Teacher Pay and Teacher Quality*

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Comments most welcome

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. Using a unique dataset of test scores for everyone 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 the eight states and territories that make up Australia. A 1% rise in average teacher pay boosts the average aptitude of students entering teacher education courses by 0.8 percentile ranks, with the effect being strongest for those just above the median. I find some evidence that higher pay variance in teaching also boosts 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, improving the average quality of the teaching workforce has received increasing policy attention.

One of the ways in which teacher quality might potentially be improved is by altering the pay structure within the teaching profession. Yet existing studies do not provide a clear picture on the relationship between teacher salaries and teacher quality. This study analyses the relationship between teacher pay and teacher aptitude, using variation within states over time. The data are drawn from Australia, a country that appears to have experienced the same decline in teacher quality as the United States. The research utilizes a dataset containing test scores for every Australian student entering university over a 15-year period, making 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 explore 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. Furthermore, there is suggestive evidence that increasing the variance of teacher pay also boosts the aptitude of potential teachers. Looking across the distribution of teacher test scores, the impact of an increase in average pay or pay dispersion is strongest in the top half of 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 quality. Section 4 presents the empirical strategy and results. The final section concludes by showing simulations of two potential policy reforms.

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 four longitudinal surveys, spanning the early-1960s to the mid-1980s, and find that the percentage of teachers who placed in the top twenty percent on national achievement tests fell markedly during this era. 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 (2005) observe a similar decline in teacher aptitude over the past two decades.

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 Quality

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

[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.

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. 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 decision of individual i, living in state s, in year t to choose a teaching career (denoted by the superscript TCH), or an alternative non-teaching career (denoted by the superscript ALT) will therefore be determined by four factors: her expected pay in teaching, her expected pay in an alternative occupation, the expected non-wage characteristics of teaching, and the expected non-wage characteristics of the alternative occupation.

[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). 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.

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

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 $\overline{WHigh}$ denoting the average wage of a high-ability person, and $\overline{WLow}$ the average wage of a low-ability worker. The mean quality of those entering teacher education courses in a given state and year ($\overline{TQ}$) will therefore be determined by:

$$\overline{TQ}_{st}^{TCH} = F\left(\frac{\overline{W}_{st}^{TCH}}{\overline{W}_{st}^{ALT}}, \frac{\overline{WHigh}_{st}^{TCH}}{\overline{WLow}_{st}^{TCH}}, \frac{\overline{WHigh}_{st}^{ALT}}{\overline{WLow}_{st}^{ALT}}, \frac{\overline{NW}_{st}^{TCH}}{\overline{NW}_{st}^{ALT}}, \frac{\overline{Q}_{st}^{TCH}}{\overline{Q}_{st}^{ALT}}\right) \tag{2}$$

The first term in parentheses is the relative wage (the average teaching wage, divided by the average wage in alternative occupations). The second term is pay variance within teaching (the ratio of high-ability to low-ability wages), while the third term is pay variance in alternative occupations. The fourth term is relative non-wage benefits (the ratio of non-wage benefits in teaching to the non-wage benefits in alternative occupations), and the fifth term is the relative availability of teacher training positions (the number of places available in teaching courses divided by the number of places in other courses).

Within this simple model, we should expect the partial derivative of teacher quality with respect to the relative wage and relative non-wage benefit terms to be positive. Likewise, as in Roy (1951) and Hoxby and Leigh (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. 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 she attended are both positively related to her students' achievement, with the teacher's test scores having the stronger effect.[3]

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. As a proxy for the return to ability in teaching and non-teaching occupations, I include the interquartile range of earnings (IQR), where *W75* and *W25* denote the wage at the 75th and 25th percentiles respectively. Within teaching, salary variance arises from pay dispersion

[3] 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).

within the government school sector, within the non-government school sector, and between the government and non-government school sectors. While the first is likely to be minimal, the second and third will be larger. 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. 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. 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). The equation to be estimated is therefore:

$$\begin{aligned}\overline{TER}_{st}^{TCH} &= \alpha + \beta_1 \frac{\overline{W}_{st}^{TCH}}{\overline{W}_{st}^{ALT}} + \beta_2 \frac{W75_{st}^{TCH}}{W25_{st}^{TCH}} + \beta_3 \frac{W75_{st}^{ALT}}{W25_{st}^{ALT}} + \beta_4 \overline{ClassSize}_{st} \\ &+ \beta_5 \frac{Places_{st}^{TCH}}{Places_{st}^{ALT}} + \beta_6 Unemp_{st} + \beta_7 Female_{st} + \delta_s + \gamma_t + \varepsilon_{st}\end{aligned} \tag{3}$$

Tertiary entrance rankings are available for all Australian students who entered an undergraduate degree 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 2000-03, 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, state and year, I therefore convert all scores into percentile rankings. While making the data usable, this has the disadvantage that regressions will only be identified from changes in rankings within universities, and not from movements between less selective universities and more selective universities. Over the years 2000-03, the correlation between this derived ranking and the comparable tertiary entrance rank (the Universities Admissions Index) is 0.74.

Salary information is derived from the annual Graduate Destination Survey, a mail-out survey conducted in April of each year. New teachers are assumed to have started work in January or February, so the salary information collected in April is matched to tertiary entrance rankings that are based on incoming university students' decisions in January of the same year (later, I also experiment with using salary information from the previous year). In the case of teachers and non-teachers, salaries are for those employed full-time. More information about the key variables is supplied in the Data Appendix. Table 1 presents summary statistics.

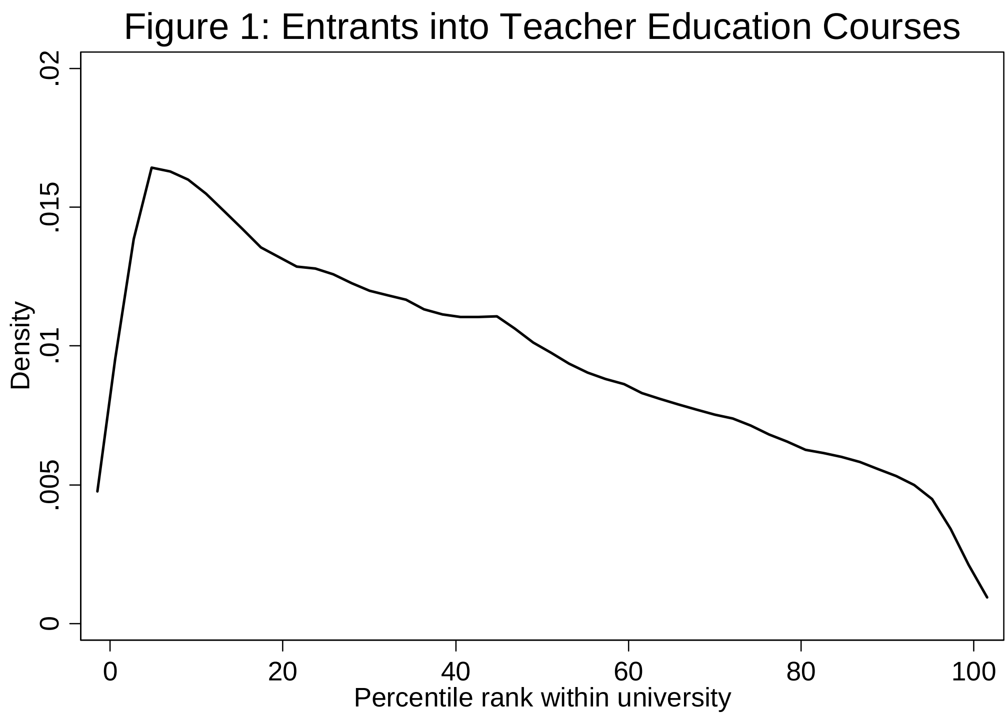
Table 1: Summary Statistics

Variable	Mean	SD	Min	Max
Percentile Ranking	39.317	6.996	2.462	54.344
Relative Teacher Pay	0.929	0.046	0.748	1.055
IQR in Teaching	1.291	0.106	1.000	2.467
IQR in Alternative Occupations	1.497	0.071	1.273	1.757
Student-Teacher Ratio	15.212	0.673	13.100	16.400
Relative Number of University Places in Teacher Education	0.071	0.034	0.002	0.211
Unemployment Rate	7.723	1.535	3.875	11.753
Female	0.763	0.425	0.000	1.000

Note: Data collapsed into 217 state-year-sex cells, and then weighted by the number of entrants into teacher education courses in a given state and year.

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 90,849 individuals for whom TER scores are available. The distribution peaks just below 5, and steadily declines thereafter. The interquartile range is from 16 to 60, while the median is 36. 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.[4]

[4] Over the period 2000-03, 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



To see the relationship between the average percentile rank of student entering teacher education courses and relative teacher salaries, Figure 2 charts the two figures over the period 1989-2003, for each of the eight states and territories in Australia.

UAI for entrants into teacher education courses was 77, the interquartile range was 70-85, and the median was 78.

Figure 2: Teacher Pay (solid line, left axis)
and Teacher Quality (dashed line, right axis)

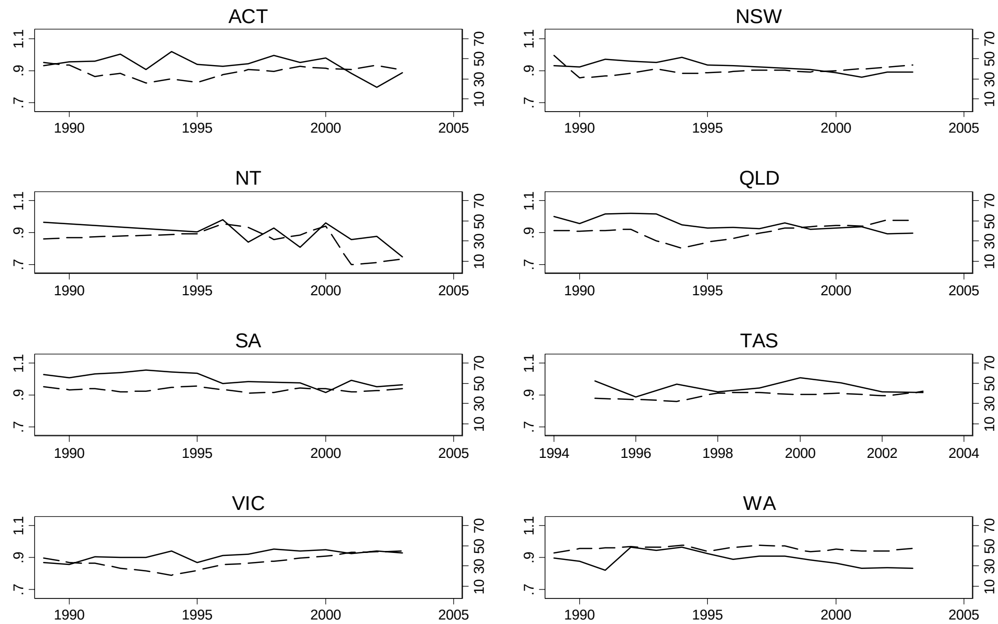


Table 2 shows the results from estimating equation (3), first for all entrants into teacher education courses, and then separately by gender. Average teacher pay appears to have a positive and significant impact on the aptitude of those entering teacher education courses. In the pooled specification, the coefficient on average teacher pay is 82, suggesting that a 1% rise in average teacher pay is associated with an 0.8 point increase in the mean percentile rank of potential teachers. The coefficient is slightly large for men than for women.

The coefficients on pay variance mostly have the expected sign (positive for variance in teaching, negative for variance in alternative occupations), but not statistically significant. Lower teacher-student ratios are associated with higher teacher quality, though the coefficient is only significant at the 10% level. 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**
Relative Teacher Pay	81.596***	91.480***	77.226***
	[20.258]	[24.590]	[19.025]
IQR in Teaching	8.079	5.674	7.67
	[8.553]	[9.063]	[8.457]
IQR in Alternative Occupations	-7.813	6.95	-11.106
	[18.240]	[18.535]	[18.180]
Student-Teacher Ratio	-3.540*	-3.386	-3.547*
	[1.721]	[2.100]	[1.572]
Relative Number of University Places in Teacher Education	20.729	-202.5	-2.484
	[35.078]	[118.604]	[30.401]
Unemployment Rate	0.009	1.407	-0.261
	[1.723]	[1.309]	[1.797]
Female	1.721	-	-
	[2.711]		
State and Year Fixed Effects?	Yes	Yes	Yes
R-squared	0.65	0.68	0.67

Note: All estimates are weighted by the number of entrants into teacher education courses in a given state and year. Robust standard errors, clustered at the state level, in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels respectively.

One possible concern is the point at which Year 12 students observe teaching wages. As discussed above, the specifications in Table 2 are based upon salary surveys conducted each April, which are then matched to university entry decisions made in January (this is done on the basis that salaries are unlikely to have changed between January and April). However, it might be the case that it is more appropriate to match university entrance decisions in January to salary information collected the previous April. Table 3 therefore shows the results from a specification in which salary measures are lagged by one year. In addition, I also lag the average student-teacher ratio, so the equation to be estimated is:

$$\overline{TER}_{st}^{TCH} = \alpha + \beta_1 \frac{\overline{W}_{st-1}^{TCH}}{\overline{W}_{st-1}^{ALT}} + \beta_2 \frac{W75_{st-1}^{TCH}}{W25_{st-1}^{TCH}} + \beta_3 \frac{W75_{st-1}^{ALT}}{W25_{st-1}^{ALT}} + \beta_4 \overline{ClassSize}_{st-1} + \beta_5 \frac{Places_{st}^{TCH}}{Places_{st}^{ALT}} + \beta_6 Unemp_{st} + \beta_7 Female_{st} + \delta_s + \gamma_t + \varepsilon_{st} \quad (4)$$

This adjustment does not make any substantial difference to the magnitude of the relative pay coefficient, which is 80 (still statistically significant at the 1% level). However, in this specification the magnitude of the relative pay coefficient is similar for men and women. Some of the pay dispersion measures are also statistically significant, with the interquartile range in teaching being positive and significant (at the 10%) level for men, and the interquartile range in alternative occupations negative and significant (at the 5% level) for all entrants, and for women.

Table 3: Lagged 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**
Relative Teacher Pay (t-1)	80.152***	78.905***	79.569***
	[8.051]	[12.887]	[8.744]
IQR in Teaching (t-1)	11.678	12.488*	11.458
	[7.613]	[5.785]	[8.044]
IQR in Alternative Occupations (t-1)	-22.317**	-8.713	-25.744**
	[8.889]	[10.339]	[8.420]
Student-Teacher Ratio (t-1)	-2.638	-2.169	-2.690*
	[1.564]	[2.283]	[1.315]
Relative Number of University Places in Teacher Education	26.863	-97.257	4.076
	[37.188]	[131.878]	[45.567]
Unemployment Rate	0.33	1.638	0.034
	[1.831]	[1.600]	[1.823]
Female	1.33		
	[2.659]		
State and Year Fixed Effects?	Yes	Yes	Yes
R-squared	0.64	0.65	0.66

Note: All estimates are weighted by the number of entrants into teacher education courses in a given state and year. Robust standard errors, clustered at the state level, in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels respectively.

Since 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 rank of the average teacher, the focus is now on how teacher pay affects the rank of the bottom decile of teachers, second decile of teachers, and so on. For example, equation (5) shows the estimating equation where the dependent variable is the rank of the student at the 10th percentile.

$$P10(TER)_{st}^{TCH} = \alpha + \beta_1 \frac{\overline{W}_{st-1}^{TCH}}{\overline{W}_{st-1}^{ALT}} + \beta_2 \frac{W75_{st-1}^{TCH}}{W25_{st-1}^{TCH}} + \beta_3 \frac{W75_{st-1}^{ALT}}{W25_{st-1}^{ALT}} + \beta_4 \overline{ClassSize}_{st-1} + \beta_5 \frac{Places_{st}^{TCH}}{Places_{st}^{ALT}} + \beta_6 Unemp_{st} + \beta_7 Female_{st} + \delta_s + \gamma_t + \varepsilon_{st} \qquad (5)$$

Table 4 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 not significant at the bottom (P10) and the top (P95), and is strongest at the 60th percentile. The magnitude of the coefficient at P60 is 132, suggesting that a 1% increase in average teacher pay would raise the percentile rank of a student at the 60th percentile by 1.3 points. Pay dispersion measures are statistically insignificant in all specifications. The student-teacher ratio is negative and statistically significant for P80–P95: to the extent that smaller classes attract better teachers, this effect appears to operate by attracting teachers at the top of the distribution.

Table 4: 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)	(2)	(3)	(4)	(5)
	P10	**P20**	**P30**	**P40**	**P50**
Relative Teacher Pay	15.18	47.827**	72.502**	99.331***	126.729***
	[14.001]	[17.180]	[22.094]	[25.825]	[28.111]
IQR in Teaching	1.256	4.275	6.09	8.82	11.1
	[5.290]	[7.334]	[8.412]	[9.263]	[10.966]
IQR in Alternative Occupations	-6.867	-7.999	-10.768	-6.813	-7.335
	[13.774]	[16.334]	[19.056]	[20.875]	[23.381]
Student-Teacher Ratio	-0.367	-1.83	-2.633	-3.103	-4.332
	[1.092]	[1.337]	[1.729]	[2.062]	[2.539]
Relative Number of University Places in Teacher Education	-24.046	1.046	10.713	16.16	22.069
	[28.141]	[37.657]	[41.604]	[44.075]	[40.851]
Unemployment Rate	0.363	0.368	0.536	0.265	0.443
	[0.852]	[1.211]	[1.503]	[1.737]	[2.332]
Female	2.197	1.356	1.665	1.936	2.263
	[2.090]	[2.900]	[3.313]	[3.493]	[3.233]
State and Year Fixed Effects?	Yes	Yes	Yes	Yes	Yes
R-squared	0.38	0.55	0.63	0.66	0.64

Panel B: P60-P95

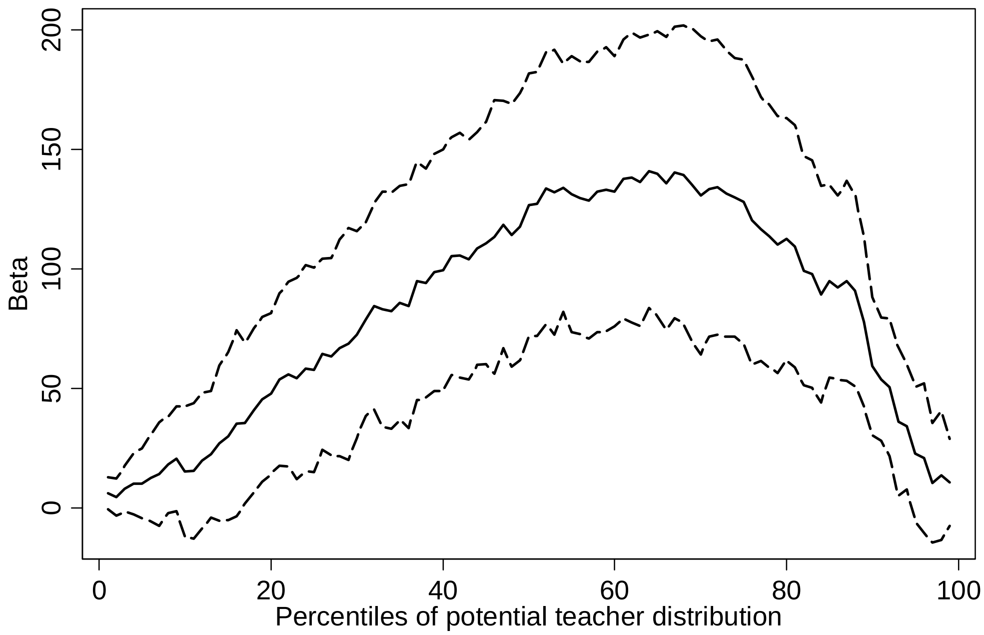
	P60	**P70**	**P80**	**P90**	**P95**
Relative Teacher Pay	132.383***	130.702***	112.455***	59.270***	22.629
	[28.861]	[33.943]	[25.799]	[14.737]	[14.346]
IQR in Teaching	13.967	13.246	12.505	7.386	0.853
	[11.086]	[12.721]	[12.652]	[8.327]	[5.085]
IQR in Alternative Occupations	-7.437	-14.978	-16.041	0.71	2.28
	[27.926]	[30.628]	[26.915]	[5.656]	[8.876]
Student-Teacher Ratio	-4.422	-5.065	-6.249**	-5.948***	-4.195***
	[2.630]	[2.896]	[1.905]	[1.297]	[0.901]
Relative Number of University Places in Teacher Education	18.903	51.494	54.149	51.305	56.930*
	[52.516]	[53.490]	[45.797]	[29.759]	[24.927]
Unemployment Rate	-0.234	-0.272	-0.83	-0.455	0.042
	[2.419]	[2.809]	[2.621]	[1.977]	[0.787]
Female	2.995	1.403	1.353	1.644	0.852
	[3.915]	[3.930]	[3.407]	[2.079]	[1.609]
State and Year Fixed Effects?	Yes	Yes	Yes	Yes	Yes
R-squared	0.67	0.64	0.65	0.61	0.6

Note: All estimates are weighted by the number of entrants into teacher education courses in a given state and year. Robust standard errors, clustered at the state level, in parentheses. *, ** 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 (5) for every percentile, and plot the coefficients for relative pay and pay variance in Figures 3 and 4, with dashed lines denoting the 95% confidence intervals.

Figure 3: Marginal Effect of Relative Teacher Pay by Percentile

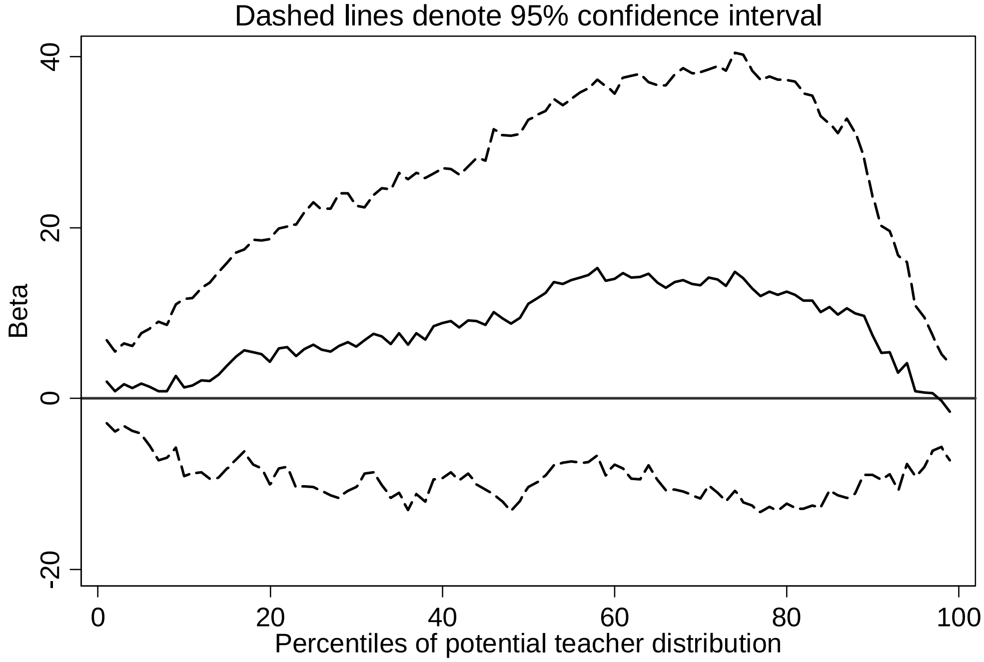
Dashed lines denote 95% confidence interval



Note: Graph shows the point estimates and associated standard errors on the relative pay measure. Calculated by separately estimating equation 5 one hundred times, with the dependent variables P1–P99.

Figure 4: Marginal Effect of Teacher Pay Variance by Percentile

Dashed lines denote 95% confidence interval



Note: Graph shows the point estimates and associated standard errors for teacher IQR. Calculated by separately estimating equation 5 one hundred times, with the dependent variables P1–P99.

Finally, Table 5 shows the results from three robustness checks. Since the fluctuations in aptitude and pay are greatest in the Northern Territory, the first column drops it from the regression. Since the previous regressions are all weighted by the number of potential teachers, and the Northern Territory has the smallest population of any Australian state or territory, this makes only a modest difference to the relative teacher pay coefficient, reducing it to 72 (statistically significant at the 5% level).

The second and third columns of Table 5 break the sample into two time periods, 1989-1996, and 1997-2003. In both specifications, the coefficient on relative teacher pay is positive and statistically significant at the 10% level. However, the magnitude of the coefficient is substantially lower in the later period, raising the possibility that the pay-aptitude relationship might have weakened in recent years.

Table 5: Robustness Checks
Dependent Variable: Average Percentile Rank of Potential Teachers

	(1) Drop NT	**(2) 1989-1996**	**(3) 1997-2003**
Relative Teacher Pay	71.743**	73.391*	23.775*
	[23.345]	[31.964]	[10.686]
IQR in Teaching	0.895	3.274	15.567
	[9.526]	[7.871]	[15.346]
IQR in Alternative Occupations	15.142	-2.824	-11.388
	[11.012]	[23.242]	[13.517]
Student-Teacher Ratio	-3.377**	-1.864	-7.795**
	[1.348]	[1.254]	[2.949]
Relative Number of University Places in Teacher Education	26.195	38.436	-13.883
	[42.942]	[38.248]	[48.265]
Unemployment Rate	1.006	0.657	-4.601***
	[1.848]	[2.330]	[1.289]
Female	1.424	0.793	3.358
	[3.098]	[3.076]	[3.504]
State and Year Fixed Effects?	Yes	Yes	Yes
R-squared	0.69	0.69	0.81

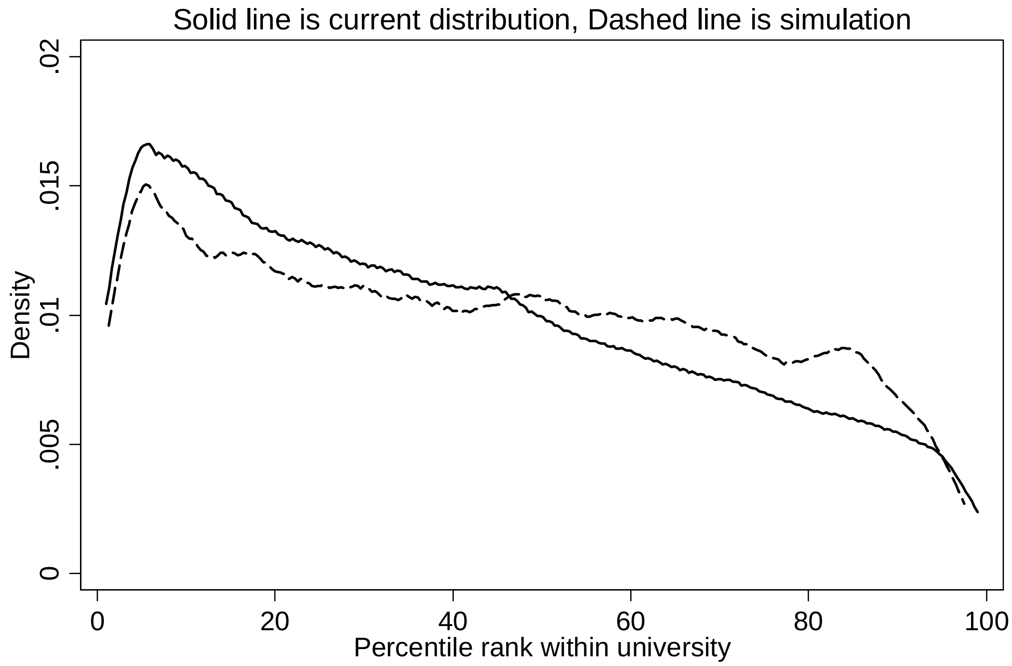
Note: All estimates are weighted by the number of entrants into teacher education courses in a given state and year. Robust standard errors, clustered at the state level, in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels respectively.

5. 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 quality is positive and significant: a 1% rise in teacher pay (relative to other occupations requiring a college degree) is associated with a 0.8 point rise in the average percentile rank of potential teachers. In lagged specifications, I also find some evidence that an increase in pay dispersion boosts the quality of potential teachers.

How might a given change in average teacher pay or pay dispersion affect the distribution of potential teachers? To see this, Figure 5 simulates a 5% pay rise for all new teachers. Note that this is a 5% rise in the pay of teachers *relative to other graduates*, 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 5 are based on the coefficient estimates depicted in Figure 3, 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, with fewer teachers below the median, and more teachers above the median.

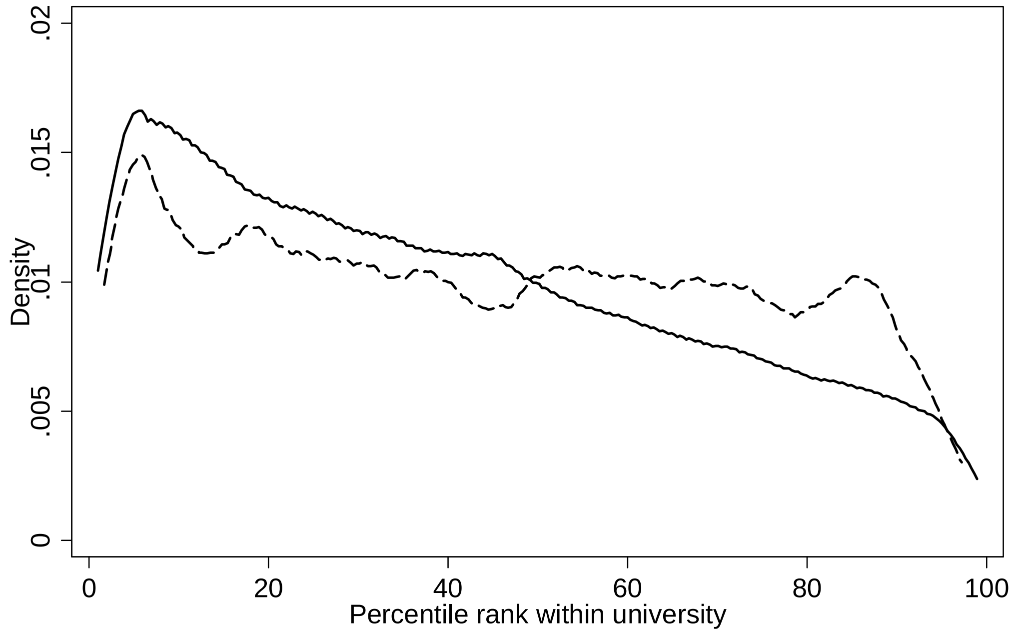
Figure 5: Simulated 5% Pay Rise for All Teachers



Next, I simulate a different policy reform, with the same total cost as the reform shown in Figure 5. Here, the pay of the top quartile is increased by 20%, while keeping the pay of the bottom three quartiles constant (relative to other graduates). This reform has two effects: first, it raises average pay by 5%, and second, it increases the interquartile range by 20%. The simulation in Figure 6 therefore combines the coefficient estimates in both Figures 3 and 4. Given that the estimates in Figure 4 are not statistically significant, this should be regarded as suggestive only – but the estimates in Figure 6 do indicate a greater increase in teacher quality than for the across-the-board pay rise.

Figure 6: Simulated 20% Pay Rise for Top Quartile 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). 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 quality 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 quality. 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. For the years 2000–2003, 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. I took three scales to have been "reasonable": 0–100, 100–500, and 100–1000. Outlying scores were therefore dropped based on the following rules:

(a) if the median TER was below 100, all scores over 100 were dropped
(b) if the median TER was 100–500, all scores below 100 and above 500 were dropped
(c) if the median TER was above 500, all scores below 100 were dropped
(d) the university reported the same score for all students, all scores were dropped

I experimented with not applying rules (a), (b) and (c), and found that this made little difference to the results.

Lastly, 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 uncertainty, I drop all students from James Cook University in that year.

The test scores in each university and year were then rescaled into percentile ranks, and those doing non-teaching courses were then dropped. Teaching 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).

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. Since most respondents graduated several months prior to the survey date, they are likely to have been hired as teachers in January or February. Salaries measured in April of a particular year are matched to the university entrance scores from January of the same 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.

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