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BETTER TEACHERS?

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Do Higher Salaries Buy Better Teachers?

by Eric A. Hanushek, John F. Kain, and Steven G. Rivkin

Do higher salaries raise the quality of teaching? Many influential reports and proposals advocate substantial salary increases as a means of attracting and retaining more talented teachers in the public schools and of encouraging harder work by current teachers. Salary policies have also been cited as important for offsetting changes in demands outside of schools and for dealing with the potentially unattractive working conditions often identified in central city schools.

The empirical evidence on the link between teacher quality and pay is, however, decidedly mixed—raising doubts that there is a strong relationship between the two. Direct analyses of student achievement, for example, provide limited evidence of any systematic relationship. Two explanations have emerged in response to this evidence. On the one hand, some argue that the true relationship between teacher quality and salaries is quite strong, but methodological and data problems have impeded the identification of salary effects. Others take a less sanguine position, arguing that the evidence captures accurately the weak performance incentives in the public schools that lead administrators to make hiring and retention decisions that are not strongly linked with teacher quality.¹ The evidence is quite strong on one point: teacher quality is an important determinant of achievement (e.g., Rivkin, Hanushek, and Kain 1998).

There are four main methodological problems that impede the estimation of the true relationship between teacher quality and salaries. Perhaps the most important is the difficulty of measuring teacher quality, because both direct measures of teacher characteristics and indirect measures based on student performance have proved problematic. Secondly, understanding the effects of salary policies requires distinguishing between shifts in salary schedules and movements along a given schedule (with, for example, increases in teacher experience), but this has proved generally difficult to do in past empirical work.

¹Loeb and Page (1998) emphasize the difficulty of identifying salary effects, and argue that methodological problems lead to inconsistent estimates of the relationship between quality and pay. On the other side, Ballou and Podgursky (1997) provide evidence that school administrators do not hire the best teaching candidates, thereby weakening the link between quality and pay.

schedules using both district and student fixed effects and controlling for student demographics.

Importantly, we concentrate on differences among salary schedules as distinct from movements along given schedules. Overall, the results provide little support for the hypothesis that pay is an important determinant of teacher quality. This finding is consistent with previous work on Texas schools that finds the majority of variation in education quality exists within rather than between schools and therefore cannot be closely linked with pay and other district or school wide factors.

Salaries and the Supply of Teacher Quality

The standard microeconomic framework for analyzing teacher supply and salaries would begin with individual labor supply decisions and aggregate these up to a market supply function. The supply of labor to district d within a geographical area j can be characterized by:

$$q_{dj}^S = f(w_d, WC_d, A_j, O_j)$$

where q^S is the supply of teacher quality for district d in area j ; w_d and WC_d are wages and working conditions, respectively, in district d ; and A_j and O_j are amenities and other employment opportunities, respectively, in area j .

The other half of the market, by simple analogy to the theory of the firm, has schools making maximizing decisions such as:

$$\max \sum_i P_{di} \text{ subject to}$$

$$P_{di} = g(q_d, X_d, F_{di}) \text{ [production function]}$$

$$B_d = w_d(q_d) + p_x X_d \text{ [budget constraint]}$$

draw inferences about supply responses from the observed pattern of teacher transitions, ultimately it is the combination of supply and demand that determines the link between quality and pay.

To fix the interpretation of the subsequent empirical work, we discuss briefly the most common issues that arise in the investigation of teacher labor markets, and outline the approach used in this analysis. Equation (1) describes the framework within which we examine these supply and demand side factors:

$$(1) \quad q_d^* = h(w_d^*, H_d, WC_d, A_j, O_j, L_{dj})$$

where H captures district hiring and retention practices and L captures worker skills and preferences and an asterisk indicates the observed outcomes of teacher quality and wage decisions.

Teacher quality (q). Fundamental to all discussions of teacher labor markets and teacher salary policies is the absence of clean measures of teacher quality. Available evidence indicates that direct measures of teacher quality, based on schooling, experience, college attended or even teacher test scores account for little of the variation in classroom performance (Hanushek 1997). This is not to say that these measures have no explanatory power, and Ferguson (1991) and Ehrenberg and Brewer (1994) both find that measured performance on teacher tests and college selectivity are systematically related to student achievement, with test scores having the strongest link.²

An alternative strategy uses information on student achievement itself as an indirect measure of teacher quality. The finding that teacher salaries have a significant impact on student achievement would imply that they have a significant effect on teacher quality. This strategy has great appeal, because it circumvents the problem of identifying the specific teacher characteristics that measure quality. However,

²The evidence suggests that test scores provide more information about teacher quality than either college selectivity or highest degree earned. Test scores have been used to measure the quality of people training to be teachers (Weaver 1983; Manski 1987; Murnane et al, 1991; Hanushek and Pace 1995; Strauss 1998). Such test measures are frequently related to state requirements for teacher certification and even for entry into teacher training programs (see Strauss 1998).

involves intertemporal issues in the measurement of salaries. Rigidities in the teacher labor market mean that the history of salaries along with expectations for the future rather than just the current salary influence the existing stock of teachers. This is a particular problem for analyses that identify teacher salary effects by inter-temporal changes in salaries within states or districts, because past salaries undoubtedly affect the current composition of teachers.⁶

By constructing annual salary schedules for single years of experience in each district over only teachers who do not have a graduate degree, we can isolate the effects of both cross-sectional and inter-temporal variations in overall salary levels.⁷ Importantly, in the analysis of teacher test scores, we restrict the sample to new teachers thereby circumventing the difficulty of aggregating across the time path of district salary structures (cf. Murnane et al., 1991). The analysis of student achievement does use contemporaneous salaries, and the fixed effect specifications are identified on the basis of changes in salary over a short period of time. We perform a detailed sensitivity analysis in an effort to identify potential problems introduced by the use of panel data.

Hiring and Retention Policies (H_d). While the relationship between salaries and employment is observed, it is not possible to infer *a priori* that the relationship is a “supply function” for teachers. Rather district hiring and retention practices are an important element in the labor market for teachers. This issue, made forcefully in a set of recent analyses (Ballou and Podgursky 1995, 1997 and Ballou 1996), is very important because it frames the interpretation of movements observed in the market. For example, the observation that retention and salaries are negatively related (controlling for all compensating differentials)

⁶Both Card and Krueger (1992) and Loeb and Page (1998) use state panels to identify the effects of salaries.

⁷We generally evaluate salary schedules at entry. Subsequently investigation shows that the results are not affected by considering salary differences for more experienced teachers. We have not investigated the possibility that salary increments for master’s degrees vary systematically across districts.

specification of the wage and compensation comparisons. Important elements of the overall market factors are also highlighted in Flyer and Rosen (1997) and Boardman, Darling-Hammond, and Mullin (1982).

The empirical evidence supports the belief that alternative earnings opportunities affect teacher labor supply. In a series of papers, Dolton and van der Klaauw (forthcoming) and van der Klaaw (1997) investigate the impact of alternative opportunities on teacher transitions. They find evidence that opportunity wages affect the probabilities of both entry and exit. These results are consistent with earlier work by Murnane and Olsen (1989, 1990), which found that opportunity wages affected duration in teaching in both Michigan and North Carolina.

In this paper, differences in alternative wage opportunities are addressed in two different ways. First, a series of region and community type dummy variables that control for any geographic variation across Texas in the wage structure are included in the empirical specifications. Second, the inclusions of student and district fixed effects effectively removes any time invariant differences in opportunity wages. *Working Conditions (WC_d)*. Much has been made of the fact that there is more to a teaching job than just the overall salary or compensation levels. Some of the earliest work considered how teacher preferences might affect the selection of schools (Greenberg and McCall 1974; Murnane 1981). More generally, teachers might be willing to take lower salaries to obtain better conditions in their schools, a proposition first found in Antos and Rosen (1975) and subsequently pursued in a variety of other analyses (e.g., Baugh and Stone 1982). Some have interpreted the push for lower class sizes by teachers as reflecting an element of teacher compensation, as opposed to an educational policy designed to improve student achievement (cf. Grissmer and Kirby 1992).

If differences in working conditions are not accounted for and they are correlated with salaries, estimates of the relationship between achievement and salaries will confound salary influences with those of other factors that affect teacher labor supply. For example, if salaries are higher in urban districts and teachers prefer suburban districts, estimates of teacher salary effects on achievement confound the impacts

The Texas Database

The ability to understand the character and outcomes of teacher labor market activities derives from the unique data base developed under the UTD Texas Schools Project, an undertaking conceived of and directed by John Kain. Working with the Texas Education Agency (TEA), this project has combined different data sources to compile matched panel data sets on students and teachers. The samples contain entire cohorts of Texas students and the universe of teachers in each year. While the data do not provide linkages of individual students and specific teachers, they do allow matching of students and teachers by school and grade for each year.

The Public Education Information Management System, TEA's state-wide educational data base, reports key demographic data including race, ethnicity and gender for both students and teachers as well as student eligibility for a subsidized lunch. It also contains detailed annual information on teacher experience, salary, education, class size, grade, population served and subject. Importantly, this data base can be merged with information on both student and teacher achievement. Beginning in 1993, the Texas Assessment of Academic Skills (TAAS) was administered each spring to eligible students enrolled in grades three through eight.⁹ These criterion referenced tests, which evaluate student mastery of grade-specific subject matter, are merged with the student and teacher information. We concentrate on reading and mathematics performance, subjects that are examined in all grades.¹⁰

⁹Many special education students are exempted from the tests, as are other students for whom the test would not be educationally appropriate. In each year roughly 15 percent of students do not take the tests, either because of an exemption or because of repeated absences on testing days. We exclude participants in bilingual or special education programs from the achievement analysis. For an explicit analysis of the achievement of special education students, see Hanushek, Kain, and Rivkin (1998).

¹⁰Reading and math tests each contain approximately 50 questions, although the number of questions and average percent correctly answered varies across time and grades. We transform all test results into standardized scores with a mean of zero and variance equal to one. The bottom one percent of test scores and the top and bottom one percent of test score gains across years are trimmed from the sample in order to reduce measurement error.

Teacher Mobility, Salaries and Student Demographics

While teacher quality is known to be a primary determinant of student achievement, the leverage that a school district has to improve the stock and performance of its teachers through compensation, class size and other non-pecuniary job characteristics is surprisingly unclear. In a competitive achievement-maximizing system, the collection of compensation, resources, alternative employment opportunities and district amenities would interact to determine the allocation of teachers, and districts with the most to offer among competing schools would get the best teachers. But, available evidence raises questions about the quality of teacher selection, suggesting that the actual distribution of teacher quality reflects the variation in hiring and retention policies as well as ability to pay and to provide other amenities.¹³ We begin with an analysis of the patterns of teacher moves in order to sort out the relative attractiveness of different districts.

Transitions Between and Within Districts (1993-96)

A primary goal of our mobility analyses is sorting out the separate influences of salary and other determinants of job attractiveness. Teachers are observed moving within districts, between districts, and out of Texas public schools entirely annually between 1993 and 1996. Importantly, we have information about salaries and student characteristics for both the sending and receiving schools for each transition.

Similar to job turnover patterns for the labor market as a whole, transitions differ sharply by teacher experience. Table 1 indicates that mobility is much higher among probationary teachers (0-2 years of experience), who are almost twice as likely as prime age teachers (11-30 years experience) to exit Texas public schools and over four times as likely to switch districts. As expected, mobility picks up again as teachers near retirement age, and almost one fourth of teachers with over thirty years of experience leave

¹³For example, Ballou (1996) demonstrates that schools do not systematically choose applicants with the strongest academic backgrounds or cognitive abilities. Murnane et al. (1991) describes the high variance in the information obtained about applicants and in the selection procedures of districts.

schools or outside of the state. The national patterns of mobility across experience categories do follow a similar pattern to that in Texas.

The pattern of moves tends to contradict the conventional wisdom that large urban districts are the proving ground for teachers, who move to suburban jobs when possible. Table 2, restricted to those changing districts, provides only weak support of the belief that teachers commonly leave urban districts for suburban positions. Among teachers in large urban districts, the majority of those switching

districts does relocate to suburban schools, but overall less than two percent of teachers in large urban districts move across districts in each year. The absolute number moving into urban districts is only slightly smaller than the number moving out.¹⁵

The bottom panel of Table 2 shows that a very similar pattern of movement holds for the subsample of probationary teachers, where again the net outflow from urban districts is small. Overall, probationary urban teachers are only one percentage point less likely to remain in the same school as probationary suburban teachers (71 versus 72 percent), and this is an identical gap to that for teachers of all experience levels. Two significant differences between new teachers starting in urban and starting in suburban districts do exist: Probationary urban teachers are roughly 3.5 percentage points more likely to exit teaching than teachers in suburban districts (not shown), while probationary suburban teachers are somewhat more likely simply to switch schools within districts.

Movement from rural districts follows a very distinct pattern. The majority of movers goes to a different rural district. Significantly fewer rural teachers move to urban districts than is the case for teachers initially in urban or suburban districts.

These aggregate transition rates among community types provide no information on the actual changes in salary and student composition. Tables 3, 4 and 5 report in increasing detail the relationship between pre-move and post-move salaries and student characteristics for teachers who switch schools and districts. Each table concentrates on how the average of specific characteristics (C) change with a move from district d to district d' , calculated as

$$(2) \quad \Delta C_{d,d'} = \overline{(C_t^{d'} - C_t^d)}$$

¹⁵During this period the share of Texas teachers in urban districts increased, implying that the small net outflow of teachers from urban districts is not simply a reflection of changes in the distribution of teaching positions across community types.

Table 3. Average Change in Salary and Student Characteristics for Teachers Changing Districts, by Gender and Experience

	men			women			all
	0-2 years experience	3-5 years experience	6-9 years experience	0-2 years experience	3-5 years experience	6-9 years experience	0-9 years experience
log base year salary	0.014 (0.004)	0.009 (0.005)	-0.003 (0.007)	0.007 (0.002)	-0.002 (0.002)	-0.002 (0.002)	0.004 (0.001)
Salary Residual	0.013 (0.003)	0.020 (0.004)	-0.002 (0.006)	0.007 (0.001)	0.004 (0.002)	-0.002 (0.002)	0.006 (0.001)
District Average Student Characteristics							
Average Test Score	0.064 (0.01)	0.074 (0.02)	0.036 (0.02)	0.087 (0.01)	0.092 (0.01)	0.075 (0.01)	0.080 (0.00)
% Hispanic	-6.0 (1.0)	-6.2 (1.5)	-2.3 (1.8)	-5.2 (0.4)	-5.3 (0.6)	-4.2 (0.6)	-5.0 (0.3)
% Black	-5.0 (0.6)	-2.2 (0.9)	0.5 (1.1)	-2.8 (0.3)	-2.9 (0.4)	-2.9 (0.4)	-2.6 (0.2)
% Subsidized Lunch	-6.0 (0.9)	-5.3 (1.5)	-2.4 (1.7)	-7.3 (0.4)	-2.4 (0.6)	-6.1 (0.6)	-6.6 (0.3)

Table 4. Average Change in Salary and in District and Campus Student Characteristics for Teachers with 0-9 Years of Experience who Change Districts, by Community Type of Origin and Destination District

Origin Community Type	Destination Community Type	log base salary	residual salary	Average Student Characteristics			
				test score	% eligible for subsidized lunch	% Black	% Hispanic
1. District Average Characteristics							
Large Urban	Suburban	-0.0065 (0.0024)	0.014 (0.002)	0.35 (0.01)	-23.9 (0.9)	-15.1 (0.6)	-18.8 (0.9)
Suburban	Suburban	0.0021 (0.0019)	0.006 (0.002)	0.12 (0.01)	-9.5 (0.6)	-4.1 (0.4)	-7.0 (0.6)
2. Campus Average Characteristics							
Large Urban	Suburban			0.34 (0.02)	-24.3 (1.3)	-15.5 (1.3)	-19.0 (1.4)
Large Urban	Large Urban (same district)			0.13 (0.01)	-9.6 (0.7)	-3.4 (0.8)	-5.3 (0.8)

Table 5. Average Change in Salary and in District and Campus Student Characteristics for Black and Hispanic Teachers with 0-9 Years of Experience who Change Campuses

Race/ethnicity of teacher	Average Student Characteristics				Number of teachers moving
	test score	% eligible for subsidized lunch	% Black	% Hispanic	
1. Between Districts Moves					
Blacks	-0.01 (0.03)	-1.3 (1.9)	5.8 (2.5)	-5.0 (1.9)	254
Hispanics	0.02 (0.01)	-4.9 (0.8)	0.2 (0.5)	-5.5 (0.9)	1,207
2. Within Districts Moves					
Blacks	0.01 (0.02)	-4.0 (1.1)	3.8 (1.6)	-6.0 (1.4)	464
Hispanics	0.03 (0.01)	-5.3 (0.6)	-0.7 (0.4)	-2.8 (0.5)	1,360

To summarize the effects on students, Table 6 reports simple school average transition rates at different points in the distribution of student and district characteristics. The table shows that teachers in schools in the top quartile of real salaries are 3 percentage points less likely to exit the public schools and almost 1 percentage point less likely to switch districts than teachers in the bottom quartile schools. Teachers in the top salary quartile are also somewhat less likely to switch schools within districts.

The most dramatic differences in school transition rates are related to student achievement. Teacher transition rates for schools in the bottom achievement quartile are much higher than those in the top quartile. Over 25 percent of teachers in the bottom quartile schools leave each year, while in the top quartile schools less than 20 percent leave. The largest difference is in the probability of exiting public schools entirely. These differences imply that the lowest achieving students are more likely to

have teachers new to the school and to the profession, and evidence from Texas strongly suggests that this will adversely affect achievement (Rivkin, Hanushek, and Kain, 1998).

Transition Regressions

The previous descriptive information on moves does not take into account the joint effects of the various influences. Table 7 presents reduced form estimates for linear models of the probability of leaving a district (either switching districts or exiting from the Texas public schools) as a function of the combined teacher and district characteristics.²¹ Separate estimates are computed by experience categories in order to allow for differences in preferences, family circumstances and job security. The direct salary effects are strongest for younger teachers: a 10 percent increase in salary is associated with a 2 percent decrease in the probability of leaving the district for probationary teachers and 1 percent decrease for teachers with 3 to 5 years of experience.

The multivariate analysis roughly follows the previously presented descriptive tables. **Higher average student achievement significantly reduces the probability of moving or exiting Texas public schools at all levels of experience.** Non-minority teachers are more likely to move the higher are the Black and Hispanic enrollment shares, although the only significant effects are related to percent Black students for younger teachers. Exactly the opposite is true for Black and Hispanic teachers, who are less likely to move the higher are these minority enrollment shares. There is little evidence of an independent effect of percent eligible for a subsidized lunch. Finally, (not shown) there is little or no evidence that the probability of moving is systematically related to average class size in any

²¹Note that these regressions expand the focus to include teachers who exit Texas public schools in addition to those who switch schools. In each year, more teachers exit than switch schools. All specifications other than those that include district fixed effects include region, community type and year dummies, school enrollment and average class size (measured for the available grades), number of campuses in a district, and teacher gender, race/ethnicity, experience and experience squared. The district fixed effect specifications drop the region and community type dummy variables.

specification, raising doubt about the frequently hypothesized impact of smaller classes on teacher decisions.²²

To consider unobserved district factors, we re-estimate the models with district fixed-effects that remove the influence of any time invariant district factors. Table 8 shows that the magnitudes of the coefficients on percent Black and percent Hispanic actually increase, suggesting that teachers respond more strongly to changes in student demographics. The inclusion of fixed effects also raises the magnitude and significance of the coefficient on eligibility for a subsidized lunch, but the direction of the effect is inconsistent with a labor supply story in which teachers prefer districts with higher income children. More likely, the negative relationship for subsidized lunch reflects institutional changes at schools related to Texas school finance reform efforts. Schools with less wealthy student populations experienced revenue increases during this period, money which may have been used to make teaching more attractive (in ways not measured here).

~~In contrast to the other variables and the findings of Murnane et al (1996), the significant salary coefficients disappear once district fixed effects are included. It could be that the true impact of salaries is quite small.~~ Alternatively, there could be insufficient salary variations across time, or the effects of hiring and retention policies could cancel out the labor supply response to higher salaries. For example, districts that raise salaries may also introduce more rigorous hiring and retention criteria, or they may experience an unobserved worsening of working conditions. Overall, the pattern of salary changes

²²Multinomial logit estimates (shown in Appendix Table A1) indicate that teacher salary is much more strongly related to the probability of switching districts (relative to remaining) than to the probability of exiting the Texas public schools. The pattern of transitions related to the percent of students who are Black, including the interactions with teacher race/ethnicity, are similar to those of the earlier tables, while the percent eligible for a subsidized lunch is positively related to the probability of switching districts.

suggests that salaries affect choices, though it is not possible to identify the precise size of the labor supply response.

Teacher Salaries, Mobility and Student Achievement

From a policy point of view, the most important question remains: Given district hiring practices, would an increase in salaries raise achievement?

Salaries may affect teacher quality in a number of ways. First, an increase in salaries likely enlarges the pool of applicants, but, even an expansion that raises average quality does not guarantee a positive relationship between teacher quality and salaries. The resulting change in quality depends crucially on both the hiring practices of districts and the decisions of teachers about retirement and exiting. Second, higher salaries might raise achievement by **raising the effort of current teachers**. For example, salary negotiations may explicitly link higher salaries with an expansion of responsibilities, or teachers may simply work harder in order to raise the likelihood of retaining their now more desirable job (in an efficiency wage sense). In the latter case, one would expect untenured teachers to have the strongest response in terms of effort. Tenure is not as prevalent or as strong in Texas as in other states, and there is substantial variation across districts in the degree of job security. However, teachers with less than three years of experience unambiguously enjoy the least amount of job security, and any effects on effort should be strongest on this group.

Two approaches used to estimate the link between teacher quality and pay are presented in turn. First, we consider the effects of starting salary on explicit measures of quality, the district average certification test scores for new teachers. Second, we examine the direct effects of salary on student achievement, controlling for student and other school characteristics.

of three community types (large city, small city and suburban); Y is a vector of three year dummies; β , λ , and the α 's are parameters to be estimated; and ϵ is a random error.

Table 9 presents eight specifications of the estimated effects of starting salary on the two test scores. The specifications differ along three dimensions: 1) whether student demographic characteristics are included; 2) whether district fixed effects are included; and 3) whether the regressions are weighted by the number of teachers in each district. The largest district is dropped because its inclusion dramatically altered the coefficients in the weighted regressions.

The results show little relationship between salary and either test score. None of the sixteen coefficients are statistically significant at any conventional level, and the same pattern (not shown) is produced if the percent who fail the test is used in place of average score. Perhaps the most striking aspect of Table 9 is the dramatic difference between weighted and unweighted results. Specifications that weight observations on the basis of the number of new teachers with valid tests in a district tend at least to produce positive point estimates, although none are statistically different from zero.

The different patterns for weighted and unweighted estimates suggest that the link between test score and salary differs by district size. This conjecture is confirmed by Table 10, which reports estimated effects of teacher salary by district size. Average teacher test scores are positively related to starting salaries only in districts that hire at least seven new teachers (the top quartile on the basis of new teachers hired), and the relationship is quite significant for the professional development test. The coefficient magnitude of 46.1 suggests that a ten percent increase in starting salary increases district average test score by 5 percentiles. It should be noted that the professional development test appears to be far more difficult than the comprehensive test, as the failure rate is almost three times as high.

Table 10. Estimated effects of starting salary on the quality of first year teachers as measured by the district average score on the Professional Development Test and the Elementary School Comprehensive Test, by quartile of district number of teachers hired (unweighted estimates with district fixed effects and student demographics; t-statistics in parentheses)

	Number of first year teachers hired			
	1	2-3	4-6	> 7
Professional Development	-90.5 (-1.16)	-28.4 (-0.74)	-27.7 (-0.48)	46.1 (3.34)
Comprehensive	-70.2 (-0.95)	-6.6 (-0.18)	-16.9 (-0.37)	15.9 (1.22)
Observations				
Professional Development	525	780	372	679
Comprehensive	525	786	371	695

One interpretation of these results is that larger districts make better use of the enlarged applicant pool generated by higher salaries. ~~The interpretation is clouded, however, because preliminary regressions show no evidence that these Excet scores are positively related to mathematics~~ or reading achievement for students in the Texas public schools.²⁶ Large districts appear to use more objective criteria in their hiring practices despite the fact that these tests do not seem to be very informative about quality. In any event, ~~the fact that other districts do not exhibit a preference for higher scores does~~

²⁶This preliminary work did not, for example, explore the possibility that test scores have different meanings for Black and White teachers, as suggested by Murnane et al. (1991). Future work will consider such possibilities. Ferguson(1991) found that district aggregate TECAT scores were positively related to district average student achievement in Texas during the late 1980s. TECAT tested subject matter knowledge, while EXCET tests mainly pedagogy. It may be possible in this analysis to explore different subsets of EXCET data to obtain measures more content related.

characteristics include information on race, ethnicity, gender, and eligibility for free or reduced price lunches. Teacher and school characteristics other than salary are computed separately for each grade and subject, and they include the average class size for regular students, the percentage of teachers grouped into seven experience categories, the percentage of teachers in five transition categories determined by status in the previous year,²⁹ and three measures of student demographic composition (percentage Black, percentage Hispanic, and percentage eligible for a subsidized lunch). The analysis focuses on the effects of the level of a district's salary schedule, as measured by the log of starting teacher salary. Individual teacher movements along the district's salary schedule are separately analyzed through inclusion of teacher experience and teacher graduate training, the primary determinants of position within the district's salary structure. Descriptive characteristics are reported in Appendix Table A2.

In the case of teacher salaries, communities that opt for higher pay scales may have other unobserved attributes that are positively related to achievement. For example, higher paying communities may have better computer facilities, better school administrators, better public services outside of education, or a community environment more conducive to learning. Each of these factors could introduce a positive bias to the estimate of teacher salary effects on achievement. On the other hand, communities with higher pay scales may have other, unobserved characteristics that tend to reduce teacher quality. Differences in housing or transportation costs, alternative job opportunities, and poorer working conditions are three types of factors that could introduce a negative bias on the estimate of teacher salary effects. We include twenty region dummies, three community type dummies, and the various school characteristics to account for the influence of such other factors on teacher labor markets, although it remains possible that important factors might not be captured by these variables.

²⁹ Included categories are: same campus but different grade, new campus but same district, different district and not in Texas public schools (with same campus and grade as the omitted category).

Table 11. Effects of District Base Salary and Teacher Characteristics on 4th and 5th Grade Achievement Gains
(Huber-White adjusted t-statistics in parentheses)

	4th Grade			5th Grade			4th and 5th Grade		
Math									
base year salary	-0.18 [-2.07]	-0.19 [-2.15]	-0.20 [-2.35]	-0.03 [-0.44]	-0.04 [-0.58]	-0.04 [-0.65]	0.68 [2.17]	0.66 [2.09]	0.62 [1.96]
% 0 yr experience		-0.08 [-2.15]	0.00 [-0.08]		-0.11 [-5.13]	-0.11 [-4.33]		-0.02 [-0.32]	0.04 [0.59]
% 1 yr experience		0.01 [0.19]	0.02 [0.62]		-0.05 [-2.14]	-0.05 [-2.12]		0.02 [0.46]	0.03 [0.55]
% in another district previous year			-0.06 [-1.06]			0.03 [0.97]			0.02 [0.26]
% did not teach previous year			-0.11 [-2.82]			0.00 [-0.25]			-0.08 [-1.57]
Reading									
base year salary	0.07 [1.03]	0.06 [0.90]	0.05 [0.85]	0.00 [0.12]	0.00 [0.09]	0.00 [-0.09]	0.79 [3.23]	0.79 [3.24]	0.80 [3.22]
% 0 yr experience		-0.08 [-2.15]	0.00 [-0.08]		-0.04 [-2.96]	-0.04 [-1.96]		0.00 [-0.02]	0.02 [0.45]
% 1 year experience		0.01 [0.19]	0.02 [0.62]		-0.03 [-1.66]	-0.02 [-1.52]		0.00 [0.00]	0.00 [-0.03]
% in another dist. previous year			-0.06 [-1.06]			-0.01 [-0.60]			0.07 [1.50]
% did not teach previous year			-0.11 [-2.82]			-0.02 [-1.28]			-0.02 [-0.62]
student fixed effects	no	no	no	no	no	no	yes	yes	yes
school nonmovers	no	no	no	no	no	no	yes	yes	yes
observations - math	156,924			472,142			92,526		
observations - reading	156,391			470,846			92,452		
<i>Results of Achievement Estimation</i>									

Table 12. IV Estimated Effects of Starting Teacher Salary on 4th and 5th Grade Math and Reading Test Score Gains (no controls for experience or turnover, Huber-White adjusted t-statistics in parentheses)

	4th Grade	5th Grade	4th and 5th Grade
Math	-0.21 [-2.02]	0 [0.07]	1.71 [4.26]
Reading	-0.01 [-0.18]	-0.01 [-0.26]	1.11 [3.54]
student fixed effects	no	no	yes
school nonmovers	no	no	yes

Note: District salary for second year teachers is used as an instrument for salary of first year teachers. Estimates based on 88,372 students for math and 88,287 for reading.

The IV results in Table 12 provide evidence consistent with the notion that changes in starting salaries are a noisy measure of changes in the overall salary structure. The math coefficient in the fixed effect model increases by a factor of 2.5, while the reading coefficient increases by roughly 50 percent. The coefficients imply that a 10 percent increase in starting salaries would raise math achievement by .17 standard deviations and reading achievement by .11 standard deviations. These magnitudes are somewhat larger than the estimated class size effects (per dollar of expenditure) obtained with the same data (Rivkin, Hanushek and Kain 1998).

The IV results strengthen the finding that changes in achievement are positively related to changes in salaries, but the question remains whether this relationship captures a causal effect. Evidence that the reduction of teacher turnover makes little or no contribution to the link between salaries and achievement raises some doubts about the underpinnings of the salary/achievement relationship, because it is the reduction of turnover that is thought to be the most likely path through which high salaries improve teacher quality.

Table 13. IV Estimated Effects of District Salary on 4th and 5th Grade Math and Reading Achievement, by Presence of Probationary Teachers and Existence of Teacher Turnover and by Controls for Region by Year Interactions (no controls for experience or turnover, Huber-White adjusted t-statistics in parentheses)

	All	years with at least one probationary teacher			years with teacher turnover		
		0	1	2	0	1	2
<i>1. No Region/Year Interactions</i>							
Math	1.71 [4.26]	2.44 [4.87]	0.50 [0.48]	0.82 [1.02]	2.26 [3.53]	1.64 [2.49]	1.11 [1.34]
Reading	1.11 [3.54]	1.29 [2.99]	0.48 [0.67]	1.12 [1.95]	1.60 [3.23]	1.10 [2.10]	0.76 [1.24]
<i>2. Includes Region/Year Interactions</i>							
Math	1.24 [2.39]	1.73 [2.56]	1.73 [1.44]	-0.16 [-0.16]	2.30 [3.33]	0.87 [0.96]	0.73 [0.70]
Reading	0.76 [1.91]	0.75 [1.33]	1.14 [1.35]	0.80 [1.13]	1.57 [2.55]	0.73 [1.08]	0.04 [0.05]
Individual fixed effects		yes	yes	yes	yes	yes	yes
School nonmovers		yes	yes	yes	yes	yes	yes
Observations							
Math		44,492	15,130	28,750	26,807	35,693	25,872
Reading		42,767	14,687	30,833	26,848	35,608	25,831

virtually unchanged by the inclusion of measures of experience and turnover in the regressions, implying they are not driven by differences in turnover rates. The results are also very similar if starting salaries are not instrumented by 2nd year salaries. Overall, these estimates suggest that if teacher salary raises achievement, it does so primarily by causing existing teachers to improve their performance *following* a salary increase. The explanations that are consistent with the estimates are very different than those that normally dominate

Conclusions

There is no question that teachers exert a tremendous impact on academic performance, but the question of how to ensure high quality teaching remains largely unanswered. Our previous analysis of achievement (Rivkin, Hanushek, and Kain 1998) indicated that teacher quality explained a substantial portion of the variation in student achievement. However, it also showed that observable teacher characteristics including education and experience explained little of the variation in teacher quality. More importantly, that analysis provides strong evidence that most if not virtually all of the variation in teacher quality occurred within schools (and thus within school districts), suggesting that school and district-wide factors such as compensation could play a minor role at most.

Nevertheless, the question of whether schools effectively buy better teachers is an important question for education policy. It is also a difficult question to answer. Interpreting the observed reactions of teachers to variations in salaries is complicated, because the outcomes combine the influences of teacher supply, teacher demand, and teacher hiring and retention policies of districts. Moreover, because of variations in the attractiveness of different teaching jobs and the complexity of the relationship between current and past salaries and the current composition of teachers, contemporaneous salaries are unlikely to capture fully variations across districts in their attractiveness. Finally, it is very difficult to measure teacher quality directly. For all of these reasons, we used a number of different approaches to gain a greater understanding of the link between pay, teacher quality and student performance.

The first component of this analysis looks at mobility across schools and districts and at exiting from Texas public schools. Though it is not possible to identify structural supply elasticities, the evidence strongly suggests that teachers prefer certain types of students over others. Except for Black teachers, the typical Texas teacher appears to favor higher achieving, nonminority students. Black teachers on the other hand, while favoring higher achievement students, systematically move toward schools with higher concentrations of Black

of region dummies into the fixed effect specifications substantially reduced the magnitude of the salary coefficients, suggesting that the coefficients capture the influences of unobserved factors that change along with salaries.

The pattern of results is perplexing, but the overall analysis suggests that as currently employed, salary policies do not appear to offer much promise for improvement in student performance. Factors other than salaries appear to play a much more important role in determining the desirability of specific districts. More importantly, the earlier finding that the variation in teacher quality within schools appears to be much larger than any between school variation suggests that districts should focus on other ways to improve the quality of teaching and academic achievement.

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Appendix Table A1. Multinomial Logit Estimated Effects of Teacher Salary and Student Demographic Characteristics on the Probabilities that Teachers switch School Districts or Exit Teaching (t statistics in parentheses, remaining in the same district is the numeraire)

	teacher experience				
	0-2 yrs	3-5 yrs	6-10 yrs	11-30 yrs	>30 years
<i>Switch Districts</i>					
log base year salary	-1.80 [-5.26]	-2.00 [-4.32]	-1.70 [-3.52]	-1.48 [-3.26]	-2.96 [-0.66]
<i>Campus Average Student Characteristics</i>					
Test Score	-0.07 [-0.92]	-0.40 [-3.84]	-0.11 [-0.97]	-0.16 [-1.43]	-1.68 [-2.05]
% elig. for subs lunch	0.46 [2.87]	-0.08 [-0.38]	0.27 [1.15]	0.39 [1.81]	0.49 [0.29]
% Black	1.05 [6.51]	0.86 [3.78]	0.86 [3.47]	0.91 [3.69]	-1.01 [-0.49]
% Hispanic	0.13 [0.76]	0.50 [2.17]	0.29 [1.14]	0.22 [0.91]	-0.77 [-0.37]
<i>Interactions with Race/ethnicity of Teacher</i>					
Black * % Black	-2.81 [-7.02]	-1.58 [-2.77]	-2.01 [-3.87]	-2.22 [-5.25]	4.22 [0.59]
Black * % Hispanic	-1.32 [-2.94]	-0.06 [-0.11]	-0.49 [-0.96]	-1.59 [-3.58]	3.04 [0.38]
Hispanic * % Black	-1.35 [-3.20]	-1.04 [-1.78]	-0.87 [-1.22]	0.01 [0.02]	-1.22 [-0.22]
Hispanic * % Hispanic	-1.15 [-5.40]	-1.10 [-4.17]	-0.71 [-2.15]	-0.80 [-2.66]	-1.77 [-0.76]

Appendix Table A2. Descriptive Statistics — Means and Standard Deviations

	4th Grade	5th Grade
Achievement Gains		
Math	-0.02 (0.65)	0.01 (0.59)
Reading	-0.03 (0.67)	0.01 (0.63)
Log District Salary		
0 yrs experience	10.00 (0.11)	10.00 (0.10)
Teacher Experience Distribution		
% 0 years	6.2	5.7
% 1 year	5.8	5.8
% 2 years	5.1	5.6
% 3-4 years	11.7	10.8
% 5-9 years	21.4	19.7
% 10-19 years	30.9	31.0
% 21-30 years	16.4	18.6
% > 30 years	2.5	2.8
Teacher Transition Distribution from Prior Year		
% same campus & grade	67.6	66.8
% same campus, different grade	12.8	11.6
% different campus, same district	4.2	5.6
% different district	3.6	3.3
% not in Texas public schools	11.7	12.7
Student Demographic Characteristics		
% Black	14.1 (20.4)	14.0 (20.4)
% Hispanic	31.0 (30.0)	31.0 (30.2)
% Eligible for subsidized lunch	46.8 (27.1)	46.7 (27.0)