Do Financial Incentives Help Low-Performing Schools Attract and Keep Academically Talented Teachers? New Evidence from California

Jennifer L. Steele,* Richard J. Murnane,**◊ and John B. Willett**

* RAND Corporation, ** Harvard Graduate School of Education, ◊ NBER

jsteele@rand.org
richard_murnane@harvard.edu
john_willett@harvard.edu

November 2008

DRAFT: Not for citation or attribution without permission of the authors.

We would like to thank the William and Flora Hewlett Foundation and the Spencer Foundation Dissertation Fellowship for each funding portions of this research. We are also grateful to the California Student Aid Commission (CSAC), the California Commission on Teacher Credentialing (CCTC), and the California State University Chancellor's Office (CSUCO) for providing our data, and particularly to Karen Vogel-Henderson, Catalina Mistler, Steve Caldwell, and Paula Rockwell at the CSAC; Dale Janssen, Marjorie Suckow, and Erin Duff at the CCTC; and Sabine Ghobriel, Daba Asemebo, and Beverly Young of the CSUCO. In addition, we appreciate the insights into the Governor's Teaching Fellowship provided by Ellen Curtis-Pierce, Philip Curtis, Anita Flemington, and Debby Ford.

Preliminary drafts of this study were presented at the Fall Conference of the Association of Public Policy Analysis and Management in November 2007, the Annual Meeting of the American Economic Association in January 2008, and the Annual Meeting of the American Educational Research Association. We are also grateful to individuals who offered helpful feedback and suggestions, including Bridget Terry Long, Brian Jacob, Eric Hanushek, Emiliana Vegas, Jason Snipes, Guido Imbens, and Joshua Angrist. All errors are the responsibility of the authors.

Do Financial Incentives Help Low-Performing Schools Attract and Keep Academically Talented Teachers? New Evidence from California

Abstract

This study capitalizes on a natural experiment that occurred in California between 2000 and 2002. In those years, the state offered a competitively allocated $20,000 incentive called the *Governor's Teaching Fellowship* (GTF) aimed at attracting academically talented, novice teachers to low-performing schools and retaining them in those schools for at least four years. Taking advantage of data on the career histories of 14,045 individuals who pursued California teaching licenses between 1998 and 2003, we use an instrumental variables strategy to estimate the unbiased impact of the GTF on the decisions of recipients to begin and continue working in low-performing schools. We find that acquiring a GTF increased by 34 percentage points the probability that recipients entered low-performing schools within two years after licensure program enrollment. However, on average, GTF recipients left low performing schools at a higher rate in their first year of teaching than academically talented teachers without GTFs who chose to work in low-performing schools.

I. Introduction

Targeted financial incentives are a popular policy strategy for attracting talented professionals to public-service jobs. The incentives exist in a number of forms. For example, conditional scholarships are financial awards that reduce the cost of professional training. In return for the award, recipients commit themselves to work in public service jobs for a specific period of time after graduation.[1] Loan forgiveness programs are similar, but differ in the timing of the benefits. Individuals take out loans to pay for training, and a portion of the loan is forgiven for each year of service in a public service job (Kirshtein, Berger, Benatar, & Rhodes, 2004). Others incentives, including signing bonuses, retention bonuses, and housing incentives, directly increase workers' compensation (Johnson, 2005). The justification for targeted incentives is that they use public (or charitable) funds to correct the market failures that arise when compensation for public service jobs does not reflect the benefits those jobs provide to society.

Targeted financial incentives can be found in a variety of professions including law, medicine, nursing, teaching, and military service. In law, for example, loan forgiveness and conditional scholarship plans are available from federal and state governments as well as from individual law schools to reward employment as a prosecutor, public defender, or legal aid provider to low-income individuals (ABA Commission on Loan Repayment and Forgiveness, 2003; Cooper, 2005). As rising higher education costs outpace inflation, some law schools have increased the debt-reduction incentives they offer. Harvard Law School, for instance, recently announced that it would supplement its existing loan forgiveness program with a conditional scholarship for third-year students planning public-interest careers (Glater, 2008). In medicine, the American Association of Medical Colleges (2006) reports that at least 44 states offer medical

[1] Failure to complete the commitment converts the awards into loans that must be repaid.

education incentives for doctors who agree to work in remote or economically disadvantaged areas that have a difficult time retaining physicians.

Targeted incentives are also popular in the teaching profession to counter the pervasive pattern that poor, minority, and low-achieving students are disproportionately taught by teachers with weak academic backgrounds and little experience and training (Becker, 1952; Clotfelter, Ladd, & Vigdor, 2005; Decker, Mayer, & Glazerman, 2004; Lankford, Loeb, & Wyckoff, 2002). They are also used to attract talent to subject areas such as computer science and chemistry in which demand exceeds supply at prevailing salaries (Jacobson, 2006; Johnson, 2005; Kirshtein et al., 2004). As of 2004, twenty-five states were implementing loan forgiveness or scholarship programs aimed at staffing shortage subject areas, and twelve states were managing loan forgiveness or scholarship programs designed to attract teachers to hard-to-staff schools (Johnson, 2005). Recruitment and retention incentives for teachers have also become more prevalent at the federal level. Legislation in 1998 allowed up to $5,000 of an individual's federal Stafford Loans to be forgiven at the end of a five-year teaching spell in a low-income school. With the Taxpayer-Teacher Protection Act of 2004, Congress temporarily raised the maximum Stafford Loan forgiveness allowance to $17,500 for teachers of mathematics, science, or special education (U.S. Department of Education, 2004), and passage of the Higher Education Reconciliation Act of 2005 made the increase permanent (Spellings, 2006).

Despite the popularity of targeted incentives in law, medicine, and education, little is known about their effectiveness in attracting skilled professionals to public service jobs and in keeping them in these jobs long enough to make real contributions (Glazerman et al., 2006; Jacobson, 2006; Kirshtein et al., 2004; Snipes, Quint, Rappaport, & Schofield, 2006). One informative study makes use of data from a natural experiment on teacher retention bonuses in

North Carolina. Using a difference-in- differences analytic strategy, Clotfelter, Glennie, Ladd, and Vigdor (2008) found that a $1,800-per-year *retention* bonus—which targeted licensed mathematics, science, and special education teachers working in high-poverty or academically failing secondary schools—reduced eligible teachers' turnover rates by 17 percent, or 5 percentage points. In the first year of implementation, 2001-02, the bonus was worth between 4 and 5 percent of an average teacher's salary in the state, which suggests that even modest financial incentives may influence teachers' decisions to remain in hard-to-staff schools.

The most rigorous research on the impact of education-based incentives comes from a study in which Field (2005) examined data from a controlled, randomized financial aid experiment conducted at NYU Law School from 1998 through 2001. She found that students who received a conditional scholarship had a 36- to 45-percent higher rate of first job placement in public interest law than those who received a financially equivalent loan forgiveness package. Field concluded that psychological debt aversion may explain why conditional scholarships had a greater impact on the job choices of law students than financially equivalent loan forgiveness programs. However, Field's study did not address the absolute effectiveness of either type of program.

A Natural Experiment in California

This study examines the impact of the California *Governor's Teaching Fellowship*, a $20,000 conditional scholarship designed to attract academically talented, newly licensed teachers to schools in the bottom half of the state's *Academic Performance Index*[2] (API) and

[2] A school's ranking on the Academic Performance Index is a function of students' performance on the Statewide Testing and Reporting (STAR) program of annual standardized tests ("California Education Code, Section 69612-69615.6," 2000).

retain them in low-performing schools for at least four years. Only prospective teachers who were enrolled in accredited, post-baccalaureate teacher licensure programs in 2000-01 or 2001-02 were eligible to apply. The fellowship was “merit-based” (California State University Office of the Chancellor, 2002, pp., p. 5) and competitive, targeting “the ‘best and brightest’ of California’s full-time preservice teaching candidates” (p. 7). Applicants submitted undergraduate and graduate school transcripts, letters of recommendation, a resume, and a personal essay, and were interviewed by telephone. In 2000-01, the state awarded 249 fellowships, and 245 recipients accepted the awards. In the program’s second year, 2001-02, the state awarded 947 fellowships, of which 945 were accepted. The following year, the program was discontinued due to high overhead costs and statewide budget constraints (California Legislative Analyst's Office, 2002). The full amount of the fellowships was paid at the time that the awards were issued, and recipients who did not fulfill their four-year commitments to teach in low-performing schools after becoming licensed were required to repay $5,000 per year of service not completed.[3] By effectively granting teachers $5,000 for each year of qualifying service, the fellowship offered a 15.1 percent annual premium over the 2000-01 average starting salary of $33,121 for California teachers (American Federation of Teachers, 2002).

Of importance to our study, the GTF intervention was a financially attractive add-on to a longstanding loan forgiveness program for California’s teacher-licensure candidates, the Assumption Program of Loans for Education (APLE). The baseline APLE contract forgives between $11,000 and $19,000 of student loans[4] in exchange for four years of service in shortage

[3] As of April 2008, 864 out of the 1,190 GTF recipients who ultimately accepted the award (73%) had completed their service commitment or repaid the state. Another 223 (19%) had repaid at least part of the award, and the remainder were still completing the service commitment or were on leave from a qualifying teaching position.

[4] Teachers of mathematics, science, or special education qualify for an additional $1,000 per year, and teachers of those three subjects working in schools with API rankings in the bottom 20% can earn yet another $1,000 annually. Thus, the largest possible award over four years is $19,000.

subject areas or hard-to-staff schools, including low-income, low-performing, rural, and poorly staffed schools.[5] Because the APLE program tracks the teaching jobs of its contract recipients for up to four years after they earn teaching licenses, we use a dataset of individuals who received APLE contracts in the academic years from 1998-99 through 2002-03 to estimate the effects of GTF availability on the employment decisions of newly licensed, academically talented teachers.

Since the 1998-99 academic year, when the APLE program expanded from 400 to 4,500 the number of loan forgiveness contracts offered per year, these contracts have been widely available to California teacher-licensure candidates, and APLE recipients have constituted a very large subset of teachers pursuing first-time teaching licenses in the state. Between the 1999-00 and 2002-03 academic years, the number of standard, in-state APLE contracts awarded each year exceeded the number of first-time, in-state teaching licenses by an annual average of 2,612, or 86 percent (Burke & Errett, 2000, 2001, 2002, 2003; California Student Aid Commission, 2004). This is possible because, while the standard APLE contracts are targeted (with a few exceptions) at teachers without prior licenses, some may nevertheless have held prior emergency credentials. It is also possible because not all APLE recipients went on to earn their licenses. Even among those who did earn licenses, not all recipients entered qualifying teaching positions. In our analytic sample of APLE recipients from 1998-99 through 2002-03, only 71 percent reported that they taught in public schools in California within the next two years. This suggests that many licensure candidates pursue APLE contracts without a decisive plan to fulfill the teaching

---

[5] APLE's designated shortage subject areas fluctuate but have often included mathematics, science, bilingual education, reading specialist, special education, and foreign language. The qualifying school categories include low-income school (where at least 30% of the students qualify for free/reduced lunch or public assistance), low-performing schools (scoring in the bottom 20% of the state), rural schools, or schools with a large share of emergency-credentialed teachers (California Student Aid Commission, 2004).

commitment specified in the contract. This pattern may be due to the relative ease of contract attainment. The two-page APLE application can be quickly completed by hand. Recipients are chosen by their licensure programs, and as the APLE program have expanded, these programs have had to work aggressively to award all the contracts allocated to them (California Student Aid Commission, 2005). The APLE program is critically important for this study because it is the only dataset that tracks the school-level employment choices of a large subset of novice California teachers in the four years after they became licensed teachers.

Research Questions

This study exploits a statewide policy discontinuity—the sudden arrival and subsequent disappearance of the GTF—to obtain unbiased estimates of the award's causal impact on the early-career decisions of its recipients. In particular, we ask: *to what extent did receiving a GTF increase the probability that an academically talented novice teacher took a job in a low-performing school?* Our second question concerns the award's impact on teachers' retention. Specifically, we ask: *did the GTF affect the probability that academically talented teachers who took jobs teaching in low-performing schools remained in these schools?*

II. Research Design

Datasets

Our dataset includes information merged from three agencies: the *California Student Aid Commission* (CSAC), which administers the APLE program, the *California Commission on Teacher Credentialing* (CCTC), which issues teaching licenses, and the *California State University Chancellor's Office* (CSUCO), which administered the Governor's Teaching

Fellowship program. Our analytic dataset contains annual panel data on 29,358 teacher-licensure candidates who received APLE contracts between the 1998-99 and 2002-03 academic years. It tracks their school placements longitudinally through the completion of their fourth teaching year, the full payoff of their student loans, *or* the 2004-05 academic year—whichever occurred first. In addition, the data describe which APLE recipients received GTF awards during the two GTF years. We find that 725 of the 1,196 GTF recipients (61 percent) appear in our database of APLE recipients. During the time that both awards were offered, an APLE contract was far easier to obtain than a GTF. Thus, it is reasonable to assume that the 39 percent of GTF recipients who do not appear in the APLE database did not have enough undergraduate or graduate school student loans to justify their pursuit of APLE contracts.[6]

To reflect the information publicly available to newly licensed teachers at the time of their job searches, the Academic Performance Index rankings that we use to classify schools as low-performing come from two years prior to the year of qualifying employment.[7] However, because California did not introduce the API ranking system until 1999, API rankings from 1999 are used to classify schools in which teachers worked prior to and during 2000-01.

Sample

---

[6] It is also possible that errors in coding social security numbers prevented some matches of GTF files, test score files, and APLE files, though the people conducting the match spot-checked the name matches at our request.

[7] Rankings from two years prior to the employment year were used because licensure candidates typically begin seeking employment during spring and summer of the school year before they begin teaching. At that point, the available school rankings are based on students' test scores from the previous year. For instance, a teacher newly employed in a low-performing school in 2002-03 would have pursued that job in the spring or summer of 2001-02, when the available school rankings would have been based on students' test scores in 2000-01. In each GTF year, the state made available a list of eligible low-performing schools based on the most recently published test scores and school rankings. As long as their schools appeared on the most recent list of low-performing schools, teachers were not penalized if the schools' rankings had risen by the time they began working there.

The analysis is limited to teacher licensure candidates who received APLE contracts between 1998-99 and 2002-03. This five-year window includes two years immediately prior to GTF availability, two years during which the GTF was offered, and one year following GTF availability. From that subset of 29,358 APLE recipients, we exclude 10,795 individuals with missing credential information, 1,166 with missing gender codes, and 46 with missing licensure test scores. Because our analysis (described below) examines the probability of teaching in a low-income school within two years after receiving an APLE contract, we also exclude 3,306 individuals who took three or more years after receiving APLE contracts to earn their professional teaching credentials.[8] These exclusions result in an analytic sample of 14,045 APLE recipients. Descriptive statistics for this analytic sample are presented in Table 1. As described by the sample distribution of the variable *eligible*, 37.1 percent of these individuals (3,709) were enrolled in licensure programs exclusively in the years prior to GTF availability, while 49.6 percent (6,969) were enrolled during GTF program years, and 24.0 percent (3,367) were not enrolled until the first year after the GTF was terminated.[9]

<Insert Table 1>

[8] Earning a professional license in California typically takes two to three semesters with full-time enrollment (California Department of Education, 2004), and the modal time from APLE contract to professional license is one year in the dataset. Our preliminary analyses suggest that the 18.8 percent of individuals in the dataset who took at least three years to obtain professional licenses are systematically different from those who did so more quickly. For instance, their highest average CBEST scores in mathematics and reading are 3.5 and 3.7 point lower, respectively, than those who earn credentials within two years, and the average number of times they take the CBEST before passing is 2.3, versus 1.6 for individuals who earn credentials in fewer than three years. Also, they are less likely to teach in low-performing schools—or to enter teaching at all—than their counterparts who earn credentials more quickly.

[9] We determine each individual's enrollment period starting from the year in which that person received an APLE contract, and ending with the individual's next credential year. Because licensure programs are encouraged to promote APLE widely among their licensure candidates (California Student Aid Commission, 2005), we assume that the APLE contract year corresponds to the first enrollment year. With rare exceptions, this assumption is consistent with credential dates and dates of GTF receipt in the dataset.

Measures

The outcome variable that addresses the first research question is a time-invariant dichotomous variable, *entry*, which describes entry into a teaching job in a low-performing school within two years after receiving an APLE contract.[10] The dichotomous (and potentially endogenous) question predictor, *gtf,* describes whether an individual actually received a GTF award. It is coded 1 for the 464 GTF recipients and 0 for the remaining 13,581 newly licensed teachers in the analytic sample. Our principal instrument—named *eligible* in Table 1—is a dichotomous variable coded 1 if the prospective teacher was enrolled in a licensure program during either year of GTF availability (2001-01 and 2001-02), and 0 if the individual was enrolled exclusively in the two years prior to GTF availability (1998-99 or 1999-2000) or the year after (2002-03).

Our sample includes data from five cohorts of APLE recipients, starting with those who received contracts in 1998-99 and ending with 2002-03 recipients. We code APLE contract year sequentially from 1 to 5 and enter this control variable, *cohort*, in our analyses to capture any secular linear trend in the probability of entering or departing from the set of low-performing schools.[11] Note that during the period under study, the California legislature expanded the number of APLE contracts that were issued, raising it from 4,500 in 1998-99 to 7,500 in 2002-03. Though our analytic sample is limited to the APLE contract holders who earned professional licenses within two years of the date when they started their programs, the distribution of the values of *cohort* in the sample reflects the APLE program's expansion over time.

---

[10] Seventy-one percent of the sample reported entering a teaching position within two years, though not all entered low-performing schools.

[11] Members of cohort 2 (1999-2000) who earned their licenses within one year would not have been eligible for the GTF, while those enrolled for two or more years would have been.

Our other key predictors describe teachers' academic background. *Test* is the individual's highest combined licensure test scores in reading, mathematics, and writing as measured by the California Basic Educational Skills Test. Scores range from 20 to 80 per section, and the overall passing score is 123. The sample mean is 155.2, and the standard deviation is 21.8. We also include dichotomous indicators of individuals' licensure program institutions. In our analytic sample, 10 percent of licensure candidates attended University of California programs; 42.2 percent attended California State University campuses, and 46.9 percent attended programs at independent colleges and universities. The latter category includes several large, vocationally oriented institutions such as National University, Azusa Pacific University, and Chapman University, as well as a few private liberal arts colleges such as USC and Claremont McKenna. This distribution closely tracks the distribution of individuals who earned their first-time California licenses in 2006-07, where the corresponding percentages were 9.4 percent UC; 44.2 percent California State; and 46.4 percent independent (Clark & Suckow, 2008). Another one percent of individuals in the analytic sample attended local district or county-based programs. Other covariates include characteristics of the licensure types. *Secondary* is a dichotomous variable coded 1 if the individual was working toward a license to teach secondary school, and zero, otherwise. Similarly, *elementary* is coded one for individuals working toward a license to teach elementary school, zero otherwise. *Other* is coded one for individuals working to obtain a license to teach special education or another related specialty, zero otherwise. *Bilingual* is a dichotomous indicator of whether the individual was prepared to teach bilingual education, as signified by possession of a Bilingual Cross-Cultural Language and Development (BCLAD) authorization.

Finally, our remaining covariates, *gender* and *age*, are demographic in nature. Seventy-one percent of the analytic sample is female. The mean age of individuals in the analytic sample at the time they received their APLE contracts was 30.6 years, with a standard deviation of 8.5 years. We did not include race/ethnicity controls in our analysis due to very low race/ethnicity reporting rates in the years prior to and concurrent with GTF availability.

Data-Analyses

Our objective is to estimate the causal impact of the GTF policy on the decisions of academically talented, newly licensed teachers to enter and remain in low-performing schools. We specify a linear probability model to describe this hypothesized relationship, as follows::

$$(1) \quad entry_i = \beta_0 + \beta_1(gtf_i) + \beta_2(X_i) + \varepsilon_i \qquad \varepsilon_i \sim N(0, \sigma_\varepsilon^2)$$

where X_i is a vector of person-level exogenous control variables, including APLE cohort year and indicators of the individual's academic background. In this model, the parameter of interest is β_1, which represents the effect of receiving the GTF on the probability that individual *i* will enter a low-performing school. We assume that residuals, ε_i, are independently and identically normally distributed with zero mean and variance σ_ε^2.

Because GTF awards were not randomly assigned, those who applied for and received the awards may have differed systematically from non-recipients in unobserved ways. Thus, question predictor *gtf* is potentially endogenous, and an ordinary least squares (OLS) estimate of β_1 is vulnerable to selection bias, though the direction of the bias is not self-evident. It may be that many individuals who applied for and received the GTF were predisposed to teach in low-performing schools and would have done so even in the absence of the incentive. If this were true, then an OLS estimate of the GTF's impact would overstate its true impact. Alternatively, it is possible that individuals who applied for and received the GTF were systematically less inclined than their peers to teach in low-performing schools but were influenced by the financial benefit and/or prestige of the award. In that scenario, the OLS estimate of β_1's influence would be downwardly biased, understating the award's true impact.

Fortunately, the *availability* of the GTF in 2000-01 and 2001-02, but in no other academic years, provides a potentially exogenous policy discontinuity leading to a natural experiment in fellowship eligibility that we use to identify the causal impact of the GTF on its recipients. We capitalize on this discontinuity and implement an instrumental variable (IV) strategy, in which we use the dichotomous indicator of a licensure candidate's enrollment during GTF availability, *eligible*, as our principal instrument (Angrist, 2006, pp., p. 87) We argue that the indicator of GTF eligibility meets the standard criteria for an effective instrument in that it predicts the probability that a participant will obtain the GTF, is not subject to reverse causation from GTF receipt, and affects our ultimate outcome, Y_i, *only* through its impact on acquisition of the GTF (Angrist & Pischke, 2008) .

We argue that the first condition is met because only those participants who were enrolled during the GTF years could in fact receive a GTF. Thus, eligibility can have *only* a neutral or positive effect on probability of receiving a GTF. To meet condition 2, we must establish that individuals' preferences for teaching in low-performing schools did not actually drive their decisions to enroll in graduate teacher preparation programs in GTF years. We believe, however, that this threat is minimal because the GTF was short-lived and not well publicized, according to selection committee members. Our search of Google News Archives and LexisNexis Academic corroborated this assertion. We found only 25 newspaper references to the GTF across the state between August 1999 and January 2003, but roughly half were either passing references to the award or short announcements congratulating local award winners. Two stories contained in-depth reporting about teacher shortages with references to the GTF, but none focused primarily on the GTF. Moreover, the GTF was not publicly announced until mid-November of the first implementation year, at a time when the December/January deadlines for admission to more competitive licensure programs in the subsequent year were fast approaching.

In compliance with the third condition, we diminish the possibility that enrollment in a GTF year had any additional, unobserved relation to the decision to teach in a low-performing school by controlling for the linear effect of APLE cohort year. We thereby capture any secular trend in the probability of entering a low-performing school during the period under study. In addition, we allow the effect of eligibility to differ across novice teachers with different academic backgrounds.

We implement the IV strategy using two-stage least squares methods. Our methodology is similar to that used by Imbens & van der Klaaw (1995) to study a change in military service requirements in the Netherlands. Our first-stage model is:

(2) $$gtf_i = \beta_0 + \beta_1(eligible_i) + \beta_2(eligible * A_i) + \beta_3(A_i) + \beta_4(K_i) + \delta_i \qquad \delta_i \sim N(0, \sigma_\delta^2)$$

In this model, potentially endogenous receipt of the GTF, is specified as function of the main effect of *eligible* and the two-way interaction of *eligible* with A_i, where A_i is a vector of the academic traits and skills prioritized by the state when it awarded the GTF. We treat all of these effects as instruments in our analysis. Covariates include the main effects of vectors A_i and K_i, the latter including participant gender and age, and the linear effect of APLE cohort year. The residual term is assumed to be independently and identically normally distributed with zero mean and variance σ_{δ}^{2}. Our second-stage equation is given in Equation (1) with vector X representing the vectors of individual characteristics A_i and K_i. [12]

To address our second research question, concerning the effect of the GTF on recipients' persistence in low-performing schools, we extend this analysis above using discrete time survival analysis. This requires us to separate the sub-sample of participants who entered a teaching position in a low-performing school and reformat their longitudinal retention data into person-period format. In a person-period dataset, each teacher contributes multiple rows to the dataset—one per year of her career in a low-performing school. The time-varying outcome Y_{ij} is coded 1 if the i^{th} teacher left the set of low-performing schools by the end of each teaching year *j*. A teacher is said to have experienced the exit event in year *j* if she taught in a low-performing school in year *j* but not in year *j+1*. Once a teacher exits, she is removed from the "risk set" in subsequent periods and contributes no more rows to the person-period dataset.

With up to four years of employment data for each APLE recipient, it is possible to determine only whether individuals exited the set of low-performing schools by the end of their first, second, and third teaching years. Those who taught four years are said to be "right-censored" (Singer & Willett, 2003, pp., p. 319) because there is no indication of how long they taught *beyond* year four or whether they "survived" to teach in year five. There are two other types of right-censoring in this dataset. Teachers whose student loans were fully repaid before they completed four years of service are right-censored in their final teaching year, as are those

[12] Angrist and Pischke (2008) explain that instrumental variable analysis yields the local average treatment effect (LATE), which is the effect of the treatment on the people who received the treatment as a result of the random assignment (compliers). The LATE excludes people who receive the treatment without being randomly assigned to it (always-takers). In this case, however, there was no way to receive the GTF without being enrolled in a GTF year (the source of exogeneity in our analysis), so all of those treated by receipt of the GTF were compliers, and none were always takers. Consequently, the GTF represents a case in which the local average treatment effect and the effect of treatment on the treated are identical.

who were teaching in 2004-05—the final year of employment records in the dataset—and had not fulfilled their four-year obligations by the end of that year.

It is possible to use a two-stage linear probability model to investigate the "risk" or hazard (i.e., the conditional probability) of exit from low-performing schools in the subsample of those who entered such schools as a function of predictors in the person-period dataset (Singer & Willett, 2003). The model extends the entry model shown in Equation 3 and applies it in a new, longitudinal context to teachers who began working in low performing schools, as shown in Equation 4:

$$(4) \quad exit_{ij} = \alpha_1(T_{1i}) + \alpha_2(T_{2i}) + \alpha_3(T_{3i}) + \beta_1(g\hat{t}f_i) + \beta_2(A_i) + \beta_3(K_i) + \delta_i \qquad \delta_i \sim N(0, \sigma^2)$$

where the terms are defined as in Equation 3, except that $exit_{ij}$ is the probability that individual *i* will leave the set of low-performing schools by the end of teaching year *j*. In addition, $g\hat{t}f_i$ is the fitted probability of receiving a GTF drawn from the first stage model estimated *in the full analytic sample*, *before* novice teachers self-select into low performing schools.[13] Also, T_{1i}, T_{1i}, and T_{1i} are dichotomous variables representing teaching years 1, 2, and 3 respectively, and their coefficients, α_1 through α_3, represent the fitted probabilities of leaving by the end of each of those years, holding constant the other terms in the model. Our parameter of interest remains β_1, the unbiased effect of GTF receipt on the probability of exit in a given year. We can also interact $g\hat{t}f_i$ with each of the teaching year indicators to explore whether GTF affects the probability of exit in some teaching years more than others.

[13] Fitting the model in separate steps prevents us from allowing for the correlation of the first-stage and second-stage residuals, thus possibly biasing the standard errors downward. However, we find only minute differences in the standard errors when we fit the first- and second-stage equations simultaneously versus sequentially in the reduced sample of entrants to low-performing schools.

III. Findings

First Stage: Who Received the GTF?

Because the GTF was targeted at teacher licensure candidates with strong academic backgrounds, we hypothesized that the effect of enrollment in a GTF year on the probability of receiving a GTF would differ by individuals' skills and traits. To ensure that the specification of our statistical models reflected the goals and priorities of the state in selecting GTF recipients, we discussed the GTF selection process with the former director of the GTF program and three former members of the twelve-person GTF selection committee. These interviews revealed that, while priorities varied among the selection committee members, there was a common desire to choose candidates with strong academic backgrounds (especially as measured by grades and course work) as well as candidates licensed in subject areas that were in short supply, including bilingual education and several secondary school subjects.[14]

These impressions are consistent with the results of fitting our first-stage models, which estimate the differential impact of enrollment in a GTF year on licensure candidates with heterogeneous academic traits and skills. Figure 1 illustrates the fitted effect of enrollment in a GTF year on the probability that candidates with particular academic traits and skills received GTFs. The corresponding first-stage parameter estimates are shown in Appendix Table A1.

<Insert Figure 1>

The most striking feature of Panel A of the figure is the difference between the probability of receiving a GTF for licensure candidates who were enrolled in a University of

---

[14] Committee members also spoke of the importance of racially/ethnically diversifying the teacher workforce and of considering applicants' reasons for wanting to teach in low-performing schools. However, due to data limitations, we are unable to consider those factors in our current analysis.

California (UC) program versus those who were enrolled in a California State University (CSU) or independent program. The fitted probabilities plotted in Panel A apply to 31-year old female elementary school teachers who received APLE contracts in 2000-01 (cohort 3) and were not authorized to teach bilingual education. At any given licensure test score, the fitted probability of receiving a GTF for a licensure candidate at UC institution is 21.7 percentage points higher than the probability for a CSU licensure candidate and 22.2 percentage points higher than for a licensure candidate at an independent college or university. The difference in fitted probabilities between UC licensure candidates and the other two groups is statistically significant ($p<.001$), while the fitted probabilities for candidates at CSU and independent institutions are not distinguishable from each other (at $\alpha=.05$). When we asked GTF committee members whether their preference for UC students was deliberate, they indicated that it was not. They speculated that these students may have been overrepresented among GTF applicants and may also have demonstrated stronger academic credentials on average.

In Panels A and B, the committee's preference for strong academic backgrounds is also reflected in the positive relationship between the probability of receiving a GTF and composite licensure test scores.[15] For example, holding all else constant, a licensure candidate with a CBEST score of 195 (i.e., at the sample 95th percentile) would have a 1.6 percentage-point higher probability of receiving a GTF than her counterpart scoring at the sample median of 152 ($p<.001$).[16]

[15] The slope of the relationship is not noticeably different when we use only math, reading, or writing scores instead of composite scores as an indicator of academic skills.

[16] While selection committee members did not have direct access to CBEST scores in the candidates' applications, they did have access to multiple indicators of academic talent, including graduate and undergraduate transcripts, letters of recommendation, and writing samples, and telephone interviews. Committee members noted that academic transcripts weighed heavily in the committee's decision making process.

Panel B shows that, holding all else constant, individuals preparing to teach secondary school had a 1.3 percentage-point higher probability of receiving a GTF than those preparing to teach elementary school. This difference is statistically significant (p<.05) and is consistent with committee members' recollection that subject matter knowledge was perceived as valuable. As Panel B also illustrates, licensure candidates who were pursuing bilingual teaching authorizations had a 3.4 percentage-point higher probability of receiving a GTF than those who were not, holding other predictors constant (p< .01). This difference is consistent with committee members' recollection that such skills were needed but in short supply in many low-performing schools.

Question 1: Effect of the GTF on New Teachers' Entry into Low-Performing Schools

Using our IVE strategy, we estimate that the GTF award increased by 34 percentage points the probability that its recipients taught in low-performing school within two years of receiving APLE contracts. Figure 2 illustrates this pattern. The upper fitted trend line, plotted between licensure years 2001 and 2003, represents the fitted entry probabilities of the GTF recipients, and the dotted lines represent the 95 percent confidence interval around the estimate. The longer, solid line represents the fitted counterfactual—the predicted probability that teachers with academic traits and skills similar to the GTF recipients would have taken teaching positions in low performing schools in the absence of the GTF program.

<Insert Figure 2>

This finding suggests that one in three GTF recipients who began working in a low performing school would not have done so in the absence of the incentive. A question of substantive interest is how this compares to a standard OLS estimate that does not account for selection effects. As noted above, we would expect the unbiased estimate to be smaller than the OLS estimate *if* GTF recipients were more likely than the sample at large to take jobs in low-performing schools. However, we instead find that controlling for the same covariates at the second-stage model, the OLS model estimates that the GTF increased the probability of entering a low-performing school by only 17.1 percentage points. (See Model 1 in Appendix Table A2.) This suggests that the individuals who received the GTF are indeed systematically different from non-recipients in the sample, but that they are in fact *less* likely than others in the sample to work in low-performing schools in the absence of the GTF. In other words, it appears that the state was successful in awarding the GTF to a substantial share of novice teachers who would not have worked in low-performing schools without it. Consequently, when we compare GTF recipients to individuals who are similar to them (based on the first stage model) the GTF's effect on the probability of teaching in a low-performing school is nearly twice as large as when we compare them to all non-recipients.

Figure 2 also shows a downward slope in the trend line indicating the probability of taking a teaching position in a low-performing school.[17] A likely explanation is the expansion of the APLE program during the period of study. This expansion may have resulted in a decline in the commitment of the marginal teacher to work in a low performing school.

Question 2: Effect of the GTF on New Teacher Retention in Low-Performing Schools

[17] When we test the sensitivity of our estimates to alternative specifications of the linear cohort trend, including quadratic and cubic specifications, our estimate of the GTF effect fluctuates within twelve percentage points. However, because of the small number of cohorts, the linear trend remains the most plausible specification.

Before considering the effect of the GTF on recipients' retention in low-performing schools, it is useful to consider the retention patterns in low-performing schools among the full analytic sample of teachers who began working in them. Figure 3 depicts both the fitted baseline hazard and survivor functions for the 9,308 licensure candidates who began teaching in the set of low-performing schools within two years after receiving APLE contracts. Panel A illustrates that, on average, the teachers' fitted hazard probability of leaving the set of low-performing schools was lowest in the first teaching year, at 0.064, and highest in the third teaching year, at 0.116. The parameter estimates that we use to generate this plot are listed under model 1 of Appendix Table A3.

<Insert Figure 3>

A surprising feature of this hazard function is its positive trajectory, indicating that teachers' probabilities of exit from low-performing schools increased rather than decreased in each teaching year, conditional on having "survived" beyond the previous years. While most models of teacher attrition show new teachers to be at greatest risk of exit in their first two years on the job (Feng, 2006; Grissmer & Kirby, 1997; Ingersoll, 2003; Murnane, Singer, Willett, Kemple, & Olsen, 1991; Reed, Rueben, & Barbour, 2006), the pattern shown here could be attributable to our definition of exit (i.e., leaving all low-performing schools in California rather than just their initial schools) and to our sample characteristics. Specifically, members of our analytic sample had invested in and completed pre-service teacher preparation programs, and their APLE contracts may have served as a baseline incentive to persist in their jobs.

As we show in the fitted survivor function in Panel B, an estimated 75.5 percent of entrants to low-performing schools remained in the set of low-performing schools beyond year three and persisted into year four. Because APLE tracks its recipients only through their fourth teaching year, we are unable to say how many left the set of low-performing schools after their agreements ended at the end of year four.

Because GTF recipients who did not complete their four-year commitments would have had to repay the state $5000 per year of unfulfilled commitment, we expected the program to have exerted a positive effect on the retention rates of GTF recipients. However, using IV methods, we find the opposite. We estimate that the probability of leaving the set of low-performing schools before the second teaching year is higher for GTF recipients than for teachers with similar traits and skills who taught in low-performing schools but for whom the GTF was not available.

<Insert Figure 4>

As shown in Figure 4, the fitted hazard of exiting the set of low-performing school by the end of the first teaching year is 17.3 percentage points for GTF recipients, compared to only 4.3 percentage points for similar non-recipients. This difference is both substantively noteworthy and statistically significant ($p<.05$). However, among teachers who survive beyond the first year, the fitted probabilities of leaving by the end of the second or third years are not significantly different (at $\alpha=.05$). Conditional upon surviving to the second teaching year, the fitted hazard of exit that year for both GTF recipients and similar non-recipients is 7.1 percentage points in the second teaching year and 9.1 percentage points in the third year. Still, the first year difference in risk has large implications in terms of the fitted three-year survival rates in the set of low-performing schools. As Panel B illustrates, the fitted probability of surviving to teach in the fourth year is only 69.9 percentage points for GTF recipients, as compared to 80.8 percentage points for similar novice teachers in low-performing schools for whom the GTF was not available.

The higher exit rate among GTF recipients in the first teaching year is striking, but it is also consistent with our finding that GTF recipients were, on average, less predisposed to teach in low-performing schools than other licensure candidates in the sample, and that a third of GTF recipients who took jobs in low-performing schools would not have done so in the absence of the award. Hence, a possible explanation for the negative impact of the GTF on initial retention is that the program attracted people to these jobs who were not aware of the difficulty of teaching in a low performing school. Once they learned this, some were willing to sacrifice the retention incentive of $5000 per year, on top of any APLE incentive they may have had for teaching in a low-performing school. However, the GTF recipients who survived beyond the first year appear to have either adapted to their surroundings or been more strongly motivated by the retention incentive. Their exit patterns in years two and three are not distinguishable from those of their non-recipient counterparts.

V. Discussion

The ideal approach to our research question would be to estimate the effect of the GTF program on all academically talented individuals who were enrolled in licensure programs in the GTF years by comparing their employment behavior to all similar licensure candidates enrolled in pre- and post-GTF years. Unfortunately, California does not collect longitudinal data on the school-level employment decisions of licensure candidates.[18] The APLE dataset provides a useful alternative because it permits us to observe up to four years of school-level employment

[18] While the *California State Teachers' Retirement System* (CalSTRS) does record teachers' employment histories, it tracks their employment only at the district level and thus does not indicate which teachers worked in low-performing schools in a given year.

decisions for a very large subset of licensure candidates who were enrolled in the GTF years or in the years before or after the program was in effect. In this sense, it approximates the ideal dataset, but because it is a subset, it also carries some limitations.

An obvious limitation is that we can only examine the employment decisions of licensure candidates who received APLE contracts. This poses a potential threat to external validity because APLE recipients are a self-selected subset whose eventual loan forgiveness payments are contingent upon teaching in shortage subject areas or hard-to-staff schools. However, the APLE program is large enough to represent a broad subset of first-time licensure candidates in California. One notable caveat to this statement is that individuals in teacher licensure programs who had no educational debt would have had no incentive to apply for APLE contracts. Thus, the set of APLE contract recipients may under-represent the number of newly licensed teachers from relatively affluent families. Also, the APLE recipients' pre-existing loan forgiveness contracts make it impossible to estimate a first-dollar effect of the GTF. However, the existence of loan forgiveness provisions in federal Perkins and Stafford Loans and in numerous state policies suggests that it is not uncommon for teacher recruitment and retention incentives to supplement one another in this way.

Magnitude and Cost of the GTF Effect

An important question to consider is whether the GTF program's estimated impact on teachers' career decisions is large enough to justify the cost to the taxpayers of California. We have estimated that for every three teachers who received the GTF, one decided to teach in a low performing school who would not otherwise have done so. Since people who did not receive APLE contracts and people who were omitted from our analytic sample due to missing data may be systematically different from people in our sample, we generalize only to the 14,045 members of our analytic sample, 464 of whom (3.3 percent) received GTFs. Based on our entry analysis, 34 percent of these individuals, or 158 teachers, entered low-performing schools who would not otherwise have done so. And based on our retention analysis, we estimate that 131 persisted into the second teaching year, 121 into the third year, and 110 into the fourth year. In other words, in our analytic sample alone, we believe that the GTF staffed 520 one-year, full-time teaching slots in low-performing schools with academically talented teachers who would not otherwise have taught in such schools.[19]

But how much did this benefit cost the state of California? Excluding administrative and overhead costs and restricting our analysis just to the value of the awards themselves, California spent $9.28 million on GTF award payments of $20,000 each to the 464 recipients in our analytic sample. Of that, roughly $560,000 has been by recipients who did not complete their teaching requirements, which, ignoring collection costs and foregone interest, leaves $8.72 million in net award payments. For that money, the state recruited 158 teachers to low-performing schools, who, within the next four years, staffed 520 one-year teaching positions in those schools. This suggests that California paid roughly $55,190 in recruitment costs for each person whose entry decision it influenced, and $16,770 in recruitment costs for every one-year teaching position the GTF staffed with an academically talented teacher. Bearing in mind that the annualized benefit to a single teacher was $5000, the question that remains is whether this money could have been spent more efficiently. It is a question to which we return in the conclusion.

[19] Of course, this is lower than the 783 one-year teaching positions we would expect GTF recipients to have filled if they remained in teaching at rates comparable to the academically talented teachers in our sample who were not eligible for the GTF.

Conclusion

We estimate that one in three GTF recipients who entered low-performing schools would not have done so in the absence of the incentive, and that roughly 70 percent of those teachers continued to work in low-performing schools for at least four years. The recruitment effect is substantial and may have yielded meaningful classroom benefits for students enrolled in struggling schools. However, we find that these teachers departed from low-performing schools in the first teaching year at a considerably higher rate than similar counterparts who were not eligible for the GTF. Moreover, the GTF's benefits carried a non-trivial financial cost: We estimate that the state spent roughly $16,770 to place an academically talented teacher into a one-year teaching position in a low-performing school. Another critical point is that the GTF was a small program. It would be a mistake to generalize from these findings in considering whether to implement a much larger scale incentive policy.

Ultimately, whether programs like the GTF represent wise expenditures depends on the cost effectiveness of alternative policy interventions. In their examination of the North Carolina teacher retention bonus, Clotfelter, Ladd, and Vigdor (2008) found that a modest $1800 incentive reduced teachers' turnover rates by 5 percentage points, or 17 percent. In contrast, the GTF had a notable recruitment effect on the treated that was somewhat offset by rapid exit from low-performing schools prior to the second teaching year. Of course, it is difficult to compare the consequences of the GTF program with those from the North Carolina retention program because important details of the programs differ. For example, the North Carolina bonus did not include a recruitment component. As a result, it probably did not attract to low performing schools teachers who otherwise would not have chosen to teach in these schools. In addition, the North Carolina bonus did not target teachers based on their academic backgrounds or on other indicators of skill, and it had a stronger effect on experienced teachers than on novices (Clotfelter et al., 2008). Novice teachers have less investment the teaching profession in terms of time, expertise, and seniority than their more experienced colleagues. Therefore, to a greater extent than experienced teachers, they may weigh employment options both within and outside of teaching when considering whether to leave a low-performing school. An annual retention bonus in the $1,800 to $5,000 range may better compensate for differences in working conditions between two schools than for the broader range of forgone labor market opportunities outside of teaching. And the potential for bonuses to offset non-teaching career options may be especially weak for academically talented novices, who are likely to have higher opportunity costs than the average teacher (Goldhaber & Player, 2005; Murnane et al., 1991).

Academic talent has long been shown to predict teachers' ability to increase student achievement, and thus from a policy perspective, the goal of distributing these teachers more equitably remains important. On the other hand, academic talent explains only a small percentage of teachers' effectiveness in raising student achievement (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2005; Kane & Staiger, 2005). Ideally, one may wish to find ways to target incentives more precisely, perhaps with a recruitment incentive based on traits like academic talent, and a structured retention incentive that considers multiple measures of classroom effectiveness.

Retention incentives might also be expanded beyond monetary support. Selection committee members suggested that if the GTF had included ongoing networking or professional development opportunities, it is possible that recipients' sense of commitment to the award and its purpose might have been strengthened. Alternative licensure programs like Teach for America (TFA) provide not only a fast-track entry into teaching, but also external recognition, a strong sense of group identity, and ongoing opportunities for networking and professional support. And TFA's recruitment efforts appear efficient: The organization spent $6379 per teacher they recruited into their 2007-08 cohort (Teach for America, 2008). However, the TFA model is not designed to emphasize teacher retention—rather, the organization portrays teaching as a starter career and seeks to incubate future leaders in business, law, medicine, and public policy who are sensitive to education issues (Teach for America, 2006). Although 61 percent of TFA recruits remain *in the teaching profession* beyond the end of their two-year commitments (Donaldson, 2008), by comparison, we estimate that 77 percent of GTF recipients remained *in low-performing schools* beyond the second year, despite their high first-year turnover rate, and that 70 percent fulfilled their four-year commitments. (Granted, the teachers in our sample received an additional incentive from the APLE program, and we do not know the proportion who left low-performing schools when their four-year commitments ended.) Designers of the GTF have told us that they focused on traditionally licensed teachers and required four years of service partly to distinguish the program from TFA as demanding a longer-term career commitment. However, the fact that GTF recipients had completed full licensure programs would not necessarily have obviated their need for professional development and networking opportunities.

Given the importance of providing high-quality teachers to disadvantaged students, and the costliness of programs like the GTF, it is also important that policies be designed in ways that make it possible to rigorously evaluate their impact. In the case of the GTF, this might have been facilitated by ranking all applicants and later comparing career outcomes of individuals ranked on either side of the award cut score. It would also be useful to create a database that tracks the school-level employment histories of all teachers in California and not just those who received APLE contracts. This could be achieved if the State Teachers Retirement System, which currently tracks teachers' employment histories at the district level, were to record (and make available to researchers) teachers' school-level assignments.

Due to the small amount of rigorous research on recruitment and retention incentives, it is difficult to say whether the GTF's recruitment effect was expensive relative to other recruitment efforts, or relative to other policies that specifically target academically talented teachers. Moreover, because the GTF was short-lived, it is not possible to learn whether long-term effects would have differed from short-term effects. Future research may help determine whether alternative interventions, including efforts to improve working conditions in low-performing schools, might have as large an impact but carry a smaller price tag.

References

ABA Commission on Loan Repayment and Forgiveness. (2003). *Lifting the burden: Law student debt as a barrier to public service*. Chicago: American Bar Associationo. Document Number)

American Association of Medical Colleges. (2006). Loan repayment/forgiveness and scholarship programs. Retrieved August 4, 2008, from http://services.aamc.org/fed_loan_pub/index.cfm?fuseaction=public.welcome&CFID=7349664&CFTOKEN=520eca1-8a0ef191-81b5-4a62-910b-05e6b3cfe2ec

American Federation of Teachers. (2002). Table III-1: Actual average beginning teacher salaries, 2000-01 and 2001-02. Retrieved December 14, 2006, from http://www.aft.org/salary/2002/download/Table_III-1.pdf

Angrist, J. D. (2006). Instrumental variables methods in experimental criminological research: What, why, and how. *Journal of Experimental Criminology, 2*(23-44).

Angrist, J. D., & Pischke, J.-S. (2008). *Mostly harmless econometrics: An empiricist's companion*. Princeton, NJ: Princeton University Press.

Becker, H. S. (1952). The career of the Chicago public school teacher. *American Journal of Sociology, 57*(5), 470-477.

Boyd, D., Grossman, P., Lankford, H., Loeb, S., & Wyckoff, J. (2005). *How changes in entry requirements alter the teacher workforce and affect student achievement* (No. No. 11844). Cambridge, MA: National Bureau of Economic Researcho. Document Number)

Burke, S., & Errett, M. (2000). *Teacher supply in California: A report to the legislature: Second annual report, 1998-99*. Sacramento, CA: California Commission on Teacher Credentialingo. Document Number)

Burke, S., & Errett, M. (2001). *Teacher supply in California: A report to the legislature: Third annual report, 1999-2000*. Sacramento, CA: California Commission on Teacher Credentialingo. Document Number)

Burke, S., & Errett, M. (2002). *Teacher supply in California: A report to the legislature: Fourth annual report, 2000-01*. Sacramento, CA: California Commission on Teacher Credentialingo. Document Number)

Burke, S., & Errett, M. (2003). *Teacher supply in California: A report to the legislature: Fifth annual report, 2001-02*. Sacramento, CA: California Commission on Teacher Credentialingo. Document Number)

California Department of Education. (2004). TEACH California: Answers to Common Questions. Retrieved August 10, 2008, from http://www.teachcalifornia.org/questions/ma01.html

California Education Code, Section 69612-69615.6. (2000). *California Education Code* Retrieved Dec. 7, 2006, from http://www.leginfo.ca.gov/cgi-bin/waisgate?WAISdocID=513042124+0+0+0&WAISaction=retrieve

California Legislative Analyst's Office. (2002). Analysis of the 2002-03 budget bill. Retrieved September 5, 2005, from http://www.lao.ca.gov/analysis_2002/education/ed_29_6610_anl02.htm

California State University Office of the Chancellor. (2002). *The 2000-2001 annual report of the Governor's Teaching Fellowship program*. Long Beach, CA: Authoro. Document Number)

California Student Aid Commission. (2004). *APLE 2002-03 report to the legislature*. Rancho Cordova, CA: Authoro. Document Number)

California Student Aid Commission. (2005). *2005-2006 Assumption Program of Loans for Education coordinator's guide and forms*. Rancho Cordova, CA: Authoro. Document Number)

Clark, T., & Suckow, M. (2008). *Teacher supply in California: A report ot the Legislature: Annual Report 2006-07*. Sacramento: California Commission on Teacher Credentialingo. Document Number)

Clotfelter, C. T., Glennie, E., Ladd, H. F., & Vigdor, J. L. (2008, Jan. 6). *Would higher salaries keep teachers in high-poverty schools? Evidence from a policy intervention in North Carolina.* Paper presented at the Annual Meeting of the American Economic Association, New Orleans, LA.

Clotfelter, C. T., Ladd, H. F., & Vigdor, J. L. (2005). Who teaches whom? Race and the distribution of novice teachers. *Economics of Education Review, 24*(4), 377-392.

Cooper, C. L. (2005, Spring). Debt of gratitude. *Equal Justice Magazine, 4*.

Decker, P. T., Mayer, D. P., & Glazerman, S. (2004). *The effects of Teach for America on students: Findings from a national evaluation*. Princeton, NJ: Mathematica Policy Researcho. Document Number)

Donaldson, M. L. (2008). *Teach for America teachers' careers: Whether, when, and why they leave low-income schools and the teaching profession*. Cambridge, MA: Harvard Universityo. Document Number)

Feng, L. (2006, April). *Why new teachers leave their initial schools.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco.

Field, E. (2005). *Educational debt burden and career choice: Evidence from a financial aid experiment at NYU Law School*. Cambridge, MA: Harvard Universityo. Document Number)

Glater, J. D. (2008, March 18). Harvard Law, hoping students will consider public service, offers tuition break. *The New York Times*, from http://www.nytimes.com/2008/03/18/us/18law.html?sq=

Glazerman, S., Silva, T., Addy, N., Avellar, S., Max, J., McKie, A., et al. (2006). *Options for studying teacher pay reform using natural experiments* (No. ED-04-CO-0112/0002). Washington, DC: Mathematica Policy Research, Inc.o. Document Number)

Goldhaber, D., & Player, D. (2005). What different benchmarks suggest about how financially attractive it is to teach in public schools. *Journal of Education Finance, 30*(3), 211-230.

Grissmer, D., & Kirby, S. N. (1997). Teacher turnover and teacher quality. *Teachers College Record, 99*(1), 45-56.

Imbens, G., & van der Klaauw, W. (1995). Evaluating the cost of conscription in the Netherlands. *Journal of Business and Economic Statistics, 13*(2), 207-215.

Ingersoll, R. M. (2003). *Is there really a teacher shortage?* Philadelphia, PA: Consortium for Policy Research in Education and Center for the Study of Teaching and Policyo. Document Number)

Jacobson, L. (2006, Sept. 27). Teacher-pay incentives popular but unproven. *Education Week,* pp. 1, 20,

Johnson, J. (2005). State financial incentive policies for recruiting and retaining effective new teachers in hard-to-staff schools. Retrieved October 20, 2006, from http://www.ecs.org/clearinghouse/61/61/6161.htm

Kane, T. J., & Staiger, D. O. (2005). *Using imperfect information to identify effective teachers*. Cambridge, MA: National Bureau of Economic Researcho. Document Number)

Kirshtein, R. J., Berger, A. R., Benatar, E., & Rhodes, D. (2004). *Workforce contingent financial aid: How states link financial aid to employment*. Indianapolis, IN: Lumina Foundation for Educationo. Document Number)

Lankford, H., Loeb, S., & Wyckoff, J. (2002). Teacher sorting and the plight of urban schools: A descriptive analysis. *Educational Evaluation and Policy Analysis, 24*(1), 37-62.

Murnane, R. J., Singer, J. D., Willett, J. B., Kemple, J. J., & Olsen, R. J. (1991). *Who will teach? Policies that matter*. Cambridge, MA: Harvard University Press.

Reed, D., Rueben, K. S., & Barbour, E. (2006). *Retention of new teachers in California*. San Francisco: Public Policy Institute of Californiao. Document Number)

Singer, J. D., & Willett, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. Oxford: Oxford University Press.

Snipes, J. C., Quint, J. C., Rappaport, S., & Schofield, L. S. (2006). *Doing what counts: Design principles for a study on teacher incentives*. Philadelphia: MDRC and the Laboratory for Student Success at Temple Universityo. Document Number)

Spellings, M. (2006). Key policy letters signed by the Education Secretary or Deputy Secretary. Retrieved Jan. 20, 2007, from http://www.ed.gov/policy/highered/guid/secletter/060301a.html

Teach for America. (2006). Teach for America -- Our alumni. Retrieved Oct. 10, 2008, from http://www.teachforamerica.org/alumni/index.htm

Teach for America. (2008). *2007 Annual Report*. New York: Authoro. Document Number)

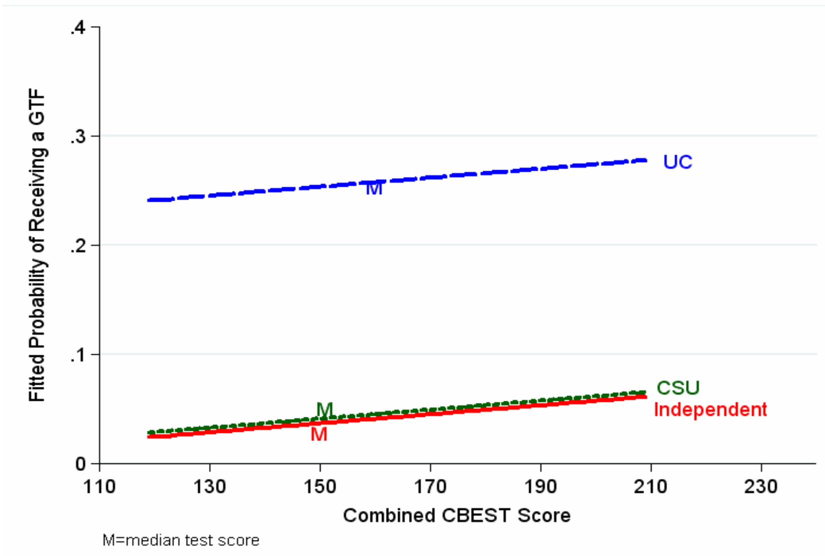
U.S. Department of Education. (2004). Enactment of the "Taxpayer-Teacher Protection Act of 2004". *Information for Financial Aid Professionals (IFAP) Library* Retrieved May 20, 2006, from http://www.ifap.ed.gov/dpcletters/GEN0414.html

Table 1. Descriptive statistics for the analytic sample of APLE recipients, 1998-99 through 2002-03 (n=14,045)

Variables	*Descriptions*	*Mean*	*Std. Dev.*
Outcome Variables			
entry	Taught in a Low-Performing School w/in 2 Years of APLE Contract Issuance (Academic Performance Index rank in bottom 50%)	0.531	
Endogenous Independent Variable			
gtf	Received a GTF	0.033	
	Did not receive a GTF	0.967	
Instrumental Variable Components			
eligible	Enrolled in licensure program in 2000-01 or 2001-02	0.496	
uc	University of California licensure program	0.100	
csu	California State University licensure program	0.422	
independent	Independent institution licensure program	0.469	
local	District- or county-based licensure program	0.009	
secondary	Prepared to teach secondary school	0.303	
bilingual	Authorized to teach bilingual education	0.113	
test	Combined math, reading, & writing score on the CBEST (scale=60–240; passing=123)	155.2	21.8
Control Variables			
cohort	1: APLE Contract Issued in 1998-99	0.142	
	2: APLE Contract Issued in 1999-2000	0.192	
	3: APLE Contract Issued in 2000-01	0.216	
	4: APLE Contract Issued in 2001-02	0.211	
	5: APLE Contract Issued in 2002-03	0.240	
gender	Male	0.241	
age	Age in years at time of APLE contract issuance	30.6	8.5

Figure 1. Estimated probabilities of receiving a GTF among APLE recipients enrolled in teacher licensure programs during the years of GTF availability, as a function of composite licensure test scores, licensure institution type (University of California, California State University, or Independent), teaching grade level (elementary or secondary), and bilingual authorization. Unless otherwise indicated, fitted values apply to female candidates at the sample mean age of 31 without bilingual authorizations. (n=14,043)

Panel A. Effect of Test Scores & Institution Type
(Shown: Elementary Licensure Candidates)



Panel B. Effect of Test Scores, Grade Level, & Bilingual Authorization
(Shown: Candidates at UC Institutions)

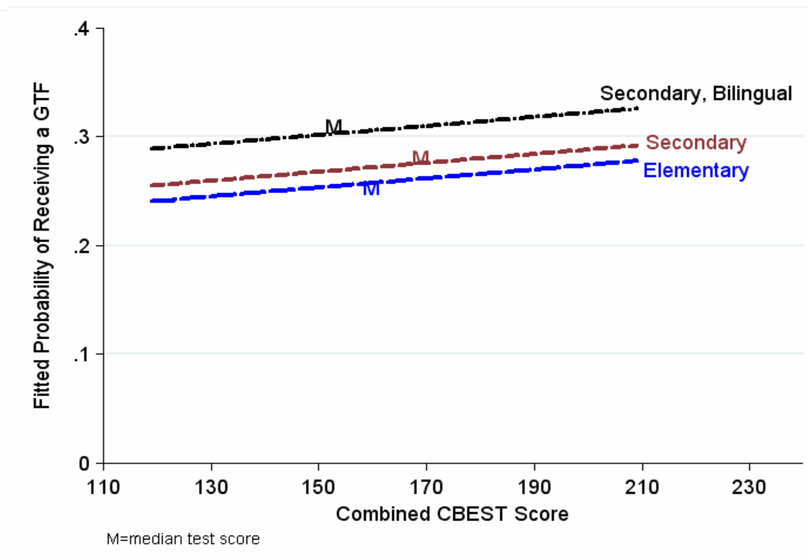
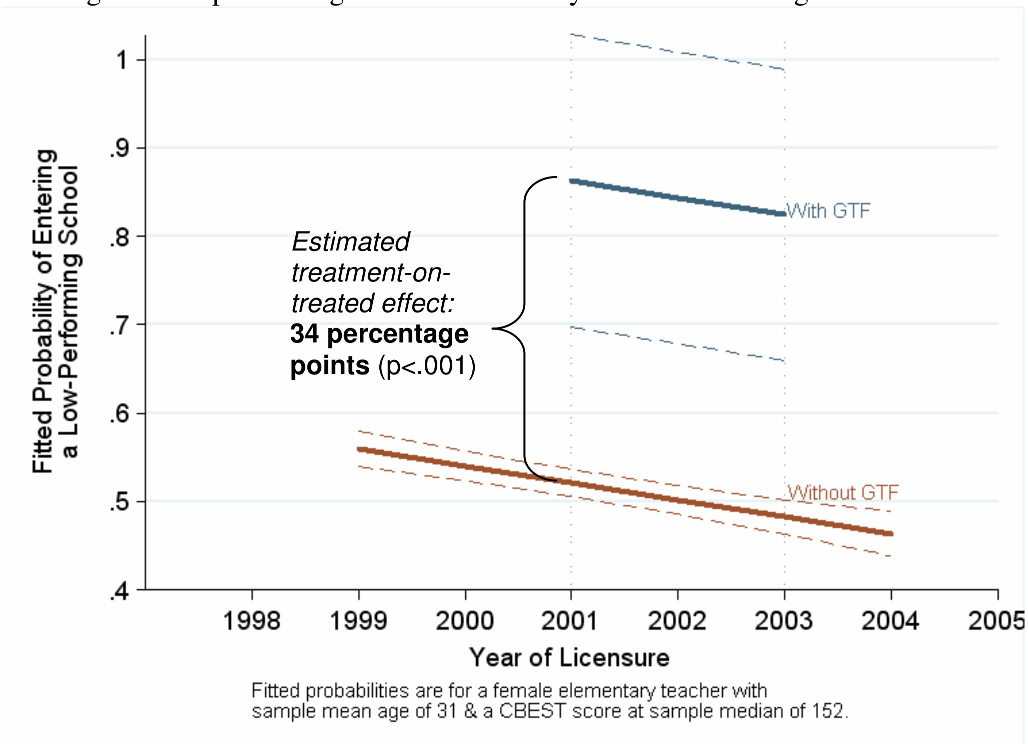


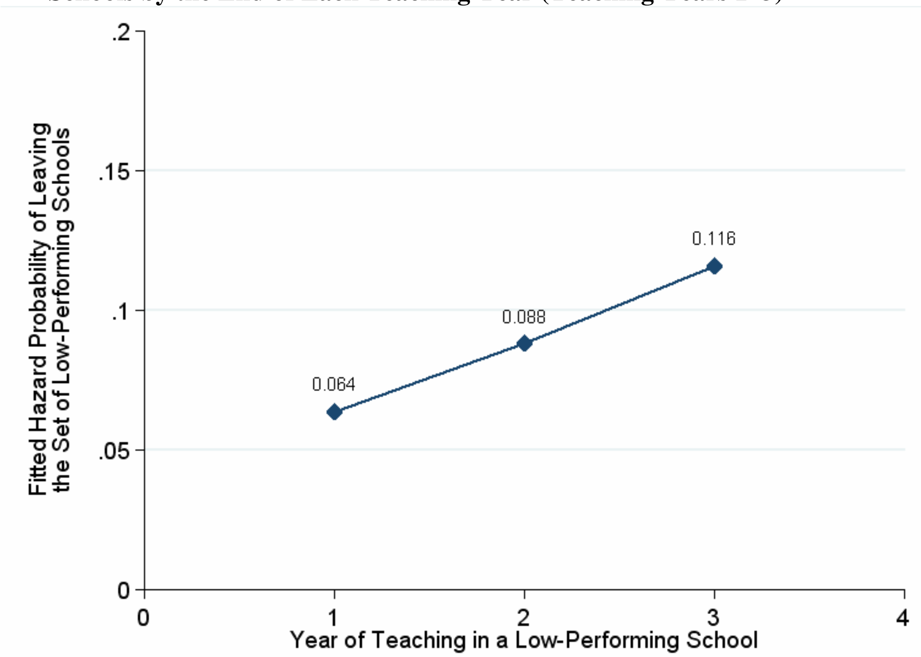
Figure 2. Impact of the GTF award (with 95-percent confidence intervals) on recipients' probability of teaching in a low-performing school within two years after receiving an APLE contract (n=14,045)



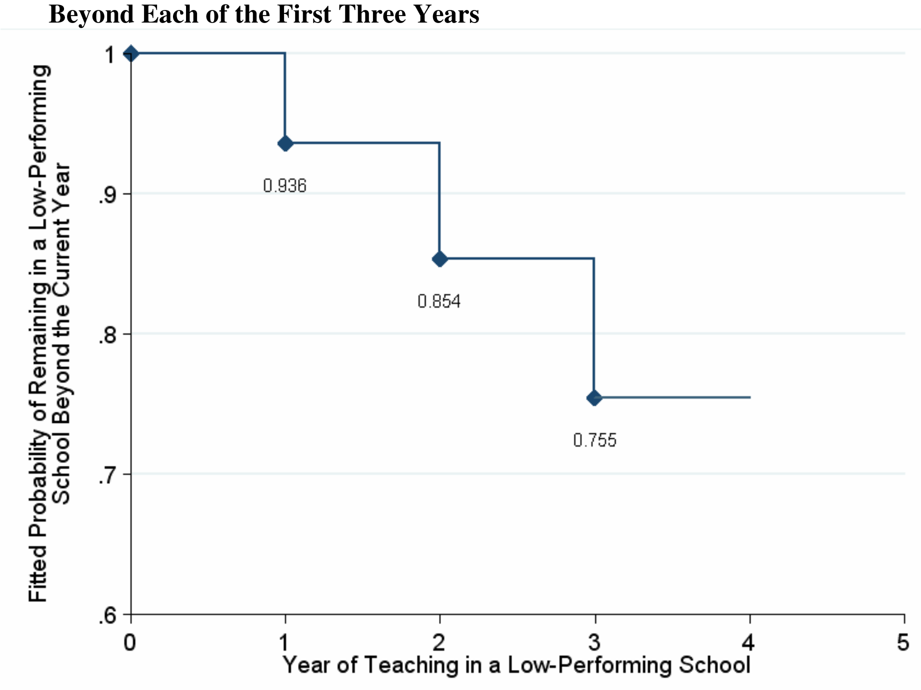
Note: Y axis origin is not zero.

Figure 3. Panel A: *Fitted baseline hazard function* describing exit from the set of low-performing schools as a function of teaching period in the full analytic sample. Panel B: Corresponding *fitted survivor function* for the full analytic sample. (n=9,308 individuals and 17,933person-period records)

A. Fitted Baseline Hazard Function Describing Exit from the Set of Low-Performing Schools by the End of Each Teaching Year (Teaching Years 1–3)



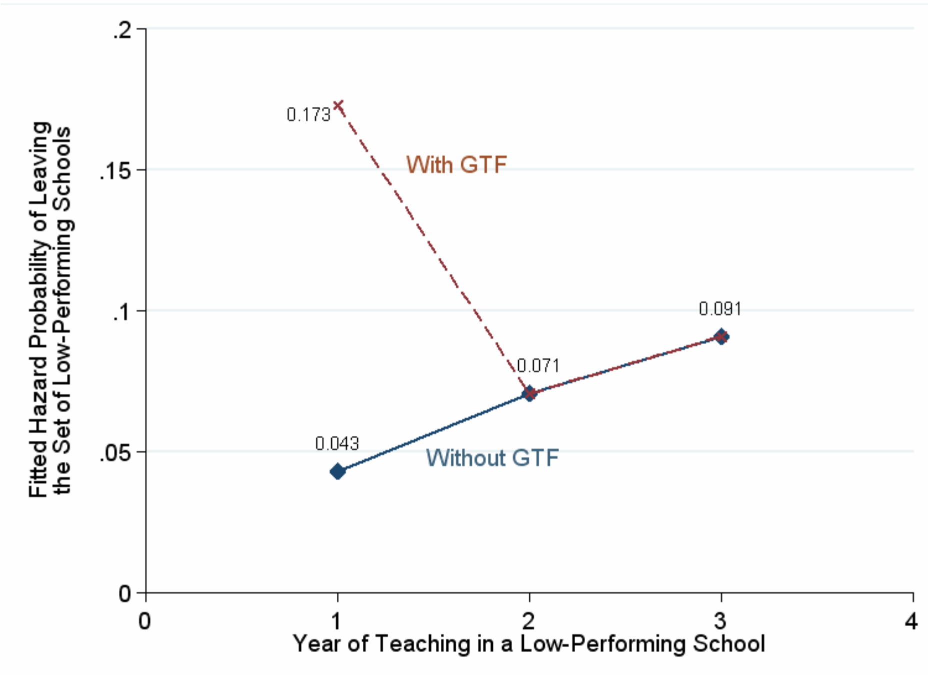
B. Fitted Baseline Probabilities of Continuing to Teach in a Low-Performing School Beyond Each of the First Three Years



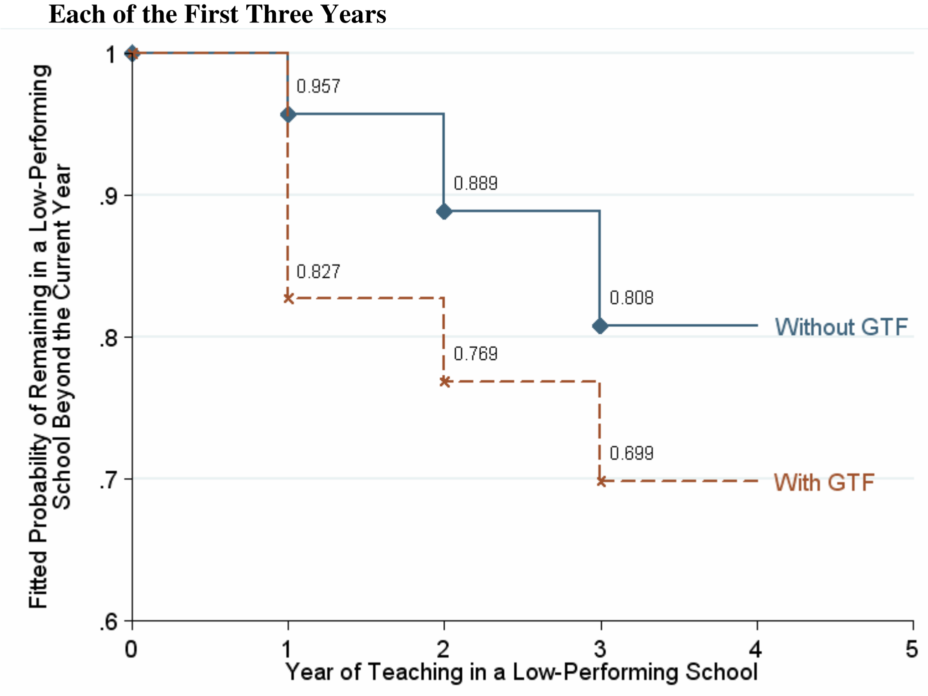
Note: Y axis origin is not zero in Panel B.

Figure 4. Impact of the GTF on the fitted probability that its recipients continued to teach in low-performing schools beyond each of their first three teaching years (n=9,308 individuals and 17,933person-period records)

A. Fitted Hazard Function Describing Exit from the Set of Low-Performing Schools by the End of Each of the First Three Teaching Years



B. Conditional Probability of Remaining in the Set of Low-Performing Schools Beyond Each of the First Three Years



Note: Y axis origin is not zero in Panel B.
Note: In both panels, "Without GTF" is based on the behavior of similar licensure candidates who were not enrolled during GTF availability.

Appendices

Table A1. First-stage fitted parameters (and standard errors)

Predictor	Estimate (standard error)
APLE Cohort (1=1998-99; 5=2002-03)	0.003** (0.001)
CSU Licensure Program (ref=Independent)	0.000 (0.004)
UC Licensure Program (ref=Independent)	-0.005 (0.007)
District Licensure Program (ref=Independent)	-0.003 (0.018)
Composite CBEST Score (range=60-240)	0.000 (0.000)
Secondary Teaching License	0.001 (0.004)
Bilingual Authorization	0.000 (0.007)
Male	-0.004 (0.003)
Age in Years (centered at mean of 31.039)	-0.001** (0.000)
Instrumental Variables	
Eligible for the GTF (Enrolled During GTF Availability)	-0.02 (0.021)
CSU * Eligible	0.005 (0.006)
UC * Eligible	0.222** (0.010)
District Program * Eligible	-0.036 (0.033)
Composite CBEST Score * Eligible	0.0004** (0.0001)
Secondary-Level License * Eligible	0.013* (0.006)
Bilingual Authorization * Eligible	0.034** (0.009)
Constant	-0.015 (0.016)
N	140,45
R-squared statistic	0.11
Df	16

~ significant at 10%; * significant at 5%; ** significant at 1%

Table A2. OLS and 2SLS second-stage parameter estimates (with standard errors) describing entry into low-performing schools within two years after APLE contract agreement

	(1)	**(2)**
Predictors	**OLS**	**IV**
Received a GTF	0.171**	0.342**
	(0.024)	(0.086)
APLE Cohort (1=1998-99; 5=2002-03)	-0.019**	-0.019**
	(0.003)	(0.003)
CSU Licensure Program (ref=Independent)	0.021*	0.021*
	(0.009)	(0.009)
UC Licensure Program (ref=Independent)	0.049**	0.032~
	(0.015)	(0.017)
District Licensure Program (ref=Independent)	-0.032	-0.028
	(0.044)	(0.044)
Composite CBEST Score (range=60-240)	-0.001**	-0.001**
	0.000	0.000
Secondary Teaching License	-0.043**	-0.043**
	(0.010)	(0.010)
Bilingual Authorization	0.145**	0.142**
	(0.014)	(0.014)
Male	0.049**	0.049**
	(0.010)	(0.010)
Age in Years (centered at mean of 31.039)	-0.003**	-0.003**
	(0.001)	(0.001)
Constant	0.714**	0.717**
	(0.033)	(0.033)
N	14,045	14,045
R-squared statistic	0.028	0.024
Df	10	10

~ significant at 10%; * significant at 5%; ** significant at 1%

Table A3. Second stage parameter estimates (and standard errors) describing the probability of exit from a low-performing school by the end of teaching years one through three

	(1) Time-Only Model	(2) IV Model with GTF Recipients' Hazard Varying by Teaching Year
Teaching Year 1	0.064**	0.054**
	(0.003)	(0.017)
Teaching Year 2	0.088**	0.081**
	(0.003)	(0.017)
Teaching Year 3	0.116**	0.102**
	(0.004)	(0.017)
GTF Recipient * Teaching Year 1		0.130*
		(0.055)
APLE Cohort (1=1998-99; 5=2002-03)		-0.014**
		(0.002)
Male		-0.006
		(0.005)
Age (centered at mean of 31.039)		0.0004
		(0.0003)
CSU Licensure Program (ref=Independent)		0.004
		(0.005)
UC Licensure Program (ref=Independent)		-0.016*
		(0.008)
District Licensure Program (ref=Independent)		0.015
		(0.034)
Composite CBEST Score (range=60-240)		0.0003**
		(0.000)
Secondary teaching license		0.008
		(0.005)
Bilingual Authorization		-0.002
		(0.006)
N individuals	9,308	9,308
N person-period records	17,933	17,933
R-squared statistic	0.09	0.09
Df	3	13

~ significant at 10%; * significant at 5%; ** significant at 1%