribution, the bonus to this objective measure is close to zero and the effort level exerted by the teacher is not much higher than under a fixed salary contract. Thus, the feasibility of an explicit contract depends on the difference between the objective evaluation and the real contribution

[12](V1) comes from the relation in case 1 and the following inequality

$$V(\beta_1^*|s=s_H) > V(\beta_1^*|s=s_L)$$

2.4 The optimal contract based both on objective and subjective performance measurement

We first consider the simple case where the subjective performance measurement is nonverifiable but otherwise perfect. This case can be generalized to situations where the subjective performance measure is a better measure of the teacher's contribution to her students than the objective performance measure.

A contract that compensates a teacher not only on her students' test scores, but also on some subjective performance measure like students' evaluation, the principal's evaluation or her colleague's evaluation is considered to be more balanced than any explicit contract. But from the school's perspective, such a contract would be offered only if it improves the school's value. In this sub-section we investigate the relationship between objective performance measure and subjective performance measure in the combined-incentive contract.

If such a contract (s, β_1, β_2) is accepted, high ability teacher exerts effort $e_H = \dfrac{\mu\beta_1 + \beta_2}{2\gamma}$ and low ability teacher exerts effort $e_L = \dfrac{\mu\beta_1 + \beta_2}{2\gamma}p$. Then the minimum base salary for high ability teacher is

$$E_\mu \left\{ s_H + \mu e_H \cdot \beta_1 + e_H \cdot \beta_2 - \gamma e_H^2 \right\} \geq W_H \text{ for } e_H = \frac{\mu\beta_1 + \beta_2}{2\gamma} \qquad (\text{III.IR}_1)$$

$$\begin{aligned} s_H(\beta_1, \beta_2) &= W_H - E_\mu \left\{ \mu e_H \cdot \beta_1 + e_H \cdot \beta_2 - \gamma e_H^2 \right\} \\ &= W_H - \frac{[1 + var(\mu)]\beta_1^2 + 2\beta_1\beta_2 + \beta_2^2}{4\gamma} \\ &= s_H(\beta_1) - \frac{2\beta_1\beta_2 + \beta_2^2}{4\gamma} \qquad < s_H(\beta_1) \text{ for } (\beta_2 > 0) \end{aligned}$$

and the minimum base salary for low ability teacher is

$$E_\mu \left\{ s_L + \mu p e_L \cdot \beta_1 + p e_L \cdot \beta_2 - \gamma e_L^2 \right\} \geq W_L \text{ for } e_L = \frac{\mu\beta_1 + \beta_2}{2\gamma} p \qquad (\text{III IR}_2)$$

$$\begin{aligned} s_L(\beta_1,\beta_2) &= W_L - E_\mu\left\{\mu p e_L\cdot\beta_1 + p e_L\cdot\beta_2 - \gamma e_L^2\right\} \\ &= W_L - p^2\frac{[1+var(\mu)]\beta_1^2 + 2\beta_1\beta_2 + \beta_2^2}{4\gamma} \\ &= s_L(\beta_1) - p^2\frac{2\beta_1\beta_2+\beta_2^2}{4\gamma} \qquad < s_L(\beta_1) \text{ for } (\beta_2 > 0) \end{aligned}$$

We notice that under the combined incentive contract, the required minimum base salary for either type of teacher to accept the contract is lower than that in a contract which only rewards teacher for her objective performance.

Similar to the analysis in the previous section the school has two choices if $s_H(\beta_1,\beta_2) > s_L(\beta_1,\beta_2)$ and setting $s = s_H(\beta_1,\beta_2)$ makes it possible to hire either type of teacher. If $(s = s_H, \beta_1, \beta_2)$ is the enforced contract, the school's value would be

$$\begin{aligned} V(\beta_1,\beta_2) &= E_\mu\left\{[\alpha e_H + (1-\alpha)p e_L] - s - \alpha(\mu e_H\beta_1 + e_H\beta_2) - (1-\alpha)(\mu\cdot p e_L\beta_1 + p e_L\beta_2)\right\} \\ &= \frac{A}{2\gamma}(\beta_1+\beta_2) - \frac{2A-1}{4\gamma}[(1+var\mu)\beta_1^2 + 2\beta_1\beta_2 + \beta_2^2] - W_H \\ &= V(\beta_1) + \frac{A}{2\gamma}\beta_2 - \frac{2A-1}{4\gamma}(2\beta_1\beta_2+\beta_2^2) \\ &> V(\beta_1) \quad \text{ for } 0 < \beta_2 + 2\beta_1 < 1 - \frac{1}{2A} < \frac{1}{2} \text{ and } A \in (\frac{1}{2}, 1) \end{aligned}$$

But different from the previous section, the school can renege on the "promised" subjective performance bonus at the end of each period since hc is not verifiable by a third party. We use the "self-enforcement" concept here to enforce an implicit contract. That is to say, the school would not renege the contract because it's better off for the school in equilibrium.

If the school reneges at the realization of $hc = 1$, the savings in salary would be β_2 for that period. Afterwards, the teacher would never believe that the school would deliver β_2. From next period on, she will adjust her effort level to $e_H = \frac{\mu\beta_1}{2\gamma}$ if she is a high ability teacher and $e_L = \frac{\mu\beta_1}{2\gamma}p$ if she is a low ability teacher[13]. The expected value

[13]This is assuming that the teacher employs trigger strategy, which is the most severe credible punishment for the school.

gain from paying the subjective performance bonus would be $\frac{V(\beta_1,\beta_2)-V(\beta_1)}{r}$, where r is the school's discount rate. Then the school should honor the implicit contract if and only if the expected gain of honoring the contract exceeds the savings in salary if it reneges this period:

$$\frac{V(\beta_1,\beta_2)-V(\beta_1)}{r} \geq \beta_2 \Leftrightarrow \frac{\frac{A}{2\gamma}\beta_2 - \frac{2A-1}{4\gamma}\beta_2(2\beta_1+\beta_2)}{r} \geq \beta_2$$

$$i.e. \beta_2\left[\frac{A}{2\gamma} - \frac{2A-1}{2\gamma}\beta_1 - \frac{2A-1}{4\gamma}\beta_2 - r\right] \geq 0 \tag{V2}$$

The optimal contract sets β_1 and β_2 to maximize $V(\beta_1,\beta_2)$, subject to the reneging constraint (V2). Define λ as the Lagrange multiplier for (V2). The optimal contract satisfies

$$\frac{\partial L}{\partial \beta_1} = \frac{A}{2\gamma} - \frac{2A-1}{2\gamma}\left[(1+var\mu)\beta_1+\beta_2\right] + \lambda\beta_2(-\frac{2A-1}{2\gamma}) = 0 \tag{10a}$$

$$\frac{\partial L}{\partial \beta_2} = \frac{A}{2\gamma} - \frac{2A-1}{2\gamma}(\beta_1+\beta_2) + \lambda(\frac{A}{2\gamma} - r - \frac{2A-1}{2\gamma}\beta_1 - \frac{2A-1}{2\gamma}\beta_2) = 0 \tag{10b}$$

When λ is zero, one of the optimal contract is to offer $\beta_2 = \frac{A}{2A-1}$ and $\beta_1 = 0$. The optimal contract involving both subjective measurement and objective measurement must have $\lambda \neq 0$, which implies $\frac{A}{2\gamma} - \frac{2A-1}{2\gamma}\beta_1 - \frac{2A-1}{4\gamma}\beta_2 - r = -\frac{A}{2\gamma} + \frac{2A-1}{2\gamma}\beta_1 + \frac{2A-1}{4\gamma}\beta_2 + r = 0$

$$\begin{aligned} 0 &= 10a - 10b = -\frac{2A-1}{2\gamma}(var\mu)\beta_1 + \lambda(-\frac{A}{2\gamma} + r + \frac{2A-1}{2\gamma}\beta_1) \\ &= -\frac{2A-1}{2\gamma}(var\mu)\beta_1 + \lambda(-\frac{2A-1}{4\gamma}\beta_2) = 0 \end{aligned}$$

$$\lambda = -2(var\mu)\frac{\beta_1}{\beta_2} \; < 0$$

plugging this into (10b), we get

$$\begin{aligned}
\frac{A}{2\gamma} - \frac{2A-1}{2\gamma}(\beta_1+\beta_2) + \lambda(-\frac{2A-1}{4\gamma}\beta_2) &= r - \frac{2A-1}{4\gamma}\beta_2 + var\mu\frac{2A-1}{2\gamma}\beta_1 = 0 \Rightarrow \\
\beta_1 &= \frac{\beta_2(2A-1)/4\gamma - r}{var\mu(2A-1)/2\gamma} \\
&= \frac{1}{2var\mu}\beta_2 - \frac{2\gamma r}{var\mu(2A-1)} \\
&= \frac{1}{2var\mu}(\beta_2 - \frac{4\gamma r}{2A-1})
\end{aligned}$$

Plugging this back into the reneging constraint, we have

$$\begin{aligned}
0 &= \frac{A}{2\gamma} - \frac{2A-1}{2\gamma}\beta_1 - \frac{2A-1}{4\gamma}\beta_2 - r \\
&= \frac{A}{2\gamma} - \frac{2A-1}{4\gamma}\beta_2 - r - \frac{2A-1}{4\gamma var\mu}(\beta_2 - \frac{4\gamma r}{2A-1}) \Rightarrow \\
\beta_2^{**} &= \frac{\frac{A}{2\gamma} - r + \frac{r}{var\mu}}{\frac{2A-1}{4\gamma}(1+\frac{1}{var\mu})} = \frac{2(var\mu A - 2var\mu\gamma r + 2\gamma r)}{(2A-1)(1+var\mu)} \\
&> 0 \text{ if } \quad A > 2\gamma r(1 - \frac{1}{var\mu})
\end{aligned}$$

[14]

$$\beta_1^{**} = \frac{A - 4\gamma r}{(2A-1)(1+var\mu)} < \frac{A}{(2A-1)(1+var\mu)} = \beta_1^* \qquad \text{for } A > 4\gamma r > 0$$

and

$$\beta_1^{**} + \beta_2^{**} = \frac{1}{2A-1} \cdot \frac{2var\mu(A-2\gamma r) + A}{(1+var\mu)} > \beta_1^*$$

[14] $\beta_2 - \frac{4\gamma r}{2A-1} = \frac{2(var\mu A - 2var\mu\gamma r + 2\gamma r)}{(2A-1)(1+var\mu)} - \frac{4\gamma r}{2A-1} = \frac{2var\mu(A-4\gamma r)}{(2A-1)(1+var\mu)}$
$> 0 \quad \text{if} \quad (4\gamma r < 1) \;\; and \; A \in (\max(\frac{1}{2}, 4\gamma r), 1)$

Under the combined incentive contract, the expected effort from either type of teacher ($\frac{\beta_1^{**}+\beta_2^{**}}{2\gamma}$ for high ability teacher and $\frac{\beta_1^{**}+\beta_2^{**}}{2\gamma}p$ for low ability teacher) is higher than that in the explicit contract ($\frac{\beta_1^{*}}{2\gamma}$ for high ability teacher and $\frac{\beta_1^{*}}{2\gamma}p$ for low ability teacher).

Notice that β_1^{**} is decreasing with $var\mu$ while β_2^{**} is increasing with $var\mu$. It's natural to expect that as the objective performance measure becomes much noisier relative to the subjective performance measure, the school relies more on the subjective measure. Moreover, it's interesting to observe that the total bonus size is larger than in any optimal explicit contract and the size actually grows with $var\mu$, the noise. The intuition behind this is that as $var\mu$ increases, the school has to reduce the bonus size attached to the objective performance; otherwise distortionary incentive would drive the teacher to exert greater effort when there is a good chance of raising the students' test scores (μ is large) and to shirk effort when the chance of improving students' test scores is small. Therefore the bonus attached to subjective performance β_2 has to increase for proper provision of incentive to the teacher. However, increased β_2^{**} gives the school a higher incentive to renege the implicit contract when $hc = 1$ is realized. Therefore the expected value gain from honoring the implicit contract ($r\beta_2$) has to be greater for the school not to deviate in equilibrium. This results in higher bonus offered by school in equilibrium as $var\mu$ increases:.

$$\frac{\partial\beta_2^{**}}{\partial var\mu} = \frac{2}{2A-1}\cdot\frac{A-4\gamma r}{(1+var\mu)^2} \qquad > 0$$

$$\frac{\partial(\beta_1^{**}+\beta_2^{**})}{\partial var\mu} = \frac{\partial\frac{1}{2A-1}\cdot\frac{2(var\mu A-2var\mu\gamma r)+A}{(1+var\mu)}}{\partial var\mu} = \frac{1}{2A-1}\cdot\frac{A-4\gamma r}{(1+var\mu)^2} > 0$$

Proposition 3 *When both subjective and objective performance measures are used to provide incentive to teachers, the feasibility of an incentive compensation scheme does NOT depend on the quality of the objective measure anymore due to the substitutability of an subjective measure. The teacher exerts the most effort. Moreover, when both types of teachers are hired in the equilibrium, the optimal wage contract has a lower base salary and higher incentive bonus than in an explicit wage contract.*

The proof is trivial.

Note that in the basic model above, the subjective performance measure hc is assumed to be perfect. We are able to obtain similar results when the subjective performance measure is not perfect, but is less noisier than the objective performance measure t. That is, all the results hold when hc is not a perfect measure of the students' gain in human capital, and when the variance of hc is smaller than the variance of $t - -var\mu$.

In this section we demonstrated that an incentive compensation scheme composed of objective and subjective performance evaluations provides the strongest incentives for teachers in a world where neither output is verifiable nor teacher effort observable. An incentive contract based on this combination of objective and subjective performance evaluations can mitigate incentive distortions caused by an imperfect objective measure. Moreover, when we combine the explicit contract based on an objective performance measure and the implicit contract based on a subjective performance measure, the combined incentive provided (supported by trigger strategy) is increasing with the variation of the objective performance measure. In the next section we describe the data that we have collected to estimate the parameters of the wage equation.

3 China's Secondary Education System and Data

Our research focuses on secondary schools in one county in China's Jiangsu Province.[15] The generous cooperation of local officials allowed us to collect a unique data set that is first composed of administrative records from ten of the county's sixteen secondary schools. These records provide us with individual level information on over 1500 teachers' demographic variables, education, salary and employment. Information on the teaching load, subjects taught and the measure of teacher quality (rank) for both 1995 and 1998 is also contained within. Before describing the contents of the data set in more detail it is important to briefly describe the current system of secondary education in China.

As in the United States, local school boards implement the national curriculum in each county. The school board regulates the textbooks and minimum standard for grade promotion but gives teachers the freedom to use their own

[15]Per our agreement with the local government we are not authorized to identify the county by name.

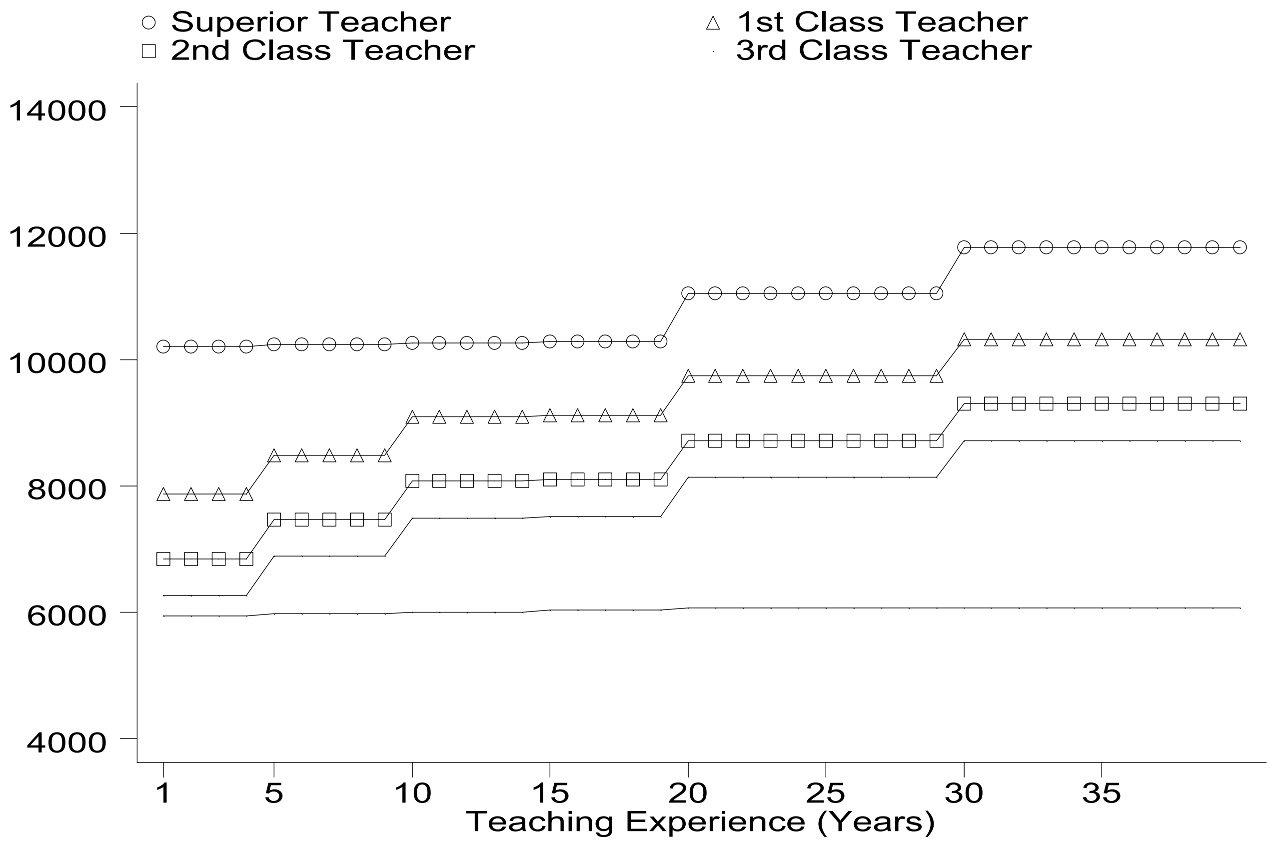


Figure 1: Teacher Salary Scale by Teaching Experience in 1998

teaching method. However, the local school board assesses the quality of each individual teacher's instruction. Based on these assessments, teachers ranking within the education system can be promoted from intern (newly hired) to third-class, to second-class, to first class and finally superior teacher. These rankings as well as years of teaching experience determine components of teachers' salaries. In figure 1 we plot the salary scale for teachers of different ranks over the years of teaching experience using 1998 data.

It is clear from this figure that teachers have a strong incentive to be ranked as a superior teacher within their first twenty years. Notice further, that irrespective of the years of experience the gap in salaries between teachers of different ranks increases as the ranking increases, which provides strong financial incentives for teachers to improve their ranks. It is important to note that teachers may also receive non pecuniary (psychic) income from the title once promoted. Teachers of higher rank also earn higher wages in outside employment opportunities such as tutoring. Finally, it is clear from the above diagram that the salaries follow a rule of thumb and are not determined in the manner suggested by our model.

In conducting assessments and determining whether an instructor will be promoted the school board examines five factors. First, they examine teaching skills. They examine the performance of that teacher's students relative to other instructors on entrance examinations and other assessments. Administrators and instructors within the same school in that subject area randomly attend the candidate's lectures to evaluate the quality of instruction. Furthermore, credit is given to teachers who introduce new effective teaching methods in the classroom. Second, the quality of the school and years of education that the instructor had completed are assessed. A national five point ranking system of higher education institutions is used to assess the quality of colleges and universities the teacher got her degree in. This information is combined with the number of articles the instructor had published on instructional methods in teaching journals to get a measure of teacher's knowledge. Thus, this system provides a strong incentive for teachers to introduce new teaching methods and if they are effective an article describing the method and evaluating the results can be published in a teaching journal. Third, a teacher's ability to regularly evaluate and monitor the performance of her students, detect problems that affect her students (intellectually or socially) and the efficacy in which these problems are dealt with are evaluated. Fourth, whether a teacher is enthusiastic while performing her job and concerns for her students performance (e.g. promptness in getting in touch with the students' families) is also assessed. Finally, the teacher's work ethic is monitored.

School board officials noted that incentives to be higher ranked have increased recently as the difference in salaries across teachers of different ranks for a given level of teaching experience has widened. Teachers salaries are increased in China through the finances of each local government, which reflects the willingness of the society to reward its teachers. Local Chinese government usually associates economic growth with the education level of its population. Annual reports even advertise the number of superior teachers in its schooling system to attract outside investment.

The officials also point out that the nationwide introduction of this system in the early 1980s increased not average effort exerted by the teachers but more so average concern towards students. Instructors would more closely monitor student performance and contact the family either by phone or by visit when a child encountered difficulties. As well, instructors increasingly tutor students who are falling behind and form peer groups of students to tutor students who are falling behind. These actions directly increase subjective evaluations and indirectly increase objective performance evaluations.

Not only are the teachers ranked but there is a clear ranking of the quality of instruction at each school within a county. It is common knowledge among the population whether a school is considered to be either a national model school or a provincial model school or a school that focuses on teaching students trade skills. Students compete for positions in the higher quality schools by writing a municipal level high school entrance examination at the completion of junior high school. This exam covers material in six subject areas and is held over a period of three days[16]. Scores on this exam are almost the sole determinant of high school admission.

Many students' families pay a supplemental tuition fee (called a donation) so that their child can attend a higher ranked school if they did not score above the cutoff level for that school. The local education bureau commonly allows schools to admit one or two expansion classes of such students[17]. The size of this donation varies both across and within schools but is substantial and often greater than the household's annual earnings. The importance of attending a stronger high school results in many students leaving their homes and residing in dormitories when attending school.

At the completion of high school, students are required to list their preferences for college and university and major they plan to study. Following the completion of this list students write a three day college entrance examination which

[16]The subject areas are chemistry, Chinese, English, mathematics, physics and political science.

[17]Class sizes average 52 - 56 students in the data. There is very little variation in class size across schools.

encompasses material in six subject areas[18]. These scores coupled with the individual's preference list determine which university or college the student could attend. However, there are many more applicants than there are positions available in colleges and universities which may result in some strategic choices made by the students when filling out their preference lists.

As these schools are ranked it is natural to examine how the resources available to each student differ across the schools. This is provided in Appendix table 1 for 1998. Notice that schools that are nationally or provincially ranked clearly have a higher percentage of instructors who are in the superior class. Surprisingly, average teaching experience is lower in ranked schools than unranked schools. This occurs since ranked schools can attract younger teachers with higher degrees. Teachers in these schools are also more likely to teach the subjects they have their degree in. Our teacher data is matched with the annual local government school investment data for the same period. It contains both the total investment and investment by various sources for the funds for each school.

We also have collected the 1995 high school entrance examination scores for '95 incoming class at nine of these schools. For each of these schools we are aware whether the student was admitted in a regular or on expansion basis and have indicators if the student was admitted based on certain skill. For example, some students are admitted to certain school if they can show evidence of exceptional art, music or athletic ability and in these situations test score plays a smaller role. Some other students are admitted prior to the entrance exam based on their strong academic records in junior high. It is clear that students who have been granted admission for one of these reasons do not face the same incentives when writing the test. Finally, we have collected the scores on the 1998 National College Entrance Examination for all the students in the county who were accepted to any higher education institute. For these students, we are aware of both the major and college which granted admission. Thus, we are able to follow over 1600 students from completion of junior high school through admission to a tertiary education institute. We

[18]There are two versions of the college entrance exams. The first is for students wishing to major in the arts and is composed of questions in Chinese, english, geology, history, mathematics and political science. The second is for students who wish to major in the sciences and covers material in biology, chemistry, Chinese, english, mathematics and physics. Both exams are scored out of 750.

examine how the schools differ in terms of performance of the incoming class, graduation outcome and investment in Appendix table 2.

It may seem striking that there does not exist a single student in the expansion class of the nationally ranked school. This school sends all the students in its expansion class to its affiliated school[19]. This results in the surprising finding that the entrance examination scores are slightly higher for the regular class than the expansion class in this school. Notice that for all the other schools that the scores on the high school entrance examination are greater and the variance in these scores lower for students in the regular class than the expansion class.

Students at the national school are most likely to attend tertiary education and at the university level. In most schools the majority of students are accepted into college level II programs or rank 2 (where five is the highest) on the national scale. A surprising finding is that school 7 and school 9, which are not ranked, place a greater percentage of students in tertiary institutions than school 2 which is ranked. This may be the result of the ranked schools encouraging their students to apply towards universities and the unranked school pushing students to apply for colleges. Notice that most students from ranked schools who continue their studies were admitted in universities while students from unranked schools were more likely admitted to college.

The local government invests substantially more funds in national and provincial model schools then those that not ranked. Investment per pupil in school 7, a provincial school seems to be the greatest. While we visited these schools we observed that the schools that are ranked tend to have more modern facilities. Schools that are ranked tend to receive more external donations than those not ranked which exacerbates the inequities across the schools. In the next section, we will examine China's teacher compensation system in greater detail.

[19]The national school is concerned with its reputation and for this reason does not retain the students in the expansion class.

4 Results I

As mentioned in the preceding section, salary differentials between teachers of different ranks have widened in recent years. School board officials feel that for the rank system to be successful it is necessary that the financial incentives indeed exist and continue to exist. Teachers must realize that not only will a higher rank provide a higher salary at any given time but also that the growth in this salary might be greater than the growth in salaries of other teachers controlling for other factors. To verify their statement we collected information on teacher salaries for both 1995 and 1998 in this county. Recall, that the teacher salary is composed of a fixed component and a variable component which is based on the individual's combination of rank and experience. Experience is measured in five year intervals. To examine the relative importance of rank and experience in determining increases in salary we estimate the following model for each possible experience rank combination (c)

$$\Delta Salary_c = \beta_0 + \beta_1 Experience_c + \beta_2 Rank_c + \varepsilon_c,\ \ \varepsilon_c \tilde{} N(0, \sigma^2) \qquad c = 1...C \tag{1}$$

where we have indicators variables for every five years of experience and for each possible teacher rank. Teachers who are not ranked and those with 15 to 20 years of experience are used as the comparison group. Our results are presented in table 1.

These results clearly show that rank is the major driving force in salary increases for teachers with less than twenty year of experience. The gain in salary for a teacher who goes from one year of experience to twenty years of experience is less than the gain in salary from going from not ranked to third class. Once a teacher has taught for more than twenty years there appears to be a return to experience but this return is smaller than that achieved by increasing rank.

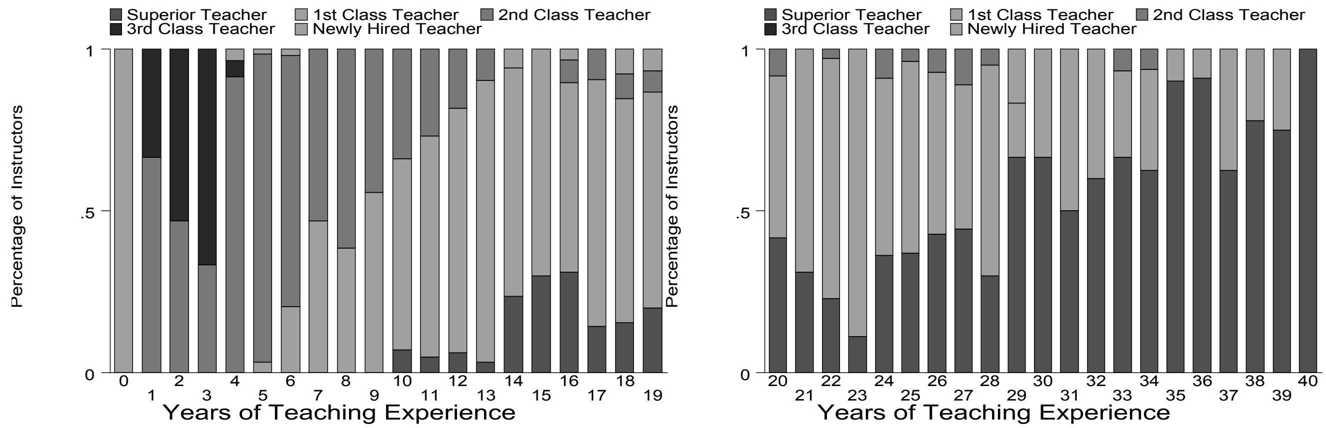
In the preceding section we illustrated in 1 that instructors have clear financial incentives for promotion early in their career. In figure 2 we illustrate the percentage of teachers at each rank for each year of experience in

Variable Name	Estimate
Superior Class Instructor	1122.000 (55.804)
First Class Instructor	903.429 (55.804)
Second Class Instructor	757.714 (55.804)
Third Class Instructor	174.857 (55.804)
O -5 Years of Experience	-174.857 (61.131)
6-10 Years of Experience	-87.429 (61.131)
11-15 Years of Experience	$-1.09e-13$ (61.131)
20-30 Years of Experience	116.5712 (61.131)
30 + Years of Experience	233.143 (61.131)
Constant	814.000 55.804
R - squared	0.970

Table 1: Facrtors Affecting Teacher Salary Increases 1995 - 1998 (Standard Errors in Parentheses)

1998. The first panel is for teachers with less than 19 years of experience and the second panel contains information for teachers with more than 19 years of experience. Notice that more than half of the teachers with ten years of experience are classified as first class teachers. As well, teachers are first classified as superior teachers once they have taught for ten years. Another interesting observation is the scarcity of second and third class teachers with more than fifteen years of teaching experience. As we do not have numerous repeated assessments of teachers in our data we are unable to adequately address two important questions. First do teachers with more than fifteen years of experience who have not been ranked above second class quit their jobs? If so do they leave because the school board increases these instructors' teaching load in order to drive them out of teaching or is it due to the belief that these assessments are not fair? School board officials claim that few teachers resign after fifteen years of experience and their resignations are uncorellated with their history of promotion. We are able to test whether instructors with fifteen years of experience who were ranked as superior or first class teachers taught fewer courses than teachers with

Figure 2: Percentage of Instructors At Each Rank



similar years of experience but are lower ranked teachers and found the converse held. Thus, it does not appear that the school board is trying to overload lower ranked teachers to persuade them to leave the profession. Second, at what age are teachers promoted to first and superior class? Although we can not address this last question we are able to predict which factors cause a teacher to increase the likelihood that they get promoted.

Recall that the decisions to promote a teacher are based on five factors. Thus we are interested to see if it is indeed the case that teachers with more experience, education, higher objective and subjective performance measures are ranked higher. To analyze the extent to which these factors affect the likelihood of being at a higher rank we employ an ordered probit estimator. This model assumes a latent variable structure of the form:

$$y^* = X\beta + \varepsilon \tag{2}$$

We observe (assuming three categories),

y $= 0$ if $\varepsilon < X\beta$

y $= 1$ if $X\beta < \varepsilon < X\beta + \delta$

y $= 2$ if $X\beta + \delta < \varepsilon$,

where $\delta > 0$, the actual values taken on by the dependent variable are irrelevant except that larger values are assumed to correspond to "higher" outcomes and

$P_o = F(X\beta)$

$P_1 = F(X\beta + \delta) - F(X\beta)$

$P_2 = 1 - F(X\beta + \delta)$.

The model easily generalizes to more than three categories as in our situation where the teacher has four possible ranks. The vector X contains personal teacher characteristics that are thought to affect promotion (age, education, highest degree attained), factors that might influence teaching performance (course load, teaching the subject in which you have your degree, years of teaching experience (Y)) and proxies for objective and subjective performance measures[20].

Proxies are required since our data does not contain direct information on objective and subjective performance evaluation measures. We will use percentage of students who are accepted into college to proxy for objective performance measures. We will use an estimate for the value added by educators to proxy for the subjective performance evaluation. To estimate the value added we use a two step process. In the first step we estimate a value added model to statistically isolate the contribution of teachers from other factors that contribute to growth in student achievement. Our data provides us with two test score measures for students who were accepted into college or university. The following equation is estimated:

[20] Munrane (1975) found that principal'e evaluations of teaching performance were highly correlated with value added but not with test scores. In our estimation we include the square and cube of both age and years of teaching experience (Y).

$$CSEE_{is} = \beta_0 + \beta_1 X_{is} + \beta_2 HSEE_{is} + \beta_3 Skills_{is} + \beta_4 Peer_s + u_s + \varepsilon_{is} \tag{3}$$

where CSEE is the score on the college entrance examination, the vector X contains personal characteristics, HSEE is the score on the high school entrance examination, the vector *Skills* contain indicator variables for individuals who were admitted to school s under special circumstances and *Peer* is the average HSEE from 1995 within that school. We estimate equation 3 using a GLS random effects estimator. In table 2 we present the results from our value added regressions using three different specifications, one which includes the skills and peer terms and one which includes the peer term and one which includes neither of these terms[21].

A surprising finding is that for students who are accepted into college there is not a negatively significant effect on rural status as there is no difference in performance for males. Rural females actually improve their performance more controlling for other factors than their urban counterparts. The coefficients on the skills variables are of expected sign as those students with exceptional academic ability improve their scores while students with exceptional talents in other areas see a large decrease in scores controlling for other factors[22]. Peer effects measured by average score on the HSEE in that school are positively related to performance. It is also interesting to notice that students admitted on the expansion basis (i.e. those who choose to make a donation to attend a better school) have a larger test score gain than students admitted on the regular basis in the same school. Finally, notice that in all of the specifications score on the high school entrance examination is a very strong predictor of the score on the college entrance examination.

In our second step we predict (u_s), the individual school student invariant component of the error term. We would expect that this term to be positively related to the salary. This term captures school specific unobserved to the econometrician factors that influence student performance including the contribution of the school's teachers.

[21]This specification and methodology is commonly used in the economics of education literature. See Ding and Lehrer (2001) for a discussion and application to identifying whether peer effects exist in China.

[22]Students with skills in art, athletics and music require field exams in addition to the college entrance examination and are subject to a substantially lower academic standard.

Variable	Specification 1	Specification 2	Specification 3
Score on HSEE	1.235 (0.061)	1.214 (0.062)	1.201 (0.062)
Rural Female	−14.732 (2.915)	−11.784 (2.858)	−14.744 2.909
Urban Female	−26.261 (3.509)	−22.491 (3.442)	−26.403 3.502
Early Admission	*N.A*	35.673 (7.275)	*N.A*
Music Talent	*N.A.*	−60.977 (14.459)	*N.A*
Athletic Talent	*N.A.*	−53.418 (25.089)	*N.A*
Art Talent	*N.A.*	−135.427 (18.350)	*N.A*
Academic Awards	*N.A.*	51.166 (17.626)	*N.A*
Peer Effects	*N.A.*	0.545 0.166	0.571 0.237
Tuition	*N.A.*	9.210 (3.401)	*N.A*
Constant	−258.442 (36.449)	−546.694 (90.740)	−562.311 131.496
Number of Observations	1278	1277	1278
R - Squared	0.592	0.695	0.617

Table 2: Random Effect Estimates of the Value Added Equation (Standard Errors in Parentheses)

With these proxies for objective and subjective performance measures we estimate equation 4. The results of our estimation are presented in table 3.

In the first two columns we report the results for all the ranked teachers in nine of our schools and in the last two columns we report the results for all the ranked teachers in schools that provided information on teaching load and sections taught. Notice that there is indeed a significant premium for education as the coefficient on university degree is more than three times as large as that on a college degree. Instructors are also more likely to be of a higher rank if they are teaching the subject in which they received their degree. Not surprisingly teaching courses in more than one subject area is negatively related to probability of promotion which stresses the importance of specialization. However, this effect disappears once we include the number of different sections taught and teaching load. This indicates that it is not the subject matter but rather the number of sections for which lecture preparations is required which reduce the likelihood of promotion. The coefficient on number of different sections taught is negatively related to the rank, indicating that instructors who encounter more students are less likely to be promoted within the system probably as a result of becoming less familiar with students which could reduce scores on the subjective assessments. Finally females are less likely to be promoted and that marital status is positively related controlling for these other factors.

As mentioned earlier value added is indeed positively related to higher rank for the full sample of teachers. This implies that teachers' salaries are positively related to clear value added objective performance measures. In the table we use the measure of value added achieved from specification 2 of table 2 but the results are robust to any measure of value added employed.

We also introduced dummy variable for the subject that the instructor taught to see if promotions were more likely in certain disciplines to each of our four specifications displayed in table. In all cases none of these estimates yielded a statistically significant estimate anything at or below the 20 percent level. Furthermore, we also investigated the introduction of school dummies and noticed that these just capture the same behavior as the effect of having

Variable	Specification 1	Specification 2	Specification 3	Specification 4
Y	0.774 (0.065)	0.517 (0.087)	0.850 (0.096)	0.574 (0.132)
Y^2	-0.026 $(3.50 * 10E - 3)$	-0.017 $(4.82 * 10E - 3)$	-0.028 $(5.42 * 10E - 3)$	-0.019 $(7.98 * 10E - 3)$
Y^3	$3.22 * 10E - 4$ $(5.67 * 10E - 5)$	$2.20 * 10E - 4$ $(8.01 * 10E - 5)$	$3.49 * 10E - 4$ $(9.27 * 10E - 5)$	$2.38 * 10E - 4$ $(1.37 * 10E - 5)$
University Degree	1.592 (0.196)	1.465 (0.198)	1.874 (0.295)	1.701 (0.297)
College Degree	0.417 (0.178)	0.456 (0.179)	0.537 (0.265)	0.550 (0.265)
Trade School Degree	-1.106 (0.275)	-1.100 (0.278)	-0.716 (0.441)	-0.708 (0.444)
Teach A Subject Degree is In	0.402 (0.111)	0.433 (0.112)	0.448 (0.175)	0.452 (0.179)
Teach in More Than One Subject Area	-0.268 (0.256)	-0.308 (0.254)	0.100 (0.669)	-0.221 (0.668)
Married	0.458 (0.159)	0.403 (0.162)	0.381 (0.228)	0.345 (0.236)
Female	-0.292 (0.101)	-0.220 (0.103)	-0.249 (0.135)	-0.180 (0.138)
Percent of Students Attend Tertiary School	1.773 (0.276)	1.834 (0.279)	1.644 (0.346)	1.730 (0.352)
Value Added in Specification 2	$7.80 * 10E - 3$ $(3.49 * 10E - 3)$	$7.84 * 10E - 3$ $(3.54 * 10E - 3)$	$3.02 * 10E - 3$ $(4.78 * 10E - 3)$	$3.44 * 10E - 3$ $(4.87 * 10E - 3)$
Age	*N.A.*	1.363 (0.392)	*N.A.*	1.614 (0.605)
Age^2	*N.A.*	-0.029 $(9.71 * 10E - 3)$	*N.A.*	-0.035 (0.015)
Age^3	*N.A.*	$2.10 * 10E - 4$ $7.82 * 10E - 5$	*N.A.*	$2.56 * 10E - 4$ $(1.25 * 10E - 4)$
Teaching Load	*N.A.*	*N.A.*	-0.067 (0.025)	-0.068 (0.025)
Sections Taught	*N.A.*	*N.A.*	-0.068 (0.038)	-0.072 (0.039)
Log Likelihood	-544.863	-531.545	-290.138	-281.565
Number of Observations	1043	1043	611	611

Table 3: Factors Affecting The Rank of a Teacher (Standard Errors in Parentheses)

a higher percentage of students attending college. Thus, we are able to conclude that the rank system in China is clearly performing as it is designed. Individuals with more experience, higher education and with stronger objective and subjective performance evaluations are receiving promotions. Promotions occur frequently and fairly quickly in one's tenure at a school and favoritism does not seem to exist in any subject area or in any one school when instructors are making subjective performance evaluations.

5 Econometric Methodology

Recall we considered an optimal linear contract based on a fixed salary s, a bonus β_1 paid to the teacher when $t = 1$ is realized and a bonus β_2 paid to the teacher when $hc = 1$ is realized. While our data set contains information on salary and objective performance measures we lack direct information on subjective assessments of teaching quality. In addition, as shown in the salary schedule does not follow our theoretical contract but rather a rule of thumb where rank and years of experience uniquely determines an individual's salary. Thus we are unable to directly estimate the model presented in this paper directly[23] we examine the promotion history of each instructor to determine the relative importance of our proxies for subjective and objective performance measures.

To accomplish this task we use promotion data for the period between 1996 and 1998. We estimate a random effects logit which explicitly accounts for unobserved ability (this unobserved ability is what our model assesses subjectively) over time for each teacher. Each period when deciding whether an individual should be promoted the reviewing committee estimates teacher's i in school s in year t overall quality, TQ_{ist}.We assume that teaching quality can be estimated using the following regression

$$TQ_{ist} = \beta' X_{ist} + s_i + \varepsilon_{ist} \tag{4}$$

[23]See Ding (2001) for an alternative empirical model of teacher promotion which permits estimation of the structural parameters.

We do not observe TQ_{ist} but rather if teacher i is promoted in period t. An instructor is promoted if $TQ_{ist} > \tau$, where τ is a threshold unobserved to the econometrician. where X_{ist} is a $K*I$ vector of observed variables and B is a $K*1$ vector of coefficients that are observed for each teacher but varies across teachers and ε_{ist} is an unobserved error term distributed iid extreme value[24]. Therefore the probability that teacher i is promoted in year t is given by

$$Prob[Promotion = 1] = exp[\beta' X_{ist} + s_i)]\}/\{1 + exp[\beta' X_{ist} + s_i)]\} \tag{5}$$

The researcher can estimate β but does not observe s for each teacher. In this random effects model, we assume that s_i ˜ $N(0, \sigma_s^2)$. [25]. This model is estimated by maximizing the conditional log-likelihood. For each individual i, with T_i observations, the T_i observations are independent when conditioned on s_i. The likelihood for an independent unit i is expressed as an integral which is computed using Gauss-Hermite quadrature. In the next section we implement this analysis and present our results[26].

6 Results II

We first estimate a model of teachers' promotions between 1996 and 1998. At present we only have complete records for 196 teachers the majority of whom were hired after 1995[27]. Explanatory variables that are thought to affect teaching quality include indicator variables for each teachers current rank which allows the threshold value for τ to

[24]In our model the X matrix does not contain a constant since we wish to estimate the cutoff value τ.

[25]If $s_i = 0$, the model reduces to the simple univariate binary logit model The unobserved protion of teaching quality is $s_i + \varepsilon_{ist}$. This term is correlated over time and schools (if instructors were to switch schools) due to the common influence of s_i.

[26]Note that the estimates of s differ by experience groups to capture that the base salary may have changed over time. Note that since $\widehat{s}_{ist}$ is estimated the estimates are not efficient.

[27]Our goal is to have information for 956 teachers. We are trying to condition on the length of time an individual has been at a particular rank to avoid what we refer to as a "left censoring problem". It may be reasonable that the amount of time an individual has been in a given rank affects future promotions especially for higher promotions such as from a first class to superior teacher. Note we can add guys who were never promoted or only promoted once in our sample to third class without these records.

Variable	*Estimates*
Objective Performance Proxy	3.303 (0.772)
Subjective Performance Proxy	0.412 (0.172)
Time as New/Unranked Teacher	3.103 (0.372)
Time as 3rd Class Teacher	3.411 (0.537)
Time as 2nd Class Teacher	−4.274 (0.588)
University Degree	2.889 (0.589)
Second Class Teacher	−1.189 (0.712)
Third Class Teacher	−1.102 (0.597)
τ	3.643 (0.484)
Number of Observations	392
- Log likelihood	142.928

Table 4: Random Effect Logit Estimates of the Promotion Equation (Standard Errors in Parentheses)

differ for each rank, the number of years a teacher has been ranked at that level and information on the teacher's education as well as our proxies for performance measures. Random effects logit estimates of factors that influence teacher promotion decisions are presented in table 4.

In these estimates we rescaled the objective and subjective performance measure so that their value lies between 0 and 1. The results indicate that the return to the objective performance is almost eight times larger than the return to the subjective performance measure. As expected in the criteria for promotion having a university degree assists in achieving a promotion. In the next section, we summarize our findings and discuss directions for future work.

7 Conclusions and Direction for Future Work

Recent education reform proposals are increasingly designed to reward educators based on what their students actually accomplish. In this paper, we examine how performance incentives could be used to reward the value added by educators. We demonstrate that an that an incentive compensation scheme composed of both objective and subjective performance evaluations of student performance and evaluation of teacher quality can be superior to one which is predicated on objective evaluation of students alone. The idea underlying the model is that subjective performance evaluations (i.e. principal's evaluations) can be used to correct any possible distortions in teacher incentives generated by an objective performance evaluation (i.e. students' test scores). Further, we find the combined incentives provided by such a contract increase (when supported by a trigger strategy) with the variation of the objective performance measure.

To examine the performance of our model we employ a data set collected in China. In China, the local school board annually assesses the quality of each individual teacher's instruction. This assessment is composed of examining the teacher's education, objective performance measures that are verifiable (i.e. punctuality, students scores) and subjective performance measures (i.e. evaluation by colleagues of teaching performance and ethics). Based on these assessments, teachers can be promoted from intern (newly hired) to third class, to second class, to first class and finally superior teacher. This ranking as well as years of teaching experience uniquely determines each teacher's compensation. Our data set allows us to measure the contribution of the quality of the teacher a student has had access to during the course of her secondary school to that student's academic achievement as measured by scores on admission examinations.

Our estimates indicate that teacher salaries are indeed positively related to both objective and subjective evaluations. We find that increases in salary are greater for higher ranked instructors. We conclude that the rank system in China is clearly performing as it is designed. Individuals with more experience, higher education and with stronger objective and subjective performance evaluations are receiving promotions. Promotions occur frequently and fairly quickly. Favoritism does not seem to exist in any subject area or in any one school when instructors are making subjective performance evaluations. Instructors who are more educated, married, male, experienced and encounter fewer students within a week are more likely higher ranked. Preliminary estimates of the factors influencing promotion indicate that teaching quality is being rewarded effectively and that the rewards to the objective performance measure is approximately eight times larger than that of the subjective performance measure. Future versions of this paper will utilize a substantially richer data set to obtain more present the results of our estimation of the parameters of the incentive contract.

Appendix Table 1: Summary Statistics on Teachers
(Standard Deviations in Parentheses)

School	1	2	3	4	5	6	7	8	9
Ranking			Close to Provincial		National	Affiliated with National	Provincial		Provincial
% of superior teachers	13.04%	10.27%	9.61%	11.36%	26.61%	9.38%	6.09%	10.00%	21.59%
% of First class teachers	24.22%	32.19%	35.90%	39.39%	22.94%	41.67%	30.43%	40.00%	35.23%
% of Second class teachers	28.57%	33.56%	28.21%	28.03%	25.69%	37.5%	50.43%	22.00%	27.27%
% of Third class teachers	21.12%	7.53%	13.46%	6.06%	9.17%	4.17%	3.48%	12.00%	2.27%
Teacher Salary (*yuan*)	11590.4 (2431.9)	9900.76 (1594.32)	9715.87 (1675.56)	9137.45 (2202.9)	10148.4 (1900.4)	9890.43 (1508.45)	9178.63 (1985.00)	9927.72 (1730.36)	10334.29 (1793.48)
Teaching Experience	11.13 (10.83)	11.22 (10.52)	10.41 (9.98)	13.05 (10.78)	9.35 (9.65)	10.52 (8.13)	7.32 (7.21)	11.68 (10.56)	10.45 (9.06)
% of teachers with university degree	22.36%	40.41%	25.64%	25.00%	75.23%	30.21%	66.96%	39.00%	63.64%
% of teachers with college degree	60.87%	53.42%	71.79%	50.00%	21.10%	68.75%	31.30%	56.00%	29.54%
% of teachers teaching subject their degrees are in	74.67%	73.29%	80.77%	61.36%	95.41%	70.83%	93.91%	77.00%	88.64%
% of teacher teaching only one subject	91.30%	87.67%	N. A.	97.72%	100.0%	91.67%	100.0%	100.0%	N. A.
Average teaching load	10.02 (2.79)	10.66 (2.51)	N. A.	10.35 (2.55)	9.32 (3.00)	10.62 (2.64)	9.95 (2.52)	9.49 (2.38)	N. A.
Average Number of classes taught weekly	2.90 (2.09)	2.90 (1.96)	N. A.	2.97 (2.48)	2.62 (1.65)	3.01 (2.25)	3.01 (1.83)	N. A.	N. A.
Average age of teachers	33.74 (11.33)	33.57 (10.70)	32.70 (10.55)	35.23 (11.07)	31.85 (9.09)	33.40 (9.24)	30.15 (7.63)	33.91 (11.08)	33.83 (10.28)
% of Female Teachers	29.19%	30.82%	39.74%	28.03%	33.95%	38.54%	46.09%	23.00%	27.27%
% of Married Teachers	66.46%	80.14%	60.90%	76.52%	60.55%	86.46%	70.43%	70.00%	67.04%
Number of Teachers	150	128	156	128	106	84	115	100	88

Appendix Table 2: Summary Statistics on School Investment and Students
(Standard Deviation in Parentheses)

School	1	2	3	4	5	6	7	8	9
Ranking			Close to province		National	Affiliated with national	Provincial		Provincial
1996 Local Government Investment	773177	1529893	1477509	1105100	3055700	863700	3474200	869500	1972800
1997 Local Government Investment	1989918	1592611	1843770	384588	3171300	1207514	5195200	1052667	2949600
1998 Local Government Investment	2016738	1871335	3076828	1135451	3792000	1328300	3107700	1286000	2521000
1996 Total Investment	2429597	4984709	3453790	3755200	6797765	2089276	5354309	2058818	5304391
1997 Total Investment	3019085	8099145	5942198	2749133	9687678	2569319	10571926	2823071	7258390
1998 Total Investment	4013414	9572058	6881194	7030145	10229143	3162165	8812696	3299000	6013006
Average Score on HSEE for Regular Class	566.71 (26.16)	565.47 (24.09)	576.81 (24.96)	551.48 (35.01)	638.52 (6.54)	464.88 (78.13)	606.85 (32.05)	554.17 (34.06)	615.76 (14.60)
Average Score on HSEE for Expansion Class	497.22 (64.41)	527.55 (55.49)	543.94 (41.39)	494.02 (62.87)	****	595.79 (24.08)	559.37 (56.36)	509.00 (56.39)	574.67 (29.83)
% of students continue tertiary education	31.28%	50.66%	52.66%	44.40%	94.95%	39.33%	40.19%	35.50%	66.24%
# of students accepted to trade school	2	3	1	4	0	3	0	1	0
# of students accepted to colleges level 2	42	102	109	84	10	42	2	53	54
# of students accepted to colleges level 1	0	1	1	0	2	2	0	1	5
# of students accepted to universities level 2	5	30	37	16	108	28	49	2	144
# of students accepted to universities level 1	3	3	8	5	135	15	29	4	54
% of students in expansion class	26.07%	29.47%	33.86%	20.90%	0.00%	33.71%	25.84%	22.50%	41.43%

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