Teacher Pay and Teacher Aptitude*

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Abstract

Can changes in teacher pay encourage more able individuals to enter the teaching profession? So far, studies of the impact of pay on the aptitude distribution of teachers have provided mixed evidence on the extent to which altering teacher salaries represents a feasible solution to the teacher quality problem. One possible reason is that these studies have been unable to separate labor supply effects from labor demand effects. To address this, I model the relationship between current salaries and the academic aptitude of future teachers (those entering teacher education courses). Using a unique dataset of test scores for every individual admitted into an Australian university between 1989 and 2003, I explore how changes in average pay or pay dispersion affect the decision to enter teacher education courses in Australia's eight states and territories. A 1 percent rise in the salary of a starting teacher boosts the average aptitude of students entering teacher education courses by 0.6 percentile ranks, with the effect being strongest for those at the median. This result is robust to instrumenting for teacher pay using uniform salary schedules for public schools. I also find some evidence that pay dispersion in the non-teaching sector affects the aptitude of potential teachers.

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1. Introduction

Recent studies have provided substantial evidence in favor of two propositions: teacher quality is an important determinant of student achievement; and teacher aptitude has declined substantially over the past generation. Partly as a result of this research, raising the average quality of the teaching workforce has received increasing policy attention.

One way that teacher quality might be improved is by altering the pay structure within the teaching profession. Yet existing studies do not provide a clear picture of the relationship between teacher salaries and teacher quality. One problem is that of determining causation. Do salaries affect teacher quality, or does teacher quality affect salaries? For example, suppose that exogenous salary increases attract better teachers, but that when education authorities observe an exogenous rise in teacher quality, they lower salaries (to cut costs). In this scenario, the supply-side and demand-side effects will offset one another, and an outside observer might erroneously conclude that higher salaries do not attract better teachers.

To address this problem, this study uses a different approach to the existing literature. Instead of looking at the quality of current teachers, I instead focus on the group from which future teachers will be drawn: those studying teacher education. Because the typical teacher education student will not enter the teaching profession for another four years, it is unlikely that educational authorities will take account of the quality of teacher education students when setting salaries. Any observed relationship between teacher pay and teacher aptitude is therefore likely to be driven only by supply-side effects.

The identification strategy in this paper uses variation in teacher pay and teacher aptitude within states over time in Australia. For Australian public school teachers, teacher salaries are set by statewide collective bargaining, and students are required to choose their major (eg. teacher education) at the time of entering university. Like the US, Australia appears to have experienced a significant decline in teacher quality over recent decades.

To measure the academic aptitude of teacher education students, the research utilizes a unique dataset, containing test scores for every Australian student entering university over a 15-year period. In effect, this makes it possible to compare the scores of those entering teacher education courses with other students. Matching this to detailed information on the salaries of new teachers makes it possible to estimate the impact of changes in teacher pay on the quality of potential teachers.

Controlling for state-specific and time-specific effects, I find that raising average pay has a positive and significant impact on the aptitude of those entering teacher education courses. This result is robust to instrumenting for average teacher pay with the uniform salary schedules for public schools. Furthermore, there is evidence that earnings inequality in the non-teaching sector lowers the aptitude of potential teachers. Looking across the distribution of teacher test scores, the impact of an increase in average pay is strongest at the middle of the teacher aptitude distribution, while pay dispersion most affects those further up the distribution.

The remainder of this paper is organized as follows. Section 2 briefly discusses the relevant literature. Section 3 outlines a simple model of teacher aptitude. Section 4 presents the empirical strategy and results. Section 5 presents several robustness checks. The final section concludes, and shows the results of a simulated across-the-board pay rise on teacher aptitude.

2. What Do We Know About the Nexus Between Teacher Quality and Teacher Pay?

Studies of US teacher quality have shown that the performance gap between the best and worst teachers is substantial. Using panel data, with teacher and student fixed effects, Rockoff (2004) and Rivkin, Hanushek and Kain (2005), conclude that moving up one standard deviation on the teacher quality distribution leads to a gain in student achievement of approximately 0.1 standard deviations. This suggests that switching from a teacher at the 10th percentile to a teacher at the 90th percentile would raise a student from the median to the 60th percentile.

At the same time, researchers using a variety of different surveys have shown that the academic aptitude of those who enter teaching in the US has fallen over the past 3-4 decades. Corcoran, Evans and Schwab (2004) combine five longitudinal surveys and find that the percentage of teachers who placed in the top twenty percent on national achievement tests fell markedly from the early-1970s to 2000. Evidence from the National Longitudinal Surveys of Youth (Bacolod 2001) and the ACT exam (Leigh and Mead 2005) support this conclusion. In Australia, Leigh and Ryan (2006) look at changes in the literacy and numeracy standards of teacher education students and new teachers. Between 1983 and 2003, they find that the average percentile rank of those entering teacher education fell from 74 to 61, while the average percentile rank of new teachers fell from 70 to 62.

Several studies have sought to determine the impact of teacher pay on teacher quality. Given that we observe a positive relationship between test scores and wages across the labor market (Murnane, Willett, and Levy 1995 for the US; Marks and Fleming 1998 for Australia), it would perhaps be surprising if the same did not hold true in the labor market for teachers. However, Ballou and Podgursky (1995, 1997) present simulations showing that since teaching labor markets are typically in a state of excess supply, raising average teacher pay would have a small effect at best on the SAT scores of prospective teachers. Exploiting natural variation in average salaries across school districts at a single point in time, Figlio (1997) finds that districts with higher teacher salaries tend to attract more teachers from selective colleges and with subject matter qualifications. While Figlio attempts to control for factors that may affect both teacher pay and teacher quality, the use of a single cross-section raises the possibility that certain districts have unobservable characteristics that are positively correlated with both teacher pay and teacher quality.

Other researchers have estimated the direct impact of teacher pay on student outcomes. A standard approach is to construct repeated cross-sections from US states in census years, allowing estimation of models with state and year fixed effects. Card and Krueger (1992) use variation in teaching wages across states, and find that a 10% rise in teachers' salaries leads to a 0.1 percentage point increase in the rate of return to schooling for white males born between 1920 and 1949. Loeb and Page (2000) also use state-level variation in relative teachers' wages from the 1960-90 censuses, and find that a 10% increase in the teaching wage reduces the high school dropout rate a decade later by 3-4%.

However, some studies focusing on more recent cohorts have found a weak or non-existent relationship between pay and student performance (see Betts 1995 using the National Longitudinal Survey of Youth; Grogger 1996 using the High School and Beyond survey). In a meta-analysis of 119 studies, Hanushek (1997) notes that 45% observe a positive relationship between teacher pay and student performance, 25% find a negative relationship, and the reminder did not specify the sign of the effect.[1] So far as I have been able to ascertain, there is no empirical evidence on the relationship between teacher quality and student performance in Australia.

3. A Simple Model of Teacher Aptitude

In the Australian context (as in most European countries, though not the US), students must choose their college major at the time of entry into university. Although moving between courses is theoretically possible, in practice most students remain in their chosen major until graduation. College entry is determined almost entirely by statewide examinations, with each course in each college having its own entry cutoff. The number of places in each course and college is predetermined by the college and the federal government. For the typical young Australian, the occupational choice is therefore made at the end of high school.

[1] One related literature looks at the relationship between teacher pay and the supply of teachers, finding a positive relationship (Zabalza 1979; Chung, Dolton and Tremayne 2004). Another literature looks at the decision to quit teaching, and generally finds a robust relationship between pay and retention (Hanushek, Kain and Rivkin 1999; Dolton and van der Klaauw 1999; cf Frijters, Shields, and Wheatley-Price 2004). In the Australian context, Webster, Wooden and Marks (2004) cite a survey by Ministerial Council on Education, Employment, Training and Youth Affairs, which found that the most-frequently mentioned factor that would assist retention was remuneration, rating above reduced workloads and improved employment conditions.

Moreover, the course choices of high-ability students will affect the choices available to low-ability students: if a large number of high-ability students switch to a particular course, the minimum entry standard for that course will rise, preventing low-ability students from enrolling. The test score distribution in teacher education courses therefore reflects the number of available places in these courses, and the demand by students. Since the vast majority of Australian students attend a university in their state, I assume that students do not move across state boundaries to attend university, and that they do not move to a different state to teach after graduating.[2]

To model this environment, suppose a simple career choice model in which all individuals select a teaching or alternative non-teaching career at the end of their high schooling. For simplicity, suppose that the alternate occupation also requires a college degree, requiring the same number of years of postsecondary studies as a teaching qualification (this makes it possible to ignore the costs of university education). Assume also that in making the occupational choice, students' decisions are not influenced by the possibility of later switching into a different career.

The probability that individual i, living in state s, in year t chooses a teaching career (denoted by the superscript TCH), instead of an alternative non-teaching career (denoted by the superscript ALT) will therefore be determined by four factors: the individual's expected pay in teaching, the expected pay in an alternative occupation, the expected non-wage characteristics of teaching, and the expected non-wage characteristics of the alternative occupation.

$$P(Teach)_{ist} = F\left[E\left(W_{ist}^{TCH}\right), E\left(W_{ist}^{ALT}\right), E\left(NW_{ist}^{TCH}\right), E\left(NW_{ist}^{ALT}\right)\right] \qquad (1)$$

[2] In 2003, only 9.8% of commencing Australian university students were studying at a university in a different state from their state of residence. Source: author's calculations, based on Department Employment, Science and Training, *Selected Higher Education Statistics*, Section 3.1, Table 4 (2003). In earlier years, this figure was almost certainly lower, since exams were not standardized across all states until the mid-1990s. Teaching in a different state after graduation is not impossible, but is made less likely by the fact that teacher education students build up contacts with local schools through their practicum teaching. Almost all Australian universities are in the major cities; very few are near state borders.

Assuming that students do move across state boundaries, teacher quality will therefore be affected by the average wage in teaching and alternative occupations, the non-wage characteristics in teaching and alternative occupations, and the quantity constraint imposed by the government on the number of places in teacher education courses and courses leading to alternative occupations.

Suppose further that the non-wage characteristics (compensating differentials) in teaching and alternative occupations do not vary by ability, but that wages do vary by ability, with *WHigh* denoting the average wage of a high-ability person, and *WLow* the average wage of a low-ability worker.[3] The mean quality of those entering teacher education courses in a given state and year ($\overline{TQ}$) will therefore be determined by:

$$\overline{TQ}_{st}^{TCH} = F\left(\overline{W}_{st}^{TCH}, \overline{W}_{st}^{ALT}, \frac{WHigh_{st}^{TCH}}{WLow_{st}^{TCH}}, \frac{WHigh_{st}^{ALT}}{WLow_{st}^{ALT}}, \overline{NW}_{st}^{TCH}, \overline{NW}_{st}^{ALT}, \frac{Q_{st}^{TCH}}{Q_{st}^{ALT}}\right) \qquad (2)$$

The first two terms in parentheses are the average teaching wage and the average wage in alternative occupations. The third and fourth terms capture pay variance within teaching and in alternative occupations (as measured by the ratio of high-ability to low-ability wages). The fifth and sixth terms are the non-wage benefits in teaching and alternative occupations, and the last term is the number of places available in teaching courses relative to other courses (taking account of the quantity constraint imposed by the Australian federal government).

Within this simple model, we should expect the partial derivative of teacher quality with respect to the teaching wage to be positive, and the partial derivative with respect to the non-teaching wage to be negative. Likewise, as in Roy (1951) and Hoxby and Leigh

[3] In practice, the assumption that compensating differentials do not vary by ability is unlikely to hold in all instances. However, this is unlikely to create a substantial bias. Student-teacher ratios, the proxy I use for non-wage benefits in teaching, are typically set at a state level, not a school level. In alternative occupations, it is more plausible that compensating differentials might be positively correlated with ability, but to the extent that compensating differentials are proportional to salaries, the pay variance terms will capture these effects.

(2004), if the returns to ability are positively correlated across occupations, then the partial derivative of teacher quality with respect to teaching pay variance should be positive, while the partial derivative of teacher quality with respect to pay variance in alternative occupations should be negative. We should expect the partial derivative of average non-wage benefits in teaching and non-teaching occupations to have the same sign as the respective average salary terms. Lastly, the partial derivative of teacher quality with respect to the relative availability of teacher training positions is expected to be negative, since expanding the number of available places in teacher education courses will have the effect of lowering the entry cutoff for these courses.

4. Empirical Strategy and Results

To test the theoretical model, I use as a proxy for teacher quality the test score rank of those who enter teacher education courses. Naturally, this is not a perfect measure of teacher quality. Were the data available, for example, it might be preferable to use student-level panel data to estimate a measure of the value-added by each teacher. However, the use of teacher aptitude as a proxy for teacher quality has been validated in other studies, which have found a strong positive correlation between teachers' classroom performance and their own standardized test scores. This relationship appears to hold for teachers' scores in state teacher certification exams (Ferguson 1991; Ferguson and Ladd 1996), and for teachers' exams when they were in high school (Ehrenberg and Brewer 1994). Comparing various predictors of teacher quality, Ehrenberg and Brewer (1994) conclude that a teacher's own test scores and the selectivity of the college that the teacher attended are both positively related to pupil achievement, with the teacher's test scores having the stronger effect.[4]

To investigate the relationship between teacher pay and teacher quality, I therefore estimate an equation in which $\overline{TER}$ denotes the average tertiary entrance rank of those entering teaching in a given state and year and $\overline{W}$ is the average wage. Since I do not

[4] A meta-analysis by Hanushek (1997) found that in 64% of studies looking at the relationship between teacher test scores and student outcomes, the relationship was positive, while the relationship was negative in only 25% of studies (in the remaining 11% of studies, the sign was unspecified).

observe the returns to ability in a given occupation, I use as a proxy the variance in starting salaries. Specifically, I estimate the interquartile range of earnings (*W75*/*W25*) in teaching, and in alternative occupations. Within teaching, salary variance arises from pay dispersion within the government school sector (which is likely to be minimal), pay dispersion within the non-government school sector, and pay gaps between the government and non-government school sectors. In non-teaching occupations, salary variation reflects both inter-occupational and intra-occupational pay dispersion.

As a proxy for the non-wage benefits in teaching, I include $\overline{ClassSize}$, the student-teacher ratio in a given state and year. *Places* denotes the number of university places in teaching and alternative courses made available by the federal government in a given state and year.[5] This is designed to take account of changes in policy that might be correlated with teacher pay schedules. To control for general labor market effects, *Unemp* is the state unemployment rate, and δ and γ are state and year fixed effects respectively.[6] The state fixed effects absorb time-invariant unobservables in a state that are correlated with both teacher pay and the aptitude of potential teachers. Year fixed effects absorb factors that affect all states at the same time, such as labor market shocks, or demographic cycles affecting student enrolment and teacher retirement. Standard errors are clustered at the state level, to take account of serial correlation (Bertrand, Duflo and Mullainathan 2002). Where g indexes gender, s indexes states, and t indexes years, the equation to be estimated is:

[5] Since there are only two private universities in Australia, almost all those studying teacher education attended a public university where the number of places are set by the federal government. For example, in 2003, 98% of university students majoring in education attended a public university. Source: author's calculations, based on Department Employment, Science and Training, *Selected Higher Education Statistics*, Section 3.2, Table 18 (2003).

[6] In Australia, the school year runs from February to December. Students in year 12 typically rank their university preferences in November of their graduating year, and have a brief opportunity to revise them when they learn their tertiary entrance rank the following January. Therefore, where the tertiary entrance rank relates to those entering university in year t, the main variables on the right side of the equation (salary figures, unemployment rates, and student-teacher ratios) are averaged across years t and t-1.

$$\overline{TER}_{gst}^{TCH} = \alpha + \beta_1 \ln\left(\overline{W}_{st}^{TCH}\right) + \beta_2 \ln\left(\overline{W}_{st}^{ALT}\right) + \beta_3 \frac{W75_{st}^{TCH}}{W25_{st}^{TCH}} + \beta_4 \frac{W75_{st}^{ALT}}{W25_{st}^{ALT}}$$
$$+ \beta_5 \overline{ClassSize}_{st} + \beta_6 \frac{Places_{st}^{TCH}}{Places_{st}^{ALT}} + \beta_7 Unemp_{st} + \beta_8 Female_g + \delta_s + \gamma_t + \varepsilon_{gst} \tag{3}$$

Tertiary entrance rankings are available for all students who commenced an undergraduate degree or diploma course at an Australian university between the years 1989 and 2003. These figures are provided to the Department of Employment, Science and Training by universities on an annual basis. Although test scores are comparable across universities in the years 1999-2003, universities did not report on a common metric in earlier years, with scales varying even between different universities in the same state and year. For each university and year, I therefore convert all scores into percentile rankings. While making the data usable, this has the disadvantage that my results will only be identified from changes in the ranking of teacher education students *within* universities, and not from movements between less selective universities and more selective universities. Over the years 1999-2003, the correlation between this derived ranking and the comparable tertiary entrance rank (the Universities Admissions Index) is 0.76.

I calculate salary information using microdata from the annual Graduate Destination Survey. For both teachers and non-teachers, salaries are for those employed full-time. The survey covers around 15,000 respondents per year, of whom 15 percent are teachers. The large sample size of the Graduate Destination Survey allows me to calculate four salary measures for each state and year: average salary for teachers, average salary for graduates in non-teaching occupations, the interquartile range of earnings in teaching, and the interquartile range of earnings in non-teaching occupations. More information about the key variables is supplied in the Data Appendix. Table 1 presents summary statistics.

Table 1: Summary Statistics

Variable	Mean	SD	Min	Max
Percentile Ranking	38.329	7.339	2.462	54.344
Log Teacher Salary	10.405	0.133	10.111	10.662
Log Salary in Alternative Occupations	10.426	0.145	10.123	10.820
IQR in Teaching	1.275	0.118	1.032	1.485
IQR in Alternative Occupations	1.473	0.046	1.386	1.770
Student-Teacher Ratio	15.170	0.696	13.100	16.350
Relative Number of University Places in Teacher Education	0.064	0.032	0.002	0.211
Unemployment Rate	7.837	1.636	4.246	11.467
Female	0.750	0.433	0.000	1.000

Note: Data collapsed into 213 state-year-sex cells, and then weighted by the number of teachers in that state.

Figure 1 shows a kernel density plot of the percentile ranks of the entrants into teacher education courses in the period 1989-2003, based on the 173,961 teacher education students for whom TER scores are available. The distribution peaks just below 5, and steadily declines thereafter. The interquartile range is from 34 to 44, while the median is 39. Note that although those in teacher education courses rank below average for university entrants, they still rank above average if compared with their entire age cohort.[7]

[7] Over the period 1999-2003, test scores for all university entrants are scaled according to the Universities Admissions Index (UAI), which is designed to rank individuals against all those in their age cohort, taking into account the fact that some students drop out of school before taking the test. In this period, the mean UAI for entrants into teacher education courses was 75, the interquartile range was 73-79, and the median was 76.

Figure 1: Entrants into Teacher Education Courses

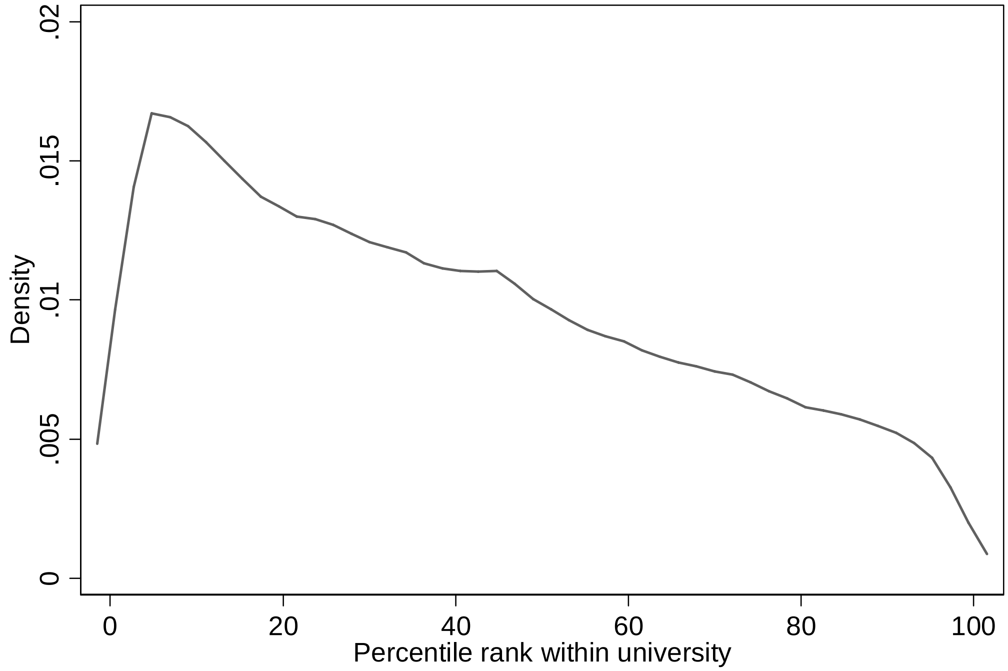


Table 2 shows the results from estimating equation (3), first for all entrants into teacher education courses, and then separately by gender. Average teacher pay appears to have a positive and significant impact on the aptitude of those entering teacher education courses. In the pooled specification, the coefficient on average teacher pay is 55.8, suggesting that a 1% rise in average teacher pay is associated with a 0.6 point increase in the mean percentile rank of potential teachers. The coefficient is around twice as large for men as for women.

The other pay coefficients have the expected sign. Average pay in alternative occupations is negative, though not significant. The coefficient on the interquartile range in teaching is small and statistically insignificant in all three specifications. This is consistent with teacher aptitude not responding to pay dispersion in the teaching sector; but more likely, it reflects the lack of any system approaching merit pay for most teachers. Leigh and Ryan (2006) show that among new teachers, there were no positive returns to aptitude in teaching through the period 1983 to 2003.

The interquartile range in alternative occupations is negative and statistically significant in all three specifications. This suggests (as a standard Roy model would predict) that a rise in earnings inequality in the non-teaching sector is likely to lower the average aptitude of potential teachers. The other controls are statistically insignificant.

Table 2: Teacher Pay and Percentile Rank of Entrants into Teacher Education Courses
Dependent Variable: Average Percentile Rank of Potential Teachers

	(1) All	**(2) Men**	**(3) Women**
Log Teacher Salary	55.815**	97.429**	45.562*
	[20.446]	[28.980]	[22.650]
Log Salary in Alternative Occupations	-91.458	-111.26	-86.851
	[50.001]	[78.057]	[47.171]
IQR in Teaching	0.61	10.709	-4.201
	[12.935]	[18.946]	[11.181]
IQR in Alternative Occupations	-58.946**	-40.421*	-65.804***
	[17.586]	[20.724]	[16.798]
Student-Teacher Ratio	-2.222	-2.553	-2.359
	[2.306]	[2.785]	[2.052]
Relative Number of University Places in Teacher Education	10.117	-109.122	-44.789
	[54.282]	[119.078]	[49.416]
Unemployment Rate	0.8	2.1	0.757
	[1.482]	[1.469]	[1.401]
Female	2.079		
	[3.683]		
State and Year Fixed Effects?	Yes	Yes	Yes
R-squared	0.69	0.67	0.73

Note: Data are collapsed into state-year-sex cells, and then weighted by the number of teachers in that state. Robust standard errors, clustered at the state level, in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels respectively.

Given that the university entrance score dataset contains the full universe of teacher entrance scores, it is also possible to estimate the equation at different points in the teacher aptitude distribution. Since the data are collapsed into state-year-sex cells, these effects are not estimated using quantile regressions, but instead by calculating for each state-year-sex cell the percentile rank of the teacher at the 10th percentile, 20th percentile, etc. Whereas estimating equation (3) provided an estimate of how teacher pay affected the tertiary entrance score of the average teacher, the focus is now on how teacher pay affects the test score of the bottom decile of potential teachers, second decile of potential teachers, and so on. For example, equation (4) shows the estimating equation where the dependent variable is the test score of the teacher education student at the 10th percentile.

$$P10(TER)_{gst}^{TCH} = \alpha + \beta_1 \ln\left(\overline{W}_{st}^{TCH}\right) + \beta_2 \ln\left(\overline{W}_{st}^{ALT}\right) + \beta_3 \frac{W75_{st}^{TCH}}{W25_{st}^{TCH}} + \beta_4 \frac{W75_{st}^{ALT}}{W25_{st}^{ALT}} + \beta_5 \overline{ClassSize}_{st} + \beta_6 \frac{Places_{st}^{TCH}}{Places_{st}^{ALT}} + \beta_7 Unemp_{st} + \beta_8 Female_g + \delta_s + \gamma_t + \varepsilon_{gst} \tag{4}$$

Table 3 shows the results of this estimation, with Panel A depicting P10, P20, P30, P40, and P50, and Panel B depicting P60, P70, P80, P90, and P95. The effect of average teacher pay is statistically significant at most percentiles, with the estimated effect being strongest at the median (P50), and weakest at the top and bottom. The magnitude of the coefficient at P50 is 92, suggesting that a 1% increase in average teacher pay would raise the percentile rank of the median student in teacher education by 0.9 points.

When looking only at the mean, non-teacher pay did not have a significant effect on the mean percentile rank of teacher education students. However, Table 3 suggests that non-teacher pay does have an effect on the aptitude of potential teachers towards the top of the distribution. The effect of non-teacher pay appears to be strongest at the 80th percentile, with a coefficient of 154 (significant at the 10% level), suggesting that a 1% increase in average non-teacher pay would lower the percentile rank of a student in teacher education by 1.5 points.

Teacher pay dispersion measures are small and statistically insignificant in all specifications. Pay dispersion in non-teaching occupations is positive and statistically significant for P10-P90, with the largest coefficient at P70. This indicates that greater earnings inequality in non-teaching occupations is likely to draw more academically able individuals out of teaching. The student-teacher ratio is negative and statistically significant for P90–P95. To the extent that smaller classes attract better teachers, this effect appears to operate primarily by attracting teachers at the top of the ability distribution.

Table 3: Teacher Pay and Percentile Rank of Entrants into Teacher Education Courses
Dependent Variable: Percentile Rank of Potential Teachers at Various Percentiles

Panel A: P10-P50

	(1) P10	(2) P20	(3) P30	(4) P40	(5) P50
Log Teacher Salary	9.74	38.773	72.124***	79.520**	91.667**
	[17.954]	[22.516]	[18.589]	[27.714]	[35.909]
Log Salary in Alternative Occupations	-45.721	-62.836	-86.199	-93.198	-111.491
	[26.826]	[41.380]	[46.074]	[52.756]	[66.600]
IQR in Teaching	1.906	-7.354	-4.166	-2.833	-0.247
	[6.537]	[9.174]	[10.338]	[11.916]	[19.616]
IQR in Alternative Occupations	-35.054***	-48.166***	-63.625***	-75.051***	-80.387**
	[8.142]	[13.157]	[13.330]	[17.609]	[26.278]
Student-Teacher Ratio	-0.428	-1.08	-1.865	-1.316	-1.692
	[1.009]	[1.448]	[1.971]	[2.384]	[3.461]
Relative Number of University Places in Teacher Education	-24.79	-12.511	-3.181	-5.904	0.691
	[31.358]	[48.327]	[53.269]	[63.976]	[68.091]
Unemployment Rate	1.561**	1.870*	2.290*	1.875	1.358
	[0.659]	[0.807]	[1.134]	[1.453]	[2.180]
Female	1.961	1.847	1.992	2.75	3.077
	[2.252]	[3.498]	[3.868]	[4.432]	[4.555]
State and Year Fixed Effects?	Yes	Yes	Yes	Yes	Yes
R-squared	0.55	0.64	0.7	0.71	0.67

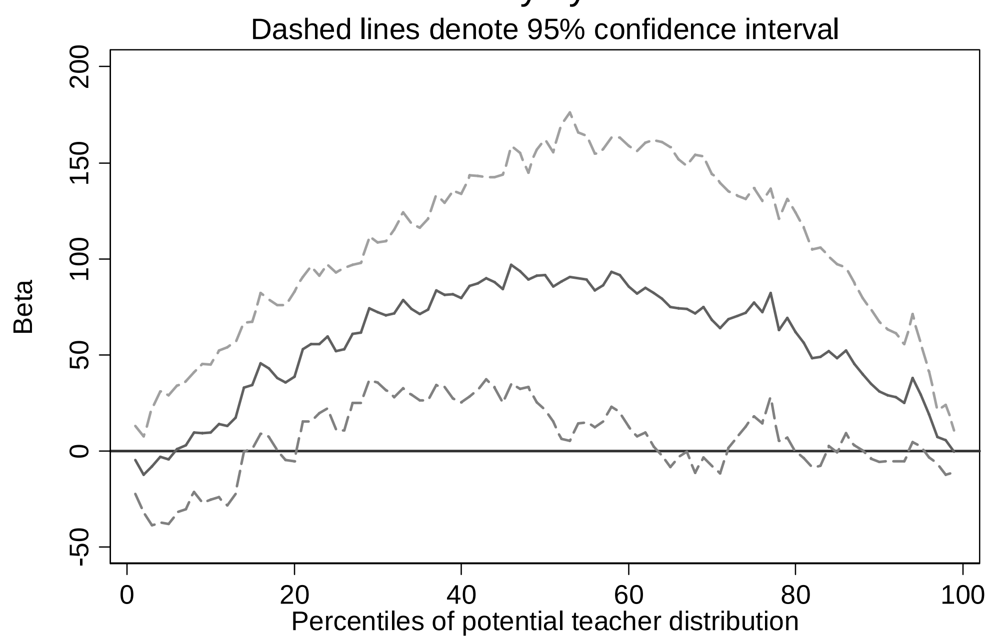
Panel B: P60-P95

	P60	P70	P80	P90	P95
Log Teacher Salary	85.673*	68.279	61.859*	30.89	29.176*
	[37.361]	[38.818]	[31.732]	[18.631]	[13.804]
Log Salary in Alternative Occupations	-119.983	-103.507	-153.982*	-121.766*	-56.675
	[72.882]	[76.014]	[71.308]	[53.742]	[42.666]
IQR in Teaching	6.073	8.957	-0.948	3.443	-5.902
	[22.575]	[23.226]	[21.700]	[13.572]	[7.178]
IQR in Alternative Occupations	-81.399**	-95.946**	-69.988**	-39.222*	1.293
	[27.885]	[34.448]	[27.765]	[17.107]	[8.266]
Student-Teacher Ratio	-1.684	-1.998	-4.883	-6.069**	-4.568***
	[3.875]	[3.975]	[3.127]	[1.812]	[1.238]
Relative Number of University Places in Teacher Education	4.215	28.602	43.567	60.291	64.661*
	[82.230]	[87.499]	[75.545]	[39.956]	[27.359]
Unemployment Rate	0.299	0.159	-0.48	-0.688	-0.042
	[2.295]	[2.539]	[2.291]	[1.680]	[1.102]
Female	3.344	2.18	1.781	1.38	0.878
	[5.524]	[5.760]	[5.002]	[2.444]	[1.636]
State and Year Fixed Effects?	Yes	Yes	Yes	Yes	Yes
R-squared	0.67	0.67	0.66	0.64	0.62

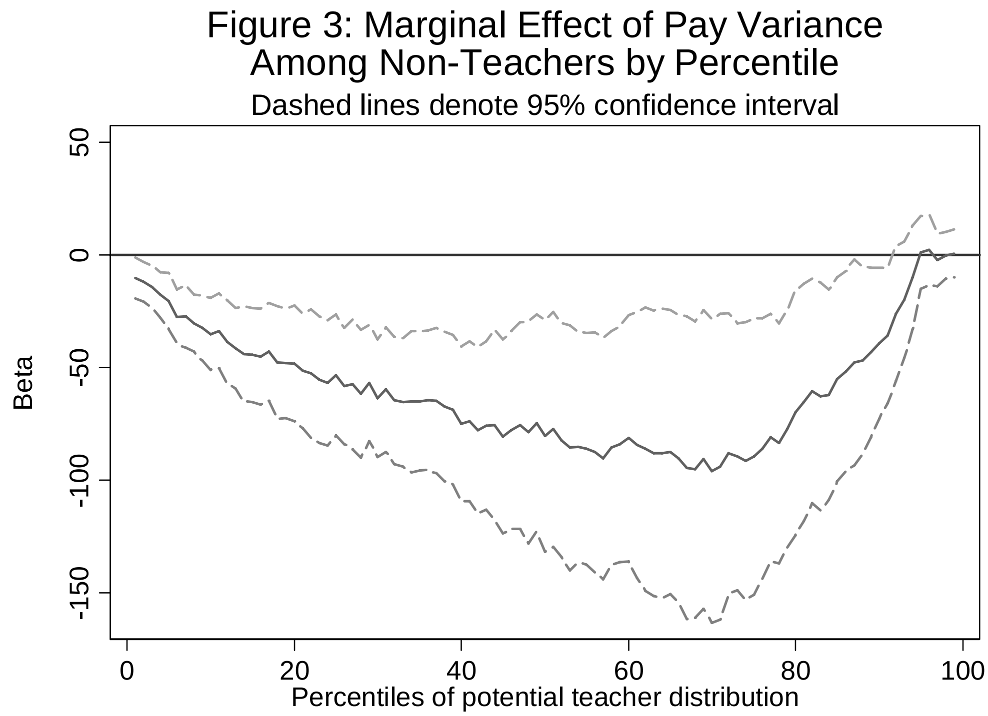
Note: Data are collapsed into state-year-sex cells, and then weighted by the number of teachers in that state. Robust standard errors, clustered at the state level, in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels respectively.

To see the effect of teacher pay across the full distribution, I re-estimate equation (4) for every percentile, and plot the two most statistically significant coefficients: average teacher pay and pay variance in non-teaching occupations. Figure 2 shows the relationship between average teacher pay and the aptitude of potential teachers, while Figure 3 shows the relationship between earnings inequality in the non-teaching sector and the aptitude of potential teachers. In both charts, dashed lines denote 95% confidence intervals. While the effect of average teacher pay is strongest at the median, the effect of earnings inequality in the non-teaching sector is stronger towards the top of the distribution.

Figure 2: Marginal Effect of Log Average Teacher Pay by Percentile



Note: Graph shows the point estimates and associated standard errors on the average teacher pay measure. Calculated by separately estimating equation 4 one hundred times, with the dependent variables P1–P99.



Note: Graph shows the point estimates and associated standard errors for non-teacher IQR. Calculated by separately estimating equation 4 one hundred times, with the dependent variables P1–P99.

5. Instrumenting Teacher Pay With Uniform Salary Schedules

As a robustness check, I instrument the average pay of a starting teacher using each state's uniform teacher salary schedules for public school teachers. This helps deal with potential measurement error when using the Graduate Destination Survey. Further, the instrumental variables approach might also be useful if one was worried that pay was endogenous to the aptitude of those entering teacher education courses. However, since the typical teacher education student will not become a teacher for another four years, endogeneity seems unlikely to be a major problem.

Uniform salary schedules cover all public school teachers in a given state. (Around three-quarters of all teachers work in public schools.) Changes in teacher salary schedules are as the result of collective bargaining agreements between the state's teacher union and the state government. The size of the salary increase will therefore be driven by the relative power of the teacher unions at a given point in time, as well as the political party in office at the state level. More information on the teacher pay schedules is provided in the Data Appendix. Since salary schedules are unavailable for certain states for particular years, the number of state-year-sex cells in these regressions is 183 (somewhat less than the 213 cells used to produce the results in column 1 of Table 2).

Since non-teacher pay and pay variance cannot be estimated from the salary schedules, I include only average teacher pay in the regressions in Table 4. The first column shows OLS results (for the subsample of states and years for which teacher salary schedules are available). The second column instruments teacher pay with the starting pay from uniform salary schedules. The third column presents reduced form results, with uniform salary schedules used in place of estimated teacher pay.

Table 4: Instrumenting with Uniform Salary Schedules
Dependent Variable: Average Percentile Rank of Potential Teachers

	(1)	(2)	(3)
	OLS	**IV**	**Reduced Form**
Log Teacher Salary	28.869**	66.384*	29.901*
	[11.359]	[28.754]	[15.182]
Student-Teacher Ratio	-0.261	-0.797	-0.341
	[2.037]	[2.123]	[2.180]
Relative Number of University Places in Teacher Education	20.935	14.721	26.775
	[76.539]	[81.655]	[76.271]
Unemployment Rate	-3.052	-2.824	-3.558
	[2.397]	[2.466]	[2.392]
Female	1.445	1.773	1.135
	[4.643]	[4.913]	[4.640]
State and Year Fixed Effects?	Yes	Yes	Yes
R-squared	0.68	0.67	0.68
F-test on excluded instrument		63.90	
		[P=0.0000]	

Note: Data are collapsed into state-year-sex cells, and then weighted by the number of teachers in that state. Robust standard errors, clustered at the state level, in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels respectively. In column 2, teacher pay is instrumented with the log of the starting salary for a beginning teacher in a public school in a given state and year. In column 3, teacher pay is the log of the starting salary for a beginning teacher in a public school in a given state and year.

As the results in Table 4 show, there is still a significant relationship between the teacher salary and the aptitude of new teachers, even instrumenting for teacher pay using uniform salary schedules. The coefficient on average teacher pay is 29 in the OLS specification, 66 in the IV specification, and 30 if uniform salary schedules are used in place of average teacher salary. Together, these results suggest that a 1% rise in average teacher pay leads to a 0.3–0.7 point increase in the mean percentile rank of potential teachers.

6. Conclusion

Combining two rich datasets – on the test scores for students entering universities, and on graduate salaries – I estimate the impact of salary variation within Australian states on the aptitude of potential teachers. The relationship between average pay and teacher aptitude is positive and significant: a 1% rise in teacher pay (relative to other occupations requiring a college degree) is associated with approximately a 0.6 point rise in the average percentile rank of potential teachers. This result is robust to instrumenting for average teacher pay using uniform salary schedules for public school teachers. The aptitude of potential teachers is also negatively associated with pay dispersion in non-teaching occupations, suggesting that earnings inequality in the non-teaching sector may hurt the teaching profession.

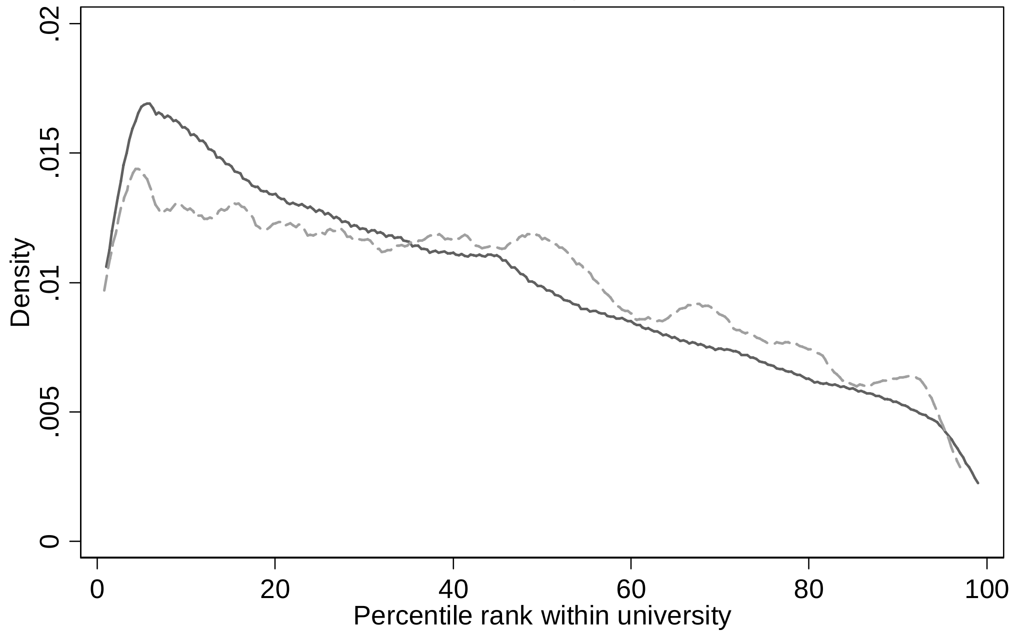
How might a given change in average starting teacher pay affect the distribution of potential teachers? To see this, Figure 4 simulates a 5% pay rise for all new teachers. (To put this in context for US readers: if we rank states by starting teacher salaries, this would be equivalent to the median state raising starting teacher salaries to the level of the 21st ranked state.[8]) Note that what is being simulated is a 5% rise in the pay of teachers *holding constant other graduate salaries*, so in reality such a reform would probably require a nominal increase in teacher pay in a single year that was closer to 10%. The estimates in Figure 4 are based on the coefficient estimates depicted in Figure 2, which allow the impact of average pay to have a different impact at each point in the aptitude distribution. The dashed line shows the kernel density estimate of the new distribution,

[8] Calculated using data provided by state departments of education to the American Federation of Teachers in 2003-04 (see http://www.aft.org/salary/). The ranking also included the District of Columbia. In 2003-04, starting teacher salaries ranged from $23,790 in Montana to $38,597 in Alaska. The 26th ranked state was Ohio ($29,790), which paid salaries approximately 5% lower than 21st ranked state, Florida ($31,467).

with fewer potential teachers below the median, and more potential teachers above the median.

Figure 4: Simulated 5% Pay Rise for All Teachers

Solid line is current distribution, Dashed line is simulation



Finally, it should be emphasized that this paper focuses only on the effect of changes in teacher pay on the pool of potential teachers (ie. those who enroll in teacher education courses). While this makes it possible to separately identify supply-side effects, this method has the disadvantage that not all potential teachers will enter the teaching profession. Inevitably, some of those who enter teacher education courses will switch into other courses, drop out of university altogether, or graduate and enter a non-teaching occupation. Most likely, those who switch into other courses will be have higher test scores, in which case the estimates above probably overstate the impact on teacher aptitude of raising pay. On the flipside, those who drop out of teacher education courses and those who enter alternative occupations may be those with lower test scores, in which case the exercise above may be an underestimate of the true impact of pay on teacher aptitude. Nonetheless, the fact that those entering teacher education courses do appear to be responding to the incentives offered to current teachers indicates that changing the teacher salary structure is a promising way of improving the quality of the future teaching workforce.

Data Appendix

University Entrance Data

Entry into university courses in Australia is based solely upon statewide standardized tests. In November of each year, prospective students rank university courses and universities. When results from the standardized test are released in January, students typically have a short period in which to change their course and university preferences. The number of places in each course and university is determined by the federal and state governments.

Data are drawn from the Student Enrolment file maintained by the Department of Employment, Science and Training (DEST), which contains the course choice, institution, tertiary entrance rank (TER), and basic demographic information on every individual admitted into an Australian university between 1989–2003. The data used in this paper cover all students entering undergraduate and diploma courses, but not those entering postgraduate courses. For the years 1999–2003, the tertiary entrance rank is expressed in the dataset as a comparable Universities Admissions Index, but for prior years the scaling varies across universities and years. The test scores in each university and year were therefore rescaled into within-university percentile ranks.

If a university reported the same score for all students, all scores were dropped. In addition, the state of Queensland officially used Overall Position (OP) scores in some years. Since an increase in the OP score denotes a fall in quality, it would be misleading to convert these scores into percentile rankings. The only university in the dataset that appears it might have reported OP scores to DEST is James Cook University in 1993. Given this possibility, I drop all students from James Cook University in that year.

After the within-university test scores of those entering teacher education courses had been calculated, those in other courses were dropped from the sample. Teacher education courses were defined as courses with Field of Study codes 50101–50499 in 1989–2000, and those with Field of Education codes 70100–79999 in 2001–2003.

The relative number of teacher education places in a given state and year is the total number of university entrants beginning teacher education courses, divided by the number of entrants commencing all other courses.

Salary Data

Annual salaries are derived from the 1988-2003 Graduate Destination Surveys. I restrict the sample to those who have just graduated with a bachelor's degree or a diploma, and are working full-time. The number of full-time primary and secondary school teachers in the surveys averages 2,371 per year, while the number of full-time graduates working in other occupations averages 13,521 per year. When the data are collapsed into state/year cells, the number of teachers averages 296 (the range is from 9–1927), while the number of graduates in other occupations averages 1690 (ranging from 56–7673). In 1988, the

Australian Capital Territory and the Northern Territory were not separately identified in the GDS.

The Graduate Destination Surveys are conducted in April of each year, using a sample of individuals who completed college the previous year. Respondents are asked for their annual salary. This salary data is then matched to the tertiary entrance ranking of those entering university the following year.

In section 5 of the paper, I experiment with instrumenting for the pay ratio in teaching with the official salary to be paid to a beginning teacher in a government school. To construct these series, I began with data generously provided to me by Linda Gale of the Australian Education Union, which covered most states and territories from the mid-1990s onwards. To obtain data for earlier years, I then wrote to all state and territory education ministers, requesting historical teacher salary schedules. Ultimately, I was able to obtain data for all states and years except Queensland before 1994 and Western Australia before 1996. As a result of these omissions, the sample size for the IV strategy is therefore slightly smaller than for the OLS specifications. I use as the beginning teacher salary the salary paid to a teacher at the bottom of the salary scale. In some instances, teachers with four-year qualifications are not paid at the bottom of the salary scale. However, since all specifications include state fixed effects, the results are identified off within-state changes, rather than levels. Since salary increments almost always raise salaries by the same percentage for teachers at all points in the scale, it will not matter whether the typical teacher actually commences at the fourth rung of the salary schedule or the first rung of the salary schedule (so long as the entry point does not change over time). As with the teacher salary data gathered from the Graduate Destination Survey, pay scales are matched to the tertiary entrance ranking of those entering university the following year.

Unemployment rates

Unemployment rates are drawn from Australian Bureau of Statistics, *Labour Force, Australia, Detailed*, Cat No 6291.0.55.001. Table 02: Labour force status by State.

Student-Teacher Ratio

Student-teacher ratios are drawn from Australian Bureau of Statistics, *Schools: Australia*, Cat No 4221.0. In 1988, ratios are calculated by combining data in Tables 7 and 18, and in 1989 from Tables 7 and 18. In subsequent years, the figures are listed in Table 18 (1990-92), Table 20 (1993-94), Table 21 (1995-96), Table 55 (1997-99) and Table 54 (2000-03). The figures are student-teaching staff ratios in 1990-2001, and full-time equivalent student-teaching staff ratios in 1988-89 and 2002-03. They are a weighted average across primary and secondary schools, and across the government and non-government sectors.

Sample Weights

All estimates are weighted by the size of the teaching workforce in that state in 1989. I assume that three-quarters of teachers are female, and one quarter are male.

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