

Teacher Effect Change Model: Latent Variable Regression in 5-Level Hierarchical Models for Evaluating Teacher Preparation Programs

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Introduction

The main goal of this deliverable is to use available data from California State University, Northridge (CSUN) to explore a model that in the future could be used to evaluate the effects of various teacher preparation programs on student learning, as measured by standardized test scores. This deliverable first provides important information about the existing data, including the number of available cases for students, teachers, and schools, descriptive statistics of students' test scores over years, missing data patterns, the percentage of linkage between students and teachers, and so on. Second, it presents a newly developed value-added model for estimating teacher effects. The logic, rationale, key features, and various advantages of this model over currently available value-added models are discussed. Third, this deliverable illustrates the models using the CSUN data bases. Two model variations are shared. One compares teachers who graduated from CSUN to those who graduated from other institutions. The second model examines potential differential effects of various specific programs within an institution, such as *Pathway*, - ACT program, Intern program, and the traditional teacher preparation program.

Mining Longitudinal Data Sets from LAUSD and CSUN

There are two sources of data bases prepared for this project; one comes from the Los Angeles Unified School District (LAUSD), and the other one comes from CSUN. The LAUSD data base contains comprehensive longitudinal information on students, teachers, and schools. Student data includes students' universal identification number, yearly achievement scores, demographic information, meal program participation, parent education, and so on. Teacher data also includes teacher's LAUSD universal identification number and background information, such as gender, ethnicity, age, credential status, teacher's education degree, etc. Likewise, school data contains some information on schools, for instance school's location, school type, Title 1 participation status, and school characteristics index.

The CSUN data base contains extensive information on students who graduated from the CSUN teacher preparation program. It includes students' CSUN identification number, course grade, type of credential earned at CSUN, type of credential program (i.e., pathway), and some background information such as gender and ethnicity. Note that the CSUN data base also contains teacher identification numbers, which makes it possible to link the CSUN and LAUSD data into one merged data base.

The data mining process was conducted to examine how much student, teacher, and school data is available for further statistical analysis. First, since this data base

contained multiple cohorts of students and each student had longitudinal measures of achievement scores, it was very important to examine how much missing data was observed and what kind of missing data patterns were identified. Second, it was necessary to calculate descriptive statistics of outcome of interest, reading Normal Curve Equivalent (NCE) scores at each year (from year 1999 to 2003) for the entire sample. These statistics provided us with a piece of important information on how much the statistics of the entire sample was different from the statistics taken from the sample used for the final statistical analysis. Due to the missing teacher identifications, the final sample might be fairly different from the entire sample. Third, missing data patterns for teacher data were examined. If teacher identification was missing, because it was impossible to link students' data to the teacher, we are unable to use that data in the analysis of estimating teacher effect.

Table 1 defines the cohort of students and presents the missing data patterns of each cohort of students. Note that only students in elementary schools were included in the analysis. Cohort 1 was defined as students who were in the 1st grade in 1999, and Cohort 2 as those who were in the 2nd grade in 1999. Thus, the students in the first cohort possibly had as many as 5-time points data from Grades 1 to 5. Likewise, the second cohort students could have as many as 4-time points data from Grades 2 to 5.

The missing data patterns in each cohort of students presented in Table 1 can be summarized as follows: The percentages of complete data for Cohorts 1, 2, 3, 4, and 5, were, respectively, 63.9%, 66.6%, 79.7%, 85.0%, and 99%. Specifically, only approximately 64% of students in Cohort 1 had reading NCE scores from Grades 1 to 5. In other words, about 36% of Cohort 1 students had at least one missing element of data between Grades 1 and 5. However, if we included students who had only missing data at one time point, the percentage of students in this category went up to 85%. These were typical missing data patterns observed in a data set from a large urban school district.

Table 2 presents the descriptive statistics of students' reading NCE scores at each year by teachers' credential programs— Non-CSUN, ACT pathway in CSUN (ACT), Intern pathway in CSUN (Intern), traditional program in CSUN (Trad), and no information on the pathway program but in CSUN (CSUN). The first noticeable item was the very small percentage of students taught by teachers who graduated from ACT and Intern program in CSUN. For example, only 0.1% of students in the sample (N = 84) fell into the Intern category in year 1999, and only approximately 1% of students across the rest of four years. This kind of small sample size in both ACT and Intern programs made it very difficult to compare students' test scores across these five categories of teacher credential programs.

Comparing the mean scores at each year between Non-CSUN teachers and CSUN teachers, we found that the Non-CSUN teachers' mean was approximately one to two points higher than the CSUN teachers' mean. For example, mean reading scores for students taught by Non-CSUN teachers in 1999 was equal to 34.9, while the mean for those taught by CSUN teachers was approximately 32.6. Likewise, the differences between those two groups were 2.7, 0.7, 1.6, in 2000, 2001, and 2003, respectively.

However, in 2002, the mean for the Non-CSUN group was approximately 1.8 points lower (44.7) than the one for the CSUN group (46.5).

Care should be taken in interpreting these descriptive statistics. The observed differences in reading NCE scores in each year between the two groups were at most 2 points, which was approximately a 0.1 effect size. Thus, differences themselves were very negligible, and these differences were based on analysis of data via cross-section instead of longitudinally. In addition, these differences were just observed once, thus they were compounded by many factors.

The numbers of teachers are presented in Table 3 by teacher credential programs. The key task was to compare teachers' effectiveness across different teacher credential programs. Thus, teacher-level data was the key inference unit. There were extremely small numbers of teachers who graduated either from ACT or Intern programs in CSUN, as the numbers of students in those two categories (see Table 2) suggests. Specifically, there were only two teachers in the ACT program and four in the Intern program in 1999. As such, the percentage of teachers who graduated either from ACT or Intern program was at most 0.5% in this data base. Note that on average, approximately 8 – 11 % of teachers in the sample graduated from CSUN programs.

Another important point to make is that there were many teachers whose total number of students was less than five. As can be seen in Table 3, for example, only 550 teachers out of 1,975 in year 1999 had more than five students. The percentages of teachers who had more than five students in each year were 27.8%, 32.9%, 34.4%, 32.3%, and 36.4%, respectively, in years 1999, 2000, 2001, 2002, and 2003. Statistical analysis for estimating teacher effects in this project was based on the data which include only teachers who have more than five students.

Note that the patterns of missing data, changed in outcome measures, and our inability to link most teachers with more than five students precluded any substantive conclusions from the analyses that follow. The data were used for illustrative purposes only and henceforth, we term CSUN as “Target institution” (TI) and non-CSUN as “Other Institutions” (OI).

The following sections describe the teacher effect change model, which is a newly developed latent variable regression 5-level hierarchical model. Background on current value-added models for estimating teacher effects is first provided and a new formulation of teacher effect and the gap parameter is discussed. Model specification and description then follows.

Teacher Effect Change Model: Latent Variable Regression in 5-Level Hierarchical Model

Current value added-models attempt to estimate relative teacher effects based on cross-classified data structure (Sanders, Saxton, & Horn, 1997; Raudenbush & Bryk, 2002; McCaffrey, Lockwood, Koretz, Louis, & Hamilton, 2004; Posnik & Bryk, 2005).

Ignoring some of the different features of those sophisticated value-added models, the key communality is that each individual teacher effect is captured by the random effect component in the models. In other words, the estimated individual teacher effect is expressed by the magnitude of residual which is attributed to a teacher's influence. In general, random effects are normally distributed with mean 0 and the variance term, τ , thus what we get regarding the teacher effectiveness from the computationally very intensive analysis is where your teacher effect is located in the distribution, and how large the positive or negative effect he or she has compared to the mean of the distribution. Thus, this kind of information might be useful when we are interested in ranking all the teachers in a district.

Compared with those value-added models, the proposed model allows us to address the following questions: Do teacher effect estimates change over time? What do the teacher effect profile trajectories look like? To what extent do teachers' background characteristics such as gender and years of teaching experience relate to the teacher effect profile trajectories? To what extent do teachers' time-varying event histories (e.g., professional development courses) relate to the teacher effect profile trajectories? To what extent are estimates of change in teacher effects influenced by school characteristics? These kinds of questions require that an individual teacher effect be estimated each year by the magnitude of gain/growth students make per year, and that such teacher effects in multiple years yield an individual teacher effect profile. Statistically speaking, this model specifies double gain/growth processes, both of students and teachers. In addition, it includes student, teacher, and school-level variables, especially students' initial status through latent variable regression within a hierarchical modeling framework. Note that this model is computationally much less demanding compared to current sophisticated value-added models.

The teacher effect change model is specified with a 5-level latent variable regression hierarchical model (LVR-HM5; see Choi & Seltzer, in press for latent variable regression 3-level model; see also Choi, 2006 for latent variable regression 4-level model). This model has the following distinctive features: (a) It takes into account standard errors of measurement in the model; (b) It deals with latent variable regression in order to adjust students' differences in terms of their initial status; (c) It models double gain/growth process both of students and teachers; (d) Since this model is built on hierarchical modeling framework, it is very flexible to include student-level, teacher-level, and school-level variables in the model; (e) It is computationally much less demanding compared to the other value-added models aforementioned.

Using 5 years of longitudinal data from a large, urban school district, we will illustrate the various possibilities of the teacher effect change model. We will employ a fully Bayesian approach to estimate the proposed model, and analyses will be done using WinBUGS (Spiegelhalter, Thomas, Best, & Lunn, 2003).

Teacher effect and Gap parameter

Estimating teacher effect has been a longstanding research agenda in education. After the “No Child Left Behind Act” (NCLB) was established as an alternative approach to estimate students’ adequate yearly progress (AYP), value-added models have been a prevailing measure of teacher/school effectiveness based on students’ progress over time. These models have the following key features: First, they deal with students’ time-series measures. This means that teacher effect is not based on student status at a single point of time but on student growth over time. Second, estimating teacher effect based on student growth involves specifying a complex design matrix in order to identify teachers’ membership at each point in time. For example, it is natural that students have been taught by a different teacher at each year, so that student’s growth is not attributed to a single teacher. Such a setting is called cross-classified nesting structure and aforementioned value-added models (i.e., Sanders et al.’s Tennessee Value-Added Assessment System (TVASS), 1997; McCaffrey et al.’s RAND value-added model, 2004; Posnik & Bryk’s Chicago Public School Model, 2005) incorporate this kind of data structure into the models.

Statistically speaking, transforming a large design matrix to estimate each teacher’s random effect is extremely computationally cumbersome. For example, if we have four years of data for approximately 10,000 students and 500 teachers, assuming that a teacher taught 20 students per year, only 100 students were taught by each teacher. This makes the design matrix not only large, but also sparse. Furthermore, it is almost impossible to specify covariance terms among teachers’ random effects, even though we could observe intra-class correlations among teachers who were in the same schools.

In this report, we define a teacher effect as the magnitude of gain students make during one school year, controlling for student’s entering status. For example, a student comes into a classroom with the previous year’s achievement test score. After a year of teaching he or she is tested at the end of the school year. A teacher is accountable for his or her student gain during a year. It is important to note that a student’s test score in the previous year is not responsible for the current year’s teacher, thus when a student’s gain during a year is estimated, the previous year’s test score must be adjusted/controlled for. The estimated average gain is defined as a teacher effect for a teacher k at certain year j . If a teacher has taught for multiple-years, the teacher has teacher effects as many as the number of teaching years. As such, teachers have time-series estimates of teacher effects.

This approach on teacher effect has three advantages over the current value-added models. First, using this framework the data becomes a fully nesting structure instead of cross-classified structure. Specifically, teachers have a group of students at each year, so we can arrange a group of students at each year as they are nested within a teacher. As a result, students’ test scores are grouped as years and in turn years of students are nested within a teacher who is also nested within a school. This kind of nesting structure and corresponding model will be discussed in detail in a following section.

The second advantage is that we can model time-series estimates of teacher effects as a function of time metric and teacher's time-varying covariates. Since we have teacher effect at every year, it can open up possibilities to examine how teacher effect estimates change over time and to what extent the differences in the change trajectories relate to the differences in teachers' time-varying covariates and time-invariant covariates.

Another advantage of this framework is how it tremendously reduces the complexity of the design matrix which is involved in the cross-classified modeling setting, since this approach deals with a fully nested data structure. This feature helps us to greatly reduce computing time.

Let us turn to the gap parameter. Teacher or school mean estimate of growth is of central interest in value-added models, and the result mean estimate of growth is viewed as a reflection of the overall teacher or/and school effect in the sampled population. Compared to that, moving beyond the single summary of teacher or school mean estimate of growth, by attending to the relationship between students' initial status and their growth rate, can help bring to light the distribution of achievement within schools (Seltzer, Choi, & Thum, 2003; Choi, Seltzer, Herman, & Yamashiro, 2007; Choi, 2006). For example, even in three schools with a similar school mean estimate of growth, we can observe three different patterns of distribution of student growth: the initial gap between high initial status students and low initial status students is either diminishing, widening, or remains unchanged over time.

Choi et al. (2007) identified some schools meeting the Washington State criteria of AYP--widening the initial gap where they had above average students making substantial progress--but for below average students little to no progress was made. In contrast, other schools making AYP had below average students making adequate progress but above average students making little gains, and as a result the initial gap diminished. These results imply that some schools are better at helping low performing students grow, while some schools are better for high performing students.

This kind of school phenomenon can be also applied to teachers. Some teachers might be more effective for low performing students than for high performing students. Other teachers might be the opposite. In a statistical model, this question can be addressed by regressing students' gain/growth on their initial status. This coefficient is a latent variable regression coefficient since both students' initial status and gain/growth are latent variables in the model. We call this a gap parameter which captures the relationship between initial status and gain in a way that shows how much of an initial gap is magnified or diminished (see also Choi, 2006).

Model

We specify a simple latent variable regression in 5-level hierarchical model (LVR-HM5) for a teacher effect change model. For the purpose of simplicity, this model does not include any student-, teacher- nor school-level observed variables except time-metric variables.

As for data structure, it is basically a 5-level data structure: test scores at year t and $t-1$ are nested within students who are nested within years. These students are in turn nested within teachers who again are nested within schools. Assuming teacher A has done four-years of teaching, for example, students' test scores are nested within years, and these years of students' test scores are nested within this teacher A. However, it is important to note that each student at year t also has a previous year test score (i.e., year $t-1$) as well as a test score at year t .

The following level-1 model specifies initial status and gain between the previous year ($t-1 = j-1$) and the current year ($t=j$) for student i ($i = 1, 2, \dots, N_{jkl}$), in year j , ($j = 1, 2, \dots, J_{kl}$), teacher k , ($k = 1, 2, \dots, K_l$) in school l ($l = 1, 2, \dots, L$). Y_{ijkl} is the outcome score at measurement occasion t ($t = 1, 2$) for student i in year j , teacher k , school l .

$$Y_{ijkl}^* = \pi_{0ijkl} + \pi_{1ijkl} \text{Time}_{ijkl}^* + \varepsilon_{ijkl}^* \quad \varepsilon_{ijkl}^* \sim N(0, 1) \quad (1)$$

In order to incorporate standard errors of measurements (SEs), we re-scale left hand and right hand sides of Equation 1 by inverse of SEs for each student i , in year j teacher k , school l . By re-scaling the outcome and time metric based on an estimate of the precision associated with each reading score, ($1/ \text{SE}(Y_{ijkl})$), ε_{ijkl}^* is assumed to be normally distributed with mean 0, but its variance is now 1. Time_{ijkl}^* takes value of 0 for the test score at the previous year ($t-1$) and 1 for the test score at the current year (t) so that π_{0ijkl} and π_{1ijkl} represent status at the previous year (i.e., initial status) and gain between the previous year ($j-1^{\text{th}}$) and the current year (j^{th} year), respectively, for student i , year j , teacher k in school l . As such, a level-1 model specifies students' gain process at each year for teacher k in school l .

In a level-2 (between-student and within-year) model, initial status for each individual student i in year j , teacher k , school l is modeled as a function of mean initial status for year j in teacher k , school l (i.e., β_{00jkl}) and its random effect. Furthermore, the gain is modeled as a function of a student's initial status. Note that a student's initial status is centered around his or her mean initial status in year j . Due to this centering, β_{10jkl} represents adjusted mean gain for year j , teacher k in school l .

$$\pi_{0ijkl} = \beta_{00jkl} + r_{0jkl} \quad r_{\pi 0jkl} \sim N(0, \tau_{\pi 0jkl}) \quad (2a)$$

$$\pi_{1ijkl} = \beta_{10jkl} + \text{Bw}_{jkl} (\pi_{0ijkl} - \beta_{00j..}) + r_{1jkl} \quad r_{\pi 1jkl} \sim N(0, \tau_{\pi 1jkl}) \quad (2b)$$

One of the key parameters in the level-2 model is the latent variable regression coefficient, Bw_{jkl} , the gap parameter, which captures the expected increase or decrease in gain when students' initial status increases one unit. As subscribers for year j , teacher k , and school l indicates, each teacher in each school has a different gap parameter at each year, as each teacher in each school has a different initial status and adjusted gain at each year. Two random effects, $r_{\pi 0jkl}$ and $r_{\pi 1jkl}$ are assumed to be normally distributed with mean 0 and variances, $\tau_{\pi 0jkl}$, and $\tau_{\pi 1jkl}$. Note that these variances differ across years, teachers, and schools. The covariance between the random effects is set to 0, since gain the parameter is conditional on an initial status parameter.

The following level-3 (between-year and within-teacher) model specifies the growth process for teacher effects. We have three outcomes: for each of the year j , teacher k , school l , initial status for entering students (i.e., teacher's initial status); adjusted expected gain (We define this as teacher effect); gap parameter.

$$\beta_{00jkl} = \gamma_{000kl} + \gamma_{001kl}Year_{jkl} + U_{00jkl} \quad U_{\beta_{00jkl}} \sim N(0, \tau_{\beta_{00}}) \quad (3a)$$

$$\beta_{10jkl} = \gamma_{100kl} + \gamma_{101kl}Year_{jkl} + Bc_1(\beta_{00jkl} - \gamma_{000kl}) + U_{10jkl} \quad U_{\beta_{10jkl}} \sim N(0, \tau_{\beta_{10}}) \quad (3b)$$

$$Bw_{jkl} = Bw_{0kl} + Bw_{1kl}Year_{jkl} + Bc_2(\beta_{00jkl} - \gamma_{000kl}) + U_{Bwjkl} \quad U_{Bwjkl} \sim N(0, \tau_{Bw}) \quad (3c)$$

$$Cov(U_{\beta_{00jkl}}, U_{\beta_{10jkl}}) = 0, \quad Cov(U_{\beta_{00jkl}}, U_{Bwjkl}) = 0, \quad Cov(U_{\beta_{10jkl}}, U_{Bwjkl}) = \tau_{\beta_{10}, Bw}$$

Those parameters are modeled as a function of another time-metric variable, $Year_{jkl}$. This variable takes values of 0, 1, 2, ... J_{kl} . With this parameterization, γ_{000kl} and γ_{001kl} represent a teacher's initial status at $Year = 0$ and rates of change in teachers' initial status, respectively. Likewise, the teacher effect parameter, β_{10jkl} , is posed as growth process using the $Year_{jkl}$ variable in the model. γ_{100kl} is teacher effect at $Year = 0$ for teacher k in school l , and γ_{101kl} represents rates of change in teacher effects over years for teacher k in school l . The gap parameter at each year is also specified as a growth process. Bw_{1kl} is rate of change over years in the gap parameter for teacher k in school l .

We stress that there are two latent variable regression coefficients in the model: Bc_1 and Bc_2 . Bc_1 capture the extent to which teachers' initial status relate to teacher effect. If Bc_1 has a positive value, it indicates that on average, the teacher effect is larger in years when entering students' test scores at the previous year are high than in years when entering students' test scores at the previous year are low. Likewise, Bc_2 captures the relationship between the gap parameter and teachers' initial status at each year.

The level-4 (between teacher within school) model specifies the relationships between teachers' growth parameters (teachers' initial status parameters, teacher effect parameters and gap parameters) and a teacher's time-invariant characteristics. The model below, however, does not include any teacher characteristics.

$$\gamma_{000kl} = \theta_{0000l} + V_{000kl} \quad V_{000kl} \sim N(0, \tau_{\gamma_{000}}) \quad (4a)$$

$$\gamma_{001kl} = \theta_{0010l} + V_{001kl} \quad V_{001kl} \sim N(0, \tau_{\gamma_{001}}) \quad (4b)$$

$$\gamma_{100kl} = \theta_{1000l} + V_{100kl} \quad V_{100kl} \sim N(0, \tau_{\gamma_{100}}) \quad (4c)$$

$$\gamma_{101kl} = \theta_{1010l} + V_{101kl} \quad V_{101kl} \sim N(0, \tau_{\gamma_{101}}) \quad (4d)$$

$$Bw_{0kl} = Bw_{00l} + V_{Bw0kl} \quad V_{Bw0kl} \sim N(0, \tau_{Bw0}) \quad (4e)$$

$$Bw_{1kl} = Bw_{10l} + V_{Bw1kl} \quad V_{Bw1kl} \sim N(0, \tau_{Bw1}) \quad (4f)$$

There are six fixed effects which represent the expected values for school l . For example, θ_{0010l} and θ_{1010l} are the average rates of change of teachers' initial status and teacher effect, respectively, in school l . Likewise, Bw_{10l} represents the average rates of change of the gap parameter in school l . The six random effects are assumed to be multivariate normally distributed with mean 0 and variance-covariance matrix, Tv .

$$\mathbf{T}_V = \begin{pmatrix} \tau_{\gamma 000} \\ \tau_{\gamma 001, \gamma 000} & \tau_{\gamma 001} \\ \tau_{\gamma 100, \gamma 000} & \tau_{\gamma 100, \gamma 001} & \tau_{\gamma 100} \\ \tau_{\gamma 101, \gamma 000} & \tau_{\gamma 101, \gamma 001} & \tau_{\gamma 101, \gamma 100} & \tau_{\gamma 101} \\ \tau_{Bw0, \gamma 000} & \tau_{Bw0, \gamma 001} & \tau_{Bw0, \gamma 100} & \tau_{Bw0, \gamma 101} & \tau_{Bw0} \\ \tau_{Bw1, \gamma 000} & \tau_{Bw1, \gamma 001} & \tau_{Bw1, \gamma 100} & \tau_{Bw1, \gamma 101} & \tau_{Bw1, Bw0} & \tau_{Bw1} \end{pmatrix} \quad (4g)$$

Finally, the level-5 (between school) model specifies school-level relationships. The fixed effects, κ 's represents grand mean value, or overall average of each parameter in the sample. Albeit the following model does not include any school-level variables in the model, it is possible to specify the relationships between growth parameters (e.g., θ_{0010l} , θ_{1010l} , and Bw_{10l}) and school characteristics by including those variables as predictors.

$$\theta_{0000l} = \kappa_{00000} + Z_{0000l} \quad Z_{0000l} \sim N(0, \tau_{\theta 00000}) \quad (5a)$$

$$\theta_{0010l} = \kappa_{00100} + Z_{0010l} \quad Z_{0010l} \sim N(0, \tau_{\theta 00100}) \quad (5b)$$

$$\theta_{1000l} = \kappa_{10000} + Z_{1000l} \quad Z_{1000l} \sim N(0, \tau_{\theta 10000}) \quad (5c)$$

$$\theta_{1010l} = \kappa_{10100} + Z_{1010l} \quad Z_{1010l} \sim N(0, \tau_{\theta 10100}) \quad (5d)$$

$$Bw_{00l} = Bw_{000} + Z_{Bw00l} \quad Z_{Bw00l} \sim N(0, \tau_{Bw000}) \quad (5e)$$

$$Bw_{10l} = Bw_{100} + Z_{Bw10l} \quad Z_{Bw10l} \sim N(0, \tau_{Bw100}) \quad (5f)$$

Six random effects are assumed to be multivariate normally distributed with mean 0 and variance-covariance matrix, \mathbf{T}_Z .

$$\mathbf{T}_Z = \begin{pmatrix} \tau_{\theta 00000} \\ \tau_{\theta 0010, \theta 0000} & \tau_{\theta 0010} \\ \tau_{\theta 1000, \theta 0000} & \tau_{\theta 1000, \gamma 0010} & \tau_{\theta 1000} \\ \tau_{\theta 1010, \theta 0000} & \tau_{\theta 1010, \theta 0010} & \tau_{\theta 1010, \gamma 1000} & \tau_{\theta 1010} \\ \tau_{Bw00, \theta 0000} & \tau_{Bw00, \theta 0010} & \tau_{Bw00, \theta 1000} & \tau_{Bw00, \theta 1010} & \tau_{Bw00} \\ \tau_{Bw10, \theta 0000} & \tau_{Bw10, \theta 0010} & \tau_{Bw10, \theta 1000} & \tau_{Bw10, \theta 1010} & \tau_{Bw10, Bw00} & \tau_{Bw10} \end{pmatrix} \quad (5g)$$

Illustration of Teacher Effect Change Models: Target Institution's Pathway Program Effects

Data

The final data set used in this project consists of 1,180 teachers in 76 elementary schools. Specifically, in year 1 (2000) there are 99 teachers who graduated from TI and 251 teachers who did not graduate from TI. In year 1, a total of 3,735 students and 350 teachers are included in the analyses. Years 2, 3, and 4 have 2,894 students, 3, 735 students, and 5,846 students, respectively. The number of students at each year who were taught by TI teachers and OI teachers are not much different in years 1, 2 and 3, but in year 4 the number of TI teachers and their students are far smaller than the number of OI teachers and their students.

Table 6 shows missing data patterns for teacher data. Only 2% of teachers in the final sample have complete data from year 1 through year 4. This means that teachers who have their students' test scores both in the previous year and in the current year are only 24 out of 1,180. Approximately 29.5% of teachers have at least two years data and the rest of teachers (approximately 70%) have only one year data. Missing data points are mainly attributed to the lack of teacher identification numbers in the original data base and partly to the lack of student test scores. In the analyses, we only included students who had test scores both in the previous year and current year. Analyses also included only teachers who had more than five students in each year. The lack of teacher data makes it difficult to estimate teacher effect profile trajectory for each individual teacher, but large numbers of teachers help us obtain more precise school-level parameter estimates.

The outcomes of interest are Stanford Achievement Test 9 reading scores in years 1, 2 and 3 and California Standard Test (CST) reading scores in year 4. The normal curve equivalent (NCE) scores are used for the analyses. Note that the standard errors of measurement (SEs) connected with students' SAT9 and CST scores were included in the analyses.

Table 4 presents descriptive statistics of outcome measures at each year by TI teacher status for the final sample. It is noticeable that the mean scores at the previous years increase over years for the OI teacher group by approximately 3 points. For TI teacher groups this kind of increment is also observed for the first three years, but in year 4 the previous year mean score slightly decreases. In terms of gain, the average gains are decreasing in consecutive years both for TI teachers and OI teachers. For TI teachers, the average gains in years 1, 2, 3, and 4 are 2.58, 1.41, -.98, and -5.97, respectively. OI teachers have a similar pattern: year 1 =2.16, year 2 =0.97, year 3 =-.64, year 4 =-5.61. As we can also see in Figure 1, gain trajectory pattern shows a slight decrease during the first three years and a fast drop between the 3rd and 4th year. This figure indicates that the trajectories of teachers' initial status and teacher effect are not a linear pattern, but two different trajectories during the first three years and the last two years.

Table 5 breaks down the TI group into 4 different categories according to the pathway programs – ACT, Intern, traditional, and TI, but with no information on the pathway. It might not provide very meaningful results due to the small sample sizes in ACT and Intern categories, but the average observed gains for students in those two categories are considerably higher than the gains for the rest of groups. For example, in year 2 the average gain in the Intern group is equal to 7.8, while the average gain for the OI group is equal to -0.97. In addition, the ACT group has 3.07 points average gain in year 3 compared to -.64 gain for the OI group.

In Tables 7-10, we present descriptive statistics of outcomes by year, teachers' credential programs, and school characteristics index (SCI). This SCI variable is a composite score originally created by the California Department of Education using the composite demographic information of school to represent the level of academic challenge. It includes students' parent education level, free/reduced price lunch eligibility, ethnic information, students' mobility, the percentage of credentialed teachers, the percentage of English learner students, etc. The score range is from 100 to 200, the highest risk school to the lowest risk school.

In this sample, the average SCI score is approximately 151 and standard deviation and range are 8.5 and approximately 40, respectively. Using these statistics, we categorized the schools in the sample into three groups: low risk, medium risk, and high risk schools. The bottom 25% of the schools are labeled as high risk schools, and the top 25% of the schools as low risk schools. The rest of the schools are labeled as medium risk schools. The first noticeable item is that the average reading scores both in previous years and current years for high risk schools are considerably lower than for low risk schools all across years. For example, mean scores in 1999 (i.e., previous year) in Table 7 are 30.4, 38.1, and 46.7, respectively, for high risk, medium risk, and low risk schools. In addition, the current year's mean scores follow the same patterns as for the previous year's mean scores. The mean scores in 2000 (i.e., current year) in year 1 are 32.4, 40.3, and 49.7 for high risk, medium risk, and low risk schools. In terms of amount of gain, the absolute amount of gain in each year decreases over years. The numbers of students in high risk schools are consistently larger than one in low risk schools, even though the number of schools in each category is exactly the same (19 schools).

Results for Teacher Effect Change Model (Model 1)

We specify the following LVR-HM5 for examining the following research questions:

- What do the teacher effect profile trajectories look like?
- Do teacher effect estimates change over time?
- What do the gap parameter profile trajectories look like?
- To what extent do teacher effect profile trajectories differ between TI teachers and OI teacher?
- To what extent are estimates of change in teacher effects influenced by school characteristics?

The level-1 and level-2 models are the same as Equations 1, 2a, and 2b.

$$Y_{ijkl}^* = \pi_{0ijkl} + \pi_{1ijkl} Time_{ijkl}^* + \varepsilon_{ijkl}^* \quad \varepsilon_{ijkl}^* \sim N(0, 1) \quad (6)$$

$$\pi_{0ijkl} = \beta_{00jkl} + r_{0jkl} \quad r_{\pi 0jkl} \sim N(0, \tau_{\pi 0jkl}) \quad (7a)$$

$$\pi_{1ijkl} = \beta_{10jkl} + Bw_{jkl} (\pi_{0ijkl} - \beta_{00j..}) + r_{1jkl} \quad r_{\pi 1jkl} \sim N(0, \tau_{\pi 1jkl}) \quad (7b)$$

Since we observe different trajectory patterns in terms of teachers' initial status and gain between years 1-3 and years 3-4, in the following level-3 (between-year and within-teacher) model, we include two year variables differentiating the first period of years and the second period of years. In addition, $Year0002_{jkl}$ and $Year0203_{jkl}$ are coded in a way that the intercepts in Equations 8a, 8b, and 8c to represent the expected value of teachers' initial status, teacher effect, and gap parameter in year 1. Due to this kind of parameterization of year variables, for example, γ_{101kl} is rate of change in teacher effect for teacher k in school l during the first three years. Similarly, γ_{102kl} is rate of change in teacher effect for teacher k in school l during the last two years.

$$\beta_{00jkl} = \gamma_{000kl} + \gamma_{001kl} Year0002_{jkl} + \gamma_{002kl} Year0203_{jkl} + U_{00jkl} \quad U_{\beta 00jkl} \sim N(0, \tau_{\beta 00}) \quad (8a)$$

$$\beta_{10jkl} = \gamma_{100} + \gamma_{101kl} Year0002_{jkl} + \gamma_{102kl} Year0203_{jkl} + Bc_1(\beta_{00jkl} - \gamma_{000}) + U_{10jkl} \quad U_{\beta 10jkl} \sim N(0, \tau_{\beta 10}) \quad (8b)$$

$$Bw_{jkl} = Bw_0 + Bw_{1kl} Year0002_{jkl} + Bw_{2kl} Year0203_{jkl} + Bc_2(\beta_{00jkl} - \gamma_{000}) + U_{Bwjkl} \quad U_{Bwjkl} \sim N(0, \tau_{Bw}) \quad (8c)$$

$$Cov(U_{\beta 00jkl}, U_{\beta 10jkl}) = 0, \quad Cov(U_{\beta 00jkl}, U_{Bwjkl}) = 0$$

Among the nine growth parameters above, parameters related to rate of change during the first period of years and the second period of years are treated as random variables in the following level-4 model.

$$\gamma_{000kl} = \theta_{0000} + \theta_{0001}(TI_{kl} - TI_{..}) + V_{000kl} \quad V_{000kl} \sim N(0, \tau_{\gamma 000}) \quad (9a)$$

$$\gamma_{001kl} = \theta_{0010} + \theta_{0011}(TI_{kl} - TI_{..}) + V_{001kl} \quad V_{001kl} \sim N(0, \tau_{\gamma 001}) \quad (9b)$$

$$\gamma_{002kl} = \theta_{0020} + \theta_{0021}(TI_{kl} - TI_{..}) + V_{002kl} \quad V_{002kl} \sim N(0, \tau_{\gamma 002}) \quad (9c)$$

$$\gamma_{101kl} = \theta_{1010l} + \theta_{1011}(TI_{kl} - TI_{..}) + V_{101kl} \quad V_{101kl} \sim N(0, \tau_{\gamma 101}) \quad (9d)$$

$$\gamma_{102kl} = \theta_{1020l} + \theta_{1021}(TI_{kl} - TI_{..}) + V_{102kl} \quad V_{102kl} \sim N(0, \tau_{\gamma 102}) \quad (9e)$$

$$Bw_{1kl} = Bw_{10l} + Bw_{11}(TI_{kl} - TI_{..}) + V_{Bw1kl} \quad V_{Bw1kl} \sim N(0, \tau_{Bw1}) \quad (9f)$$

$$Bw_{2kl} = Bw_{20l} + Bw_{21}(TI_{kl} - TI_{..}) + V_{Bw2kl} \quad V_{Bw2kl} \sim N(0, \tau_{Bw2}) \quad (9g)$$

The level-4 (between-teacher and within-school) model basically specifies a set of contrasts between TI teachers and OI teachers. The TI_{kl} variable takes on a value of 1 for TI teachers and 0 for otherwise. Since this variable is centered around the grand mean, θ_{1010l} is the expected rate of change in teacher effect during the first three years for school l . Also, θ_{1011l} is the expected rate of change in teacher effect during the last two years for school l .

Finally, the level-5 (between school) model examines the extent to which differences in school's level of risk relates to differences in rate of change in teacher

effects. Due to the centering of the SCI_k variable around the grand mean value, κ_{10100} represents the overall rate of change in teacher effects during the first period of years, and κ_{10101} is the effect of a school's level of risk on the rate of change in teacher effects. In a similar way, we can interpret κ_{10200} as the overall rate of change in teacher effects during the second period of years and κ_{10201} as the effect of a school's level of risk on it.

$$\theta_{1010l} = \kappa_{10100} + \kappa_{10101}(SCI_k - SCI.) + Z_{1010l} \quad Z_{1010l} \sim N(0, \tau_{\theta_{1010}}) \quad (10a)$$

$$\theta_{1020l} = \kappa_{10200} + \kappa_{10201}(SCI_k - SCI.) + Z_{1020l} \quad Z_{1020l} \sim N(0, \tau_{\theta_{1020}}) \quad (10b)$$

$$Bw_{10l} = Bw_{100} + Bw_{101}(SCI_k - SCI.) + Z_{Bw_{10l}} \quad Z_{Bw_{10l}} \sim N(0, \tau_{Bw_{10}}) \quad (10c)$$

$$Bw_{20l} = Bw_{200} + Bw_{201}(SCI_k - SCI.) + Z_{Bw_{20l}} \quad Z_{Bw_{20l}} \sim N(0, \tau_{Bw_{20}}) \quad (10d)$$

$$\text{Cov}(Z_{1010l}, Z_{1020l}) = \tau_{\theta_{1010}, \theta_{1020}}$$

Table 7 presents the results from above teacher effect change model. Let us first consider the results of how teachers' initial status changes over years. The estimate of rate of change during years 2000-2003 (θ_{0010}) is 4.19 and its 95% interval ranges from 3.30 to 5.05. This indicates that entering students' average test scores increase on average of 4.19 per year during the first three years. However, the change rate between years 2002 and 2003 in terms of teachers' initial status is slightly smaller than one between years 2000 and 2002 ($\theta_{0020} = 3.09$). The contrasts between TI teachers and OI teachers in these two parameters are not statistically significant. Figure 2 shows the fitted growth trajectories of initial status for the first three years for OI and TI teachers.

Second, the rate of change of the teacher effects during the first three years has a positive value ($\kappa_{10100} = .729$), but since its 95% interval (-.164, 1.608) includes a value of 0, it is not marginally statistically significant. However, the teacher effects during the last two years decrease on average by approximately 2.21 ($\kappa_{10200} = -2.209$ and its 95% interval = -3.99, -.45). As in the case of teachers' initial status, there is no difference between TI teachers and OI teachers in the rates of change either during the first three years or the last two years.

Third, we can see interesting findings on the gap parameter. The estimate of change slope of the gap parameters during the first three years (Bw_{10}) is -.031 (its 95% interval = -.051, -.010). In addition, the gap parameter is decreasing during the last two years (i.e., $Bw_{20} = -.060$, 95% interval = -.100, -.021). These results suggest that in each year students with initially low test scores gain more than those with initially higher test scores. Thus, the initial gap becomes diminished at the end of each year. Furthermore, this kind of gain pattern is getting stronger over the years, since the two estimates of the change slopes regarding the gap parameter have statistically significant negative values. These results are partly attributed to the artifact of the scale of outcomes. The outcomes in this analysis are NCE scores which are likely to be fallible in accommodating high performers' growth (i.e., ceiling effect) and are subject to erroneously overestimate low performer's growth (i.e., floor effect).

Fourth, the estimate of the relationship between teachers' initial status and teacher effect (Bc_1) has a negative value, but it is not statistically significant. Likewise, there is no significant relationship between teachers' initial status and the gap parameter.

Fifth, a school's level of risk has a positive effect on the rates of change of teacher effects during the first three years. The estimate (κ_{10101}) is .114 and its 95% interval is .057 and .170. Since this school characteristics index (SCI) variable has low value (as low as 100) for high risk schools, the positive estimate indicates that teachers in low risk schools have more positive rates of change in teacher effect than those in high risk schools. As can be seen in Figure 3, teachers in a low risk schools (a school with one standard deviation above the average SCI of the sample) have a positive growth rate of teacher effects, while those in a high risk schools have a negative one. However, this SCI variable has no significant effect on the rate of change of teacher effect during the last two year.

Results for Different Effects of TI Pathway teacher Preparation Programs: Teacher Effect Change model (Model 2)

In order to examine the extent to which teacher effects are different between OI teachers and TI pathway teachers, the following model is specified. As described earlier, there are five categories: OI and four TI categories (ACT, Intern, Traditional, and TI but no pathway information). The level 1, level 2, and level 3 models are specified as the same as those in Model 1. Equations 11 and 12a, 12b are level 1 and level 2 models where each individual student's initial status and gain are estimated. Moreover, the relationship between students' initial status and gain (i.e., gap parameter) is also specified in Equation 12b. The level-3 model is presented in Equations 13a, 13b, and 13c. Each of these equations specifies an individual teacher's initial status trajectory, effect trajectory, and gap parameter trajectory.

$$Y_{ijkl}^* = \pi_{0ijkl} + \pi_{1ijkl} Time_{ijkl}^* + \varepsilon_{ijkl}^* \quad \varepsilon_{ijkl}^* \sim N(0, 1) \quad (11)$$

$$\pi_{0ijkl} = \beta_{00jkl} + r_{0jkl} \quad r_{\pi 0jkl} \sim N(0, \tau_{\pi 0jkl}) \quad (12a)$$

$$\pi_{1ijkl} = \beta_{10jkl} + Bw_{jkl}(\pi_{0ijkl} - \beta_{00j..}) + r_{1jkl} \quad r_{\pi 1jkl} \sim N(0, \tau_{\pi 1jkl}) \quad (12b)$$

$$\beta_{00jkl} = \gamma_{000kl} + \gamma_{001kl} Year0002_{jkl} + \gamma_{002kl} Year0203_{jkl} + U_{00jkl} \quad U_{\beta 00jkl} \sim N(0, \tau_{\beta 00}) \quad (13a)$$

$$\beta_{10jkl} = \gamma_{100} + \gamma_{101kl} Year0002_{jkl} + \gamma_{102kl} Year0203_{jkl} + Bc_1(\beta_{00jkl} - \gamma_{000}) + U_{10jkl} \quad U_{\beta 10jkl} \sim N(0, \tau_{\beta 10}) \quad (13b)$$

$$Bw_{jkl} = Bw_0 + Bw_{1kl} Year0002_{jkl} + Bw_{2kl} Year0203_{jkl} + Bc_2(\beta_{00jkl} - \gamma_{000}) + U_{Bw_{jkl}} \quad U_{Bw_{jkl}} \sim N(0, \tau_{Bw}) \quad (13c)$$

$$Cov(U_{\beta 00jkl}, U_{\beta 10jkl}) = 0, \quad Cov(U_{\beta 00jkl}, U_{Bw_{jkl}}) = 0$$

The following seven equations constitute a level-4 model. Each equation has 4 indicator variables – ACT_{kl} , $Intern_{kl}$, $Trad_{kl}$, and TI_{kl} . Each variable takes a value of 1 if teacher k in school l falls into the corresponding category. For example, if a teacher graduated from the intern program in TI, then $Intern_{kl}$ is 1 and the other variables are equal to 0. Using this coding scheme, θ_{1011} represents the difference between OI and ACT

teachers with respect to teacher effect growth during the first three years. Likewise, θ_{1014} captures the difference between OI and TI teachers with no pathway information.

$$\gamma_{000kl} = \theta_{0000} + \theta_{0001}ACT_{kl} + \theta_{0002}Intern_{kl} + \theta_{0003}Trad_{kl} + \theta_{0004}TI_{kl} + V_{000kl}$$

$$V_{000kl} \sim N(0, \tau_{\gamma000}) \quad (14a)$$

$$\gamma_{001kl} = \theta_{0010} + \theta_{0011}ACT_{kl} + \theta_{0012}Intern_{kl} + \theta_{0013}Trad_{kl} + \theta_{0014}TI_{kl} + V_{001kl}$$

$$V_{001kl} \sim N(0, \tau_{\gamma001}) \quad (14b)$$

$$\gamma_{002kl} = \theta_{0020} + \theta_{0021}ACT_{kl} + \theta_{0022}Intern_{kl} + \theta_{0023}Trad_{kl} + \theta_{0024}TI_{kl} + V_{002kl}$$

$$V_{002kl} \sim N(0, \tau_{\gamma002}) \quad (14c)$$

$$\gamma_{101kl} = \theta_{1010l} + \theta_{1011}ACT_{kl} + \theta_{1012}Intern_{kl} + \theta_{1013}Trad_{kl} + \theta_{1014}TI_{kl} + V_{101kl}$$

$$V_{101kl} \sim N(0, \tau_{\gamma101}) \quad (14d)$$

$$\gamma_{102kl} = \theta_{1020l} + \theta_{1021}ACT_{kl} + \theta_{1022}Intern_{kl} + \theta_{1023}Trad_{kl} + \theta_{1024}TI_{kl} + V_{102kl}$$

$$V_{102kl} \sim N(0, \tau_{\gamma102}) \quad (14e)$$

$$Bw_{1kl} = Bw_{10l} + Bw_{11}ACT_{kl} + Bw_{12}Intern_{kl} + Bw_{13}Trad_{kl} + Bw_{14}TI_{kl} + V_{Bw1kl}$$

$$V_{Bw1kl} \sim N(0, \tau_{Bw1}) \quad (14f)$$

$$Bw_{2kl} = Bw_{20l} + Bw_{21}ACT_{kl} + Bw_{22}Intern_{kl} + Bw_{23}Trad_{kl} + Bw_{24}TI_{kl} + V_{Bw2kl}$$

$$V_{Bw2kl} \sim N(0, \tau_{Bw2}) \quad (14g)$$

At level 5, school characteristics variable, SCI_k , is included as a predictor for school mean growth rate of teacher effects (θ_{1010l} and θ_{1020l}) and school mean rates of change in gap parameters (Bw_{10l} and Bw_{20l}) during the first three years and the last two years.

$$\theta_{1010l} = \kappa_{10100} + \kappa_{10101}(SCI_k - SCI.) + Z_{1010l} \quad Z_{1010l} \sim N(0, \tau_{\theta1010}) \quad (15a)$$

$$\theta_{1020l} = \kappa_{10200} + \kappa_{10201}(SCI_k - SCI.) + Z_{1020l} \quad Z_{1020l} \sim N(0, \tau_{\theta1020}) \quad (15b)$$

$$Bw_{10l} = Bw_{100} + Bw_{101}(SCI_k - SCI.) + Z_{Bw10l} \quad Z_{Bw10l} \sim N(0, \tau_{Bw10}) \quad (15c)$$

$$Bw_{20l} = Bw_{200} + Bw_{201}(SCI_k - SCI.) + Z_{Bw20l} \quad Z_{Bw20l} \sim N(0, \tau_{Bw20}) \quad (15d)$$

One of the key parameters of interest is κ_{10101} , which captures the effect of a school's level of risk on school average growth rate of teacher effects during the first three years. Bw_{101} is a coefficient which captures the relationship between a school's level of risk and school average rates of change in gap parameter.

Table 12 presents the results from Model 2. As we can expect from the fact that there are a very small number of teachers in TI pathway programs, the estimates to capture the differences between OI teachers and TI pathway teachers are not statistically significant. For example, the estimate of difference between OI and ACT (θ_{1011}) in terms of growth rate of teacher effects is equal to 1.315, but its 95% interval ranges from -1.852 to 4.463.

However, as we found in the results from Model 1, growth rate of teacher effects during the first three years is faster for teachers in a low risk school than for those in a high risk school. The estimate to capture this kind of relationship is κ_{10101} , which is equal to 0.121 and its 95% interval only includes positive values (0.050, 0.192). As we can see

in Figure 3, the growth rate of teacher effects is slightly negative, but teacher effects for the teachers in a low risk school are increasing over time.

Summary and Further Research Possibilities

The primary purpose of this deliverable is to propose a new statistical model for evaluating teacher effects, a teacher effect change model using latent variable regression and 5-level hierarchical analyses. The model allows us to estimate teacher effects by the magnitude of gain that his or her students make during a year. In addition, it estimates a gap parameter which indicates how any initial gap among students is magnified, diminished, or unchanged over time. Furthermore, we can estimate individual teachers' growth trajectories and gap parameters. It is also possible to model the relationship between teacher effect growth trajectory and teacher characteristic variables, as well as teacher's gap parameter growth trajectory and teacher characteristic variables. The model's application provided a number of lessons learned and suggests future research possibilities:

1. The existing data used for this study suggests the challenges of assembling appropriate data for examining the longitudinal effects of teacher preparation programs on student learning. Our study found extensive missing data in students' achievement scores and teacher identifications. In terms of student data, more than 30% of students in Cohorts 1 and 2 have more than one missing achievement score in their elementary school years. The situation is worse for the teacher data and magnified even further by the requirement to link teachers with a minimum n of students, or when looking for the effects of individual programs within an institution. For example, in the current data bases (LAUSD data years '99, '00, '01, '02, and '03), less than 1% of students of the entire population are identified as students either of ACT graduated teachers or of Intern graduated teachers. These limitations severely limit the statistical power in comparing the performance of teachers by teachers' credential programs and functionally preclude any substantive conclusions from the current data. We suspect more recent data may have fewer such problems, in that at least the state test has remained stable over a period of years and record keeping is likely to have improved. Nonetheless, the challenges of missing data are likely to persist.
2. Descriptive statistics of reading NCE scores in years '99, '00, '01, '02, and '03 suggests that teachers from "Other Institutions" have slightly, but not significantly, higher mean scores than "Target Institution" teachers. However, these differences are not only negligible (0.1 effect size) but also possibly compounded by many factors beyond teacher or school's accountability.
3. When the teacher change models are fit to the data, there are no significant differences between target institution teachers and other teachers in the rates of change during either the first three years (years '99 – '02) or the last two years ('02 – '03). Similarly there were no significant differences between

teachers prepared in various specific programs (e.g., Other institutions vs. various specific programs at the target institution), and those from unknown programs at the target institution. Nonetheless, the results suggest a viable model for exploring potential differences.

4. The current analysis show a negative value for growth rate of gap parameters' negative value, which suggests that in each year students with initially low test scores gain more than those with initially higher test scores. Furthermore, this pattern becomes stronger over the years. It is likely that these results are partly attributed to the artifact of the outcome scale. That is, the NCE's are likely fallible in accommodating high performers' growth (i.e., ceiling effect) and are subject to erroneously overestimating low performers' growth (i.e., floor effect). While the current data are illustrative only, these patterns merit additional exploration in future studies.
5. Similarly, the current data show an interesting relationship between growth in teacher effects and a school's level of risk. The results suggest that teachers in a low risk school have larger teacher effects than those in a high risk school. Furthermore, the growth rate of teacher effects for teachers in a low risk school takes a positive value, while the growth rate for those in a high risk school is a negative value. In other words, teachers in schools serving more advantaged students show larger effects than their peers in less advantaged schools and the effect appears to magnify over time. Again, while the data here are illustrative only, the patterns are worth following up in future studies.
6. It would be worthwhile to replicate the proposed models with more current data. The data used for the current study contains student data from 1999 to 2003. As mentioned earlier, the available student outcome measure changed from SAT9 to CST in 2001. Thus, if we could use data from 2001 to the current year, we would have a stable student measure. Because NCLB regulated teacher data from 2002, it is likely there is less missing teacher data and the possibility of drawing substantive inferences. From a statistical point of view, a more complete data set would enable us to conduct exploratory statistical modeling analysis using many predictors in student-level, teacher-level, and school-level models.
7. The models proposed here enable the exploration of a number of additional questions with respect to teacher effects: Who are identified as effective teachers? Who are the teachers that beat the odds? For example, there might be a very effective teacher in a high risk school. What kind of characteristics do teachers have that are identified as effective teachers? These kinds of questions can be addressed by estimating random effects of individual teacher effect.
8. Finally, it is well to recognize that the model and its estimates of effects on student learning are only as good as the underlying measure of learning, in

these state-wide standardized tests. There are limits to what can be measured with such tests and, as the Standards for Educational and Psychological Measurement make clear, it is inappropriate to make any decisions about any individual based on a single test score. As one piece of evidence, however, we believe the models we have demonstrated show great promise.

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Table 1
Missing data patterns by cohort: Students' Reading NCE scores

Year	1999	2000	2001	2002	2003	
Grade	1	2	3	4	5	→ Cohort 1
	2	3	4	5		→ Cohort 2
	3	4	5			→ Cohort 3
	4	5				→ Cohort 4
	5					→ Cohort 5

Missing Pattern*	Frequency	Percent	Cum. Frequency	Cum. Percent
Cohort 1				
0_11111	1594	63.94	1594	63.94
1_.1111	124	4.97	1718	68.91
1_1.111	179	7.18	1897	76.09
1_11.11	49	1.97	1946	78.06
1_111.1	84	3.37	2030	81.43
1_1111.	89	3.57	2119	85.00
2_..111	15	0.60	2134	85.60
2_1.11	4	0.16	2138	85.76
2_11.1	8	0.32	2146	86.08
2_111.	6	0.24	2152	86.32
2_11.11	20	0.80	2172	87.12
2_11.11	16	0.64	2188	87.77
2_111.	13	0.52	2201	88.29
2_111.1	15	0.60	2216	88.89
2_111.	5	0.20	2221	89.09
2_111..	75	3.01	2296	92.10
3_...11	3	0.12	2299	92.22
3_..1.1	2	0.08	2301	92.30
3_..11.	3	0.12	2304	92.42
3_1..1	4	0.16	2308	92.58
3_11..	5	0.20	2313	92.78
3_1...1	32	1.28	2345	94.06
3_11.1.	2	0.08	2347	94.14
3_11.1..	14	0.56	2361	94.71
3_111..	65	2.61	2426	97.31
4_....1	8	0.32	2434	97.63
4_..1..	4	0.16	2438	97.79
4_1...1	6	0.24	2444	98.03
4_1....	49	1.97	2493	100.00

* In the column labeled "missing pattern", the number before the underscore denotes the number of missing data points, and the symbol "1" and "." following the underscore denote whether data are "observed" or "missing", respectively.

Missing Pattern*	Frequency	Percent	Cum. Frequency	Cum. Percent
Cohort 2				
0_1111	1764	66.57	1764	66.57
1_.111	211	7.96	1975	74.53
1_1.11	78	2.94	2053	77.47
1_11.1	99	3.74	2152	81.21
1_111.	132	4.98	2284	86.19
2_..11	13	0.49	2297	86.68
2_.1.1	16	0.60	2313	87.28
2_.11.	24	0.91	2337	88.19
2_1..1	38	1.43	2375	89.62
2_1.1.	19	0.72	2394	90.34
2_11..	120	4.53	2514	94.87
3_...1	7	0.26	2521	95.13
3_.1.	5	0.19	2526	95.32
3_1..	18	0.68	2544	96.00
3_1...	96	3.62	2640	99.62
4_....	10	0.38	2650	100.00
Cohort 3				
0_111	1598	79.66	1598	79.66
1_.11	37	1.84	1635	81.51
1_1.1	106	5.28	1741	86.79
1_11.	132	6.58	1873	93.37
2_..1	8	0.40	1881	93.77
2_.1.	10	0.50	1891	94.27
2_1..	107	5.33	1998	99.60
3_...	8	0.40	2006	100.00
Cohort 4				
0_11	870	84.96	870	84.96
1_.1	56	5.47	926	90.43
1_1.	87	8.50	1013	98.93
2_..	11	1.07	1024	100.00
Cohort 5				
0_1	293	98.99	293	98.99
1_.	3	1.01	296	100.00

* In the column labeled “missing pattern”, the number before the underscore denotes the number of missing data points, and the symbol “1” and “.” following the underscore denote whether data are “observed” or “missing”, respectively.

Table 2

Descriptive statistics of students' test scores at each year by the teacher credential programs using the entire sample of students

	N Obs	N	Mean	SD	Min	Max
Year 1999 (Reading SAT 9 NCE score)						
OI	5558	5153	34.89	16.96	1.0	99.0
TI : ACT	38	34	41.21	17.16	13.1	84.6
TI : Intern	89	86	24.79	14.08	1.0	71.8
TI : Traditional	630	591	31.43	16.16	1.0	89.6
TI : No Pathway Info	2067	1895	33.90	17.72	1.0	99.0
Year 2000 (Reading SAT 9 NCE score)						
OI	7528	7068	38.67	17.91	1.0	99.0
TI : ACT	63	61	33.16	18.86	1.0	79.6
TI : Intern	117	111	36.57	20.32	1.0	99.0
TI : Traditional	600	570	36.91	17.11	1.0	93.3
TI : No Pathway Info	3150	2978	37.55	17.50	1.0	99.0
Year 2001 (Reading SAT 9 NCE score)						
OI	8895	8477	42.63	18.46	1.0	99.0
TI : ACT	135	133	38.41	15.35	1.0	79.6
TI : Intern	204	196	43.02	17.49	1.0	99.0
TI : Traditional	1061	1027	42.87	18.75	1.0	99.0
TI : No Pathway Info	3539	3369	43.27	18.99	1.0	99.0
Year 2002 (Reading SAT 9 NCE score)						
OI	8681	8281	44.70	18.12	1.0	99.0
TI : ACT	165	160	48.28	17.61	1.0	93.3
TI : Intern	188	178	44.20	18.87	6.7	99.0
TI : Traditional	1352	1295	47.05	19.02	1.0	99.0
TI : No Pathway Info	4400	4163	46.68	19.27	1.0	99.0
Year 2003 (Reading CST NCE score)						
OI	10076	9908	40.32	17.99	1.0	99.0
TI : ACT	355	350	39.26	16.63	1.0	99.0
TI : Intern	189	189	37.65	18.59	1.0	99.0
TI : Traditional	1321	1317	38.80	17.84	1.0	99.0
TI : No Pathway Info	3636	3616	39.08	18.81	1.0	99.0

Table 3
The number of teachers in each year by teacher credential programs

	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Year 1999				
OI	1819	92.10	1819	92.10
TI : ACT	2	0.10	1821	92.20
TI : Intern	4	0.20	1825	92.41
TI : Traditional	32	1.62	1857	94.03
TI : No Pathway Info	118	5.97	1975	100.00
* 550 teachers out of 1,975 have more than 5 students				
Year 2000				
OI	2128	91.13	2128	91.13
TI : ACT	4	0.17	2132	91.31
TI : Intern	6	0.26	2138	91.56
TI : Traditional	33	1.41	2171	92.98
TI : No Pathway Info	164	7.02	2335	100.00
* 768 teachers out of 2,335 have more than 5 students				
Year 2001				
OI	2469	90.34	2469	90.34
TI : ACT	8	0.29	2477	90.63
TI : Intern	11	0.40	2488	91.04
TI : Traditional	54	1.98	2542	93.01
TI : No Pathway Info	191	6.99	2733	100.00
* 932 teachers out of 2,733 have more than 5 students				
Year 2002				
OI	2579	88.90	2579	88.90
TI : ACT	8	0.28	2587	89.18
TI : Intern	10	0.34	2597	89.52
TI : Traditional	71	2.45	2668	91.97
TI : No Pathway Info	233	8.03	2901	100.00
* 938 teachers out of 2,901 have more than 5 students				
Year 2003				
OI	2617	90.71	2617	90.71
TI : ACT	16	0.55	2633	91.27
TI : Intern	8	0.28	2641	91.54
TI : Traditional	65	2.25	2706	93.80
TI : No Pathway Info	179	6.20	2885	100.00
1,051 teachers out of 2,885 have more than 5 students				

Table 4
 Descriptive statistics of outcomes: by year and OI vs. TI teachers from the final sample of students

Group	Variable	N	Mean	SD	Min	Max
Year 1 (1999-2000)						
OI (N = 251)	Read99	2,089	36.04	16.94	1.0	99.0
	Read00	2,089	38.20	16.74	1.0	99.0
	Gain	2,089	2.16	10.95	-31.2	44.4
TI (N = 99)	Read99	1,646	32.35	15.77	1.0	99.0
	Read00	1,646	34.93	16.26	1.0	99.0
	Gain	1,646	2.58	10.77	-40.7	48.1
Subtotal=350		3,735				
Year 2 (2000-2001)						
OI (N = 212)	Read00	1,647	39.50	16.88	1.0	99.0
	Read01	1,647	40.48	16.33	1.0	99.0
	Gain	1,647	0.97	11.80	-46.9	55.2
TI (N = 83)	Read00	1,247	36.64	15.99	1.0	99.0
	Read01	1,247	38.06	15.64	1.0	99.0
	Gain	1,247	1.41	12.05	-51.8	59.4
Subtotal=295		2,894				
Year 3 (2001-2002)						
OI (N = 229)	Read01	1,849	41.87	16.80	1.0	99.0
	Read02	1,849	41.23	15.77	1.0	99.0
	Gain	1,849	-0.64	11.62	-37.8	46.9
TI (N = 115)	Read01	1,886	44.96	17.85	1.0	99.0
	Read02	1,886	43.97	17.05	1.0	99.0
	Gain	1,886	-0.98	11.97	-45.0	57.3
Subtotal=344		3,735				
Year 4 (2002-2003)						
OI (N = 583)	Read02	4,977	45.62	17.39	1.0	99.0
	Read03	4,977	40.00	17.20	1.0	99.0
	Gain	4,977	-5.61	13.62	-62.7	58.7
TI (N = 96)	Read02	8,69	43.94	17.17	1.0	99.0
	Read03	8,69	37.97	16.84	1.0	99.0
	Gain	8,69	-5.97	13.93	-52.5	42.7
Subtotal=679		5,846				
Total =		1,180	16,210			

Table 5
Descriptive statistics of outcomes: by year and teacher credential programs from the final student sample

Group	Variable	N	Mean	SD	Min	Max
Year 1 (1999-2000)						
OI (N = 251)	Read99	2,089	36.04	16.94	1.0	99.0
	Read00	2,089	38.20	16.74	1.0	99.0
	Gain	2,089	2.16	10.95	-31.2	44.4
TI : ACT (N = 2)	Read99	39	34.77	16.69	6.7	73.7
	Read00	39	34.61	18.17	1.0	78.2
	Gain	39	-0.16	8.93	-17.9	30.4
TI : Intern (N = 3)	Read99	46	25.98	11.36	6.7	68.5
	Read00	46	26.90	15.38	1.0	61.0
	Gain	46	0.91	9.70	-20.8	21.6
TI : Traditional (N = 13)	Read99	177	33.51	14.79	1.0	79.6
	Read00	177	35.94	15.65	1.0	71.8
	Gain	177	2.43	11.10	-29.8	42.1
TI : No Pathway Info (N = 81)	Read99	1,384	32.34	15.95	1.0	99.0
	Read00	1,384	35.08	16.25	1.0	99.0
	Gain	1,384	2.73	10.81	-40.7	48.1
Subtotal=350		3,735				
Year 2 (2000-2001)						
OI (N = 212)	Read00	1,647	39.50	16.88	1.0	99.0
	Read01	1,647	40.48	16.33	1.0	99.0
	Gain	1,647	0.97	11.80	-46.9	55.2
TI : ACT (N = 2)	Read00	27	35.26	14.14	13.1	68.5
	Read01	27	36.85	10.48	13.1	59.3
	Gain	27	1.58	12.09	-28.3	20.7
TI : Intern (N = 2)	Read00	14	30.79	22.74	1.0	71.8
	Read01	14	38.60	23.35	15.4	89.6
	Gain	14	7.80	8.68	-3.8	18.3
TI : Traditional (N = 20)	Read00	316	38.87	15.50	6.7	82.7
	Read01	316	37.70	14.31	1.0	79.6
	Gain	316	-1.16	11.00	-51.8	26.8
TI : No Pathway Info (N = 59)	Read00	890	35.98	16.03	1.0	99.0
	Read01	890	38.21	16.09	1.0	99.0
	Gain	890	2.23	12.32	-35.7	59.4
Subtotal=295		2,894				
Group	Variable	N	Mean	SD	Min	Max

Year 3 (2001-2002)						
OI (N = 229)	Read01	1,849	41.87	16.80	1.0	99.0
	Read02	1,849	41.23	15.77	1.0	99.0
	Gain	1,849	-0.64	11.62	-37.8	46.9
TI : ACT (N = 3)	Read01	54	40.99	15.13	10.4	70.9
	Read02	54	44.06	17.02	1.0	71.8
	Gain	54	3.07	10.64	-20.8	26.8
TI : Intern (N = 4)	Read01	65	47.20	18.98	10.4	99.0
	Read02	65	48.93	19.35	13.1	99.0
	Gain	65	1.72	9.36	-17.6	24.3
TI : Traditional (N = 30)	Read01	450	45.12	18.17	1.0	99.0
	Read02	450	44.20	16.91	1.0	99.0
	Gain	450	-0.91	11.33	-35.8	33.5
TI : No Pathway Info (N = 78)	Read01	1,317	44.95	17.78	1.0	99.0
	Read02	1,317	43.64	16.96	1.0	99.0
	Gain	1,317	-1.31	12.31	-45.0	57.3
Subtotal=344		3,735				
Year 4 (2002-2003)						
OI (N = 583)	Read02	4,977	45.62	17.39	1.0	99.0
	Read03	4,977	40.00	17.20	1.0	99.0
	Gain	4,977	-5.61	13.62	-62.7	58.7
TI : ACT (N = 5)	Read02	40	37.06	14.38	6.7	64.9
	Read03	40	35.30	13.43	12.0	61.0
	Gain	40	-1.76	9.81	-23.9	18.0
TI : Intern (N = 2)	Read02	16	51.01	18.48	20.4	93.3
	Read03	16	46.50	15.68	20.0	75.0
	Gain	16	-4.51	14.00	-25.7	20.6
TI : Traditional (N = 24)	Read02	241	44.29	16.13	1.0	84.6
	Read03	241	36.58	16.68	1.0	99.0
	Gain	241	-7.70	13.92	-34.8	34.3
TI : No Pathway Info (N = 65)	Read02	572	44.08	17.63	1.0	99.0
	Read03	572	38.50	17.09	1.0	99.0
	Gain	572	-5.58	14.11	-52.5	42.7
Subtotal=679		5,846				
Total = 1,180		16,210				

Table 6
 Teachers' teaching record frequency

Missing pattern*	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0_1111	24	2.03	24	2.03
1_111	28	2.37	52	4.41
1_1.11	20	1.69	72	6.10
1_11.1	15	1.27	87	7.37
1_111.	35	2.97	122	10.34
2_..11	92	7.80	214	18.14
2_1.1	27	2.29	241	20.42
2_11.	23	1.95	264	22.37
2_1..1	34	2.88	298	25.25
2_1.1.	17	1.44	315	26.69
2_11..	32	2.71	347	29.41
3_...1	441	37.37	788	66.78
3_..1.	106	8.98	894	75.76
3_1..	112	9.49	1006	85.25
3_1...	174	14.75	1180	100.00

* in the column labeled "missing pattern", the number before the underscore denotes the number of missing data points, and the symbol "1" and "." following the underscore denote whether data are "observed" or "missing", respectively.

Table 7

Descriptive statistics by school compositional index and teacher credential programs:
Year 1 (1999-2000)

Year 1	N Tch	Sch Inx	N Stu	Variable	Mean	SD	Min	Max
OI	92	high risk N=17	824	Read99	30.38	13.86	1.0	74.7
				Read00	32.36	14.78	1.0	86.9
				Gain	1.98	10.86	-31.2	36.4
	124	mid risk N=24	1,030	Read99	38.14	17.79	1.0	99.0
				Read00	40.25	16.64	1.0	99.0
				Gain	2.1	10.85	-30.7	44.4
	35	low risk N= 9	235	Read99	46.65	15.79	6.7	84.6
				Read00	49.69	15.58	13.1	99.0
				Gain	3.03	11.73	-25.3	37.8
Subtotal	251 teachers	50 schools	2,089 students					
TI : ACT	2	mid risk N= 2	39	Read99	34.77	16.69	6.7	73.7
				Read00	34.61	18.17	1.0	78.2
				Gain	-0.16	8.93	-17.9	30.4
	subtotal	2 teachers	2 schools	39 students				
TI : Intern	2	high risk N= 2	40	Read99	25.77	11.77	6.7	68.5
				Read00	25.83	15.08	1.0	61.0
				Gain	0.05	9.23	-20.8	21.6
	1	mid risk N= 1	6	Read99	27.40	8.83	13.1	35.8
				Read00	34.08	16.83	10.4	54.3
				Gain	6.68	11.67	-8.1	18.5
	subtotal	3 teachers	3 schools	46 students				
TI : Tradition	6	high risk N= 6	81	Read99	27.72	13.39	1.0	59.3
				Read00	29.08	15.02	1.0	70.1
				Gain	1.35	8.85	-24.0	22.6
	4	mid risk N= 4	56	Read99	37.27	14.04	13.1	79.6
				Read00	41.40	12.62	10.4	61.7
				Gain	4.12	13.36	-23.2	30.8
	3	low risk N= 3	40	Read99	39.96	14.47	6.7	67.7
				Read00	42.21	15.41	6.7	71.8
				Gain	2.25	11.73	-29.8	42.1
subtotal	13 teachers	13 schools	177 students					
TI : No Pathway Info	35	high risk N= 16	590	Read99	30.12	14.54	1.0	77.0
				Read00	32.97	15.36	1.0	82.7
				Gain	2.85	10.65	-40.7	36.0
	36	mid risk N= 22	607	Read99	32.87	16.26	1.0	99.0
				Read00	35.82	16.13	1.0	82.7
				Gain	2.94	11.17	-33.9	48.1
	10	low risk N= 7	187	Read99	37.66	17.77	1.0	84.6
				Read00	39.35	18.29	1.0	99.0
				Gain	1.69	10.05	-23.3	31.0
subtotal	81 teachers	45 schools	1,384 students					
total	350 teachers	76 schools	3,735 students					

Table 8
 Descriptive statistics by school compositional index and teacher credential programs:
 Year 2 (2000-2001)

Year 2	N TCH	Sch Inx	N Stu	Variable	Mean	SD	Min	Max	
OI	82	high risk N=12	680	Read00	35.08	14.44	1.0	86.9	
				Read01	35.65	14.97	1.0	89.6	
				gain	0.57	11.52	-37.7	42.7	
	95	mid risk N=16	732	Read00	40.57	17.41	1.0	99.0	
				Read01	42.19	16.15	1.0	99.0	
				gain	1.61	11.3	-29	42.8	
	35	low risk N=6	235	Read00	48.97	17.36	6.7	99.0	
				Read01	49.14	16.04	6.7	99.0	
				gain	0.17	13.88	-46.9	55.2	
Subtotal	212 teachers	34 schools	1,647 students						
TI : ACT	1	high risk N= 1	15	Read00	38.98	14.98	13.1	68.5	
				Read01	36.61	9.26	23.0	54.3	
				gain	-2.36	12.50	-28.3	13.7	
	1	mid risk N= 1	12	Read00	30.62	12.03	21.8	65.6	
				Read01	37.15	12.26	13.1	59.3	
				gain	6.52	9.94	-11.1	20.7	
	subtotal	2 teachers	2 schools	27 students					
	TI : Intern	2	mid risk N= 2	14	Read00	30.79	22.74	1.0	71.8
					Read01	38.60	23.35	15.4	89.6
gain					7.80	8.68	-3.8	18.3	
subtotal	2 teachers	2 schools	14 students						
TI : Tradition	9	high risk N=6	158	Read00	35.75	14.57	10.4	82.7	
				Read01	34.74	13.77	6.7	71.8	
				gain	-1.00	10.23	-26.3	26.8	
	8	mid risk N= 8	125	Read00	40.25	15.72	6.7	77.0	
				Read01	39.20	13.70	1.0	72.8	
				gain	-1.05	12.22	-51.8	23.4	
	3	low risk N= 2	33	Read00	48.57	14.58	10.4	74.7	
				Read01	46.23	15.13	20.4	79.6	
				gain	-2.34	9.88	-21.7	22.7	
subtotal	20 teachers	16 schools	316 students						
TI : No Pathway Info	28	high risk N=11	432	Read00	32.98	14.85	1.0	84.6	
				Read01	35.70	15.11	1.0	93.3	
				gain	2.72	12.53	-35.7	38.9	
	25	mid risk N= 13	362	Read00	36.99	15.81	1.0	99.0	
				Read01	38.23	15.23	6.7	74.7	
				gain	1.23	11.20	-34.6	38.0	
	6	low risk N = 4	96	Read00	45.65	17.74	17.3	89.6	
				Read01	49.41	18.73	10.4	99.0	
				gain	3.76	14.94	-27.3	59.4	
subtotal	59 teachers	28 schools	890 students						
total	295 teachers	76 schools	2,894 students						

Table 9
 Descriptive statistics by school compositional index and teacher credential programs:
 Year 3 (2001-2002)

Year 3	N TCH	Sch Inx	N Stu	Variable	Mean	SD	Min	Max	
OI	103 N=12	high risk	837	Read01	39.62	16.05	1.0	99.0	
				Read02	37.78	15.45	1.0	93.3	
				Gain	-1.84	12.08	-34.9	44.0	
	98 N=17	mid risk	824	Read01	42.13	16.87	6.7	99.0	
				Read02	42.55	15.2	1.0	93.3	
				Gain	0.41	11.1	-34.8	46.9	
	28 N=6	low risk	188	Read01	50.75	16.83	17.3	99.0	
				Read02	50.78	14.87	18.9	99.0	
				Gain	0.03	11.25	-37.8	25.3	
Subtotal	229	35	1,849						
TI : ACT	1 N= 1	high risk	14	Read01	34.83	16.46	10.4	62.9	
				Read02	29.50	16.77	1.0	62.9	
				Gain	-5.33	8.11	-20.8	3.8	
	2 N= 2	mid risk	40	Read01	43.14	14.22	10.4	70.9	
				Read02	49.16	14.04	18.9	71.8	
				Gain	6.01	9.89	-14.0	26.8	
subtotal	3	3	54						
TI : Intern	1 N= 1	high risk	18	Read01	44.38	12.33	18.9	65.6	
				Read02	44.47	14.17	13.1	64.2	
				Gain	0.09	8.33	-17.6	14.7	
	3 N= 3	mid risk	47	Read01	48.29	21.00	10.4	99.0	
				Read02	50.63	20.88	13.1	99.0	
				Gain	2.34	9.74	-14.4	24.3	
subtotal	4	4	65						
TI : Tradition	12 N= 8	high risk	168	Read01	41.01	19.02	1.0	93.3	
				Read02	39.31	16.20	1.0	82.7	
				Gain	-1.69	11.70	-35.8	28.1	
	12 N= 10	mid risk	183	Read01	43.74	16.80	10.4	99.0	
				Read02	44.63	17.30	6.7	89.6	
				Gain	0.88	11.45	-27.8	33.5	
	6 N= 4	low risk	99	Read01	54.63	15.77	6.7	89.6	
				Read02	51.71	14.43	13.1	99.0	
				Gain	-2.92	10.02	-22.9	22.2	
subtotal	30	22	450						
TI : No Pathway Info	31 N= 11	high risk	473	Read01	39.74	15.77	1.0	82.7	
				Read02	38.54	14.69	1.0	79.6	
				Gain	-1.20	12.50	-35.9	57.3	
	35 N= 16	mid risk	637	Read01	46.04	17.78	1.0	99.0	
				Read02	44.80	16.99	6.7	99.0	
				Gain	-1.24	11.93	-37.4	45.3	
	12 N= 8	low risk	207	Read01	53.52	18.27	6.7	99.0	
				Read02	51.77	17.94	1.0	99.0	
				Gain	-1.75	13.06	-45.0	39.6	
	subtotal	78 teachers	35 schools	1,317 students					
	total	344 teachers	76 schools	3,735 students					

Table 10
 Descriptive statistics by school compositional index and teacher credential programs:
 Year 4 (2002-2003)

Year 4	N TCH	Sch Inx	N Stu	Variable	Mean	SD	Min	Max
OI	201 N=16	high risk	1780	Read02	40.49	16.04	1.0	99.0
				Read03	36.15	15.81	1.0	99.0
				gain	-4.33	13.54	-51.6	58.7
	282 N=36	mid risk	2387	Read02	46.42	17.15	1.0	99.0
				Read03	39.92	16.7	1.0	99.0
				gain	-6.5	13.59	-62.7	50.1
	100 N=16	low risk	810	Read02	54.55	16.96	1.0	99.0
				Read03	48.72	18.39	1.0	99.0
				gain	-5.83	13.68	-50.8	44.3
Subtotal	583 students	76 schools	4,977 students					
TI : ACT	1 N= 1	high risk	6	Read02	37.95	17.56	6.7	57.0
				Read03	39.50	15.46	12.0	54.0
				gain	1.55	6.90	-9.0	11.0
	3 N= 3	mid risk	23	Read02	35.43	15.48	10.4	64.9
				Read03	33.56	14.89	13.0	61.0
				gain	-1.86	10.70	-23.9	18.0
	1 N= 1	low risk	11	Read02	39.98	10.47	15.4	55.9
				Read03	36.63	8.76	26.0	51.0
				gain	-3.34	9.52	-18.1	11.6
subtotal	5	5 Schs	40					
TI : Intern	1 N= 1	mid risk	9	Read02	50.78	23.98	20.4	93.3
				Read03	50.33	19.37	20.0	75.0
				gain	-0.45	14.96	-25.3	20.6
	1 N= 1	low risk	7	Read02	51.30	9.33	41.9	64.2
				Read03	41.57	7.97	33.0	52.0
				gain	-9.72	11.62	-25.7	10.1
subtotal	2	2 Schs	16					
TI : Tradition	10 N= 7	high risk	110	Read02	42.06	16.79	1.0	84.6
				Read03	37.11	16.61	1.0	99.0
				gain	-4.94	12.95	-34.6	34.3
	9 N= 8	mid risk	93	Read02	46.19	16.06	6.7	84.6
				Read03	35.70	16.89	1.0	68.0
				gain	10.48	14.89	-34.8	29.7
	5 N= 3	low risk	38	Read02	46.10	13.73	27.2	71.8
				Read03	37.21	16.73	1.0	69.0
				gain	-8.89	12.97	-34.8	21.1
subtotal	34	18	241					
TI : No Pathway Info	25 N= 13	high risk	241	Read02	40.34	16.32	1.0	89.6
				Read03	35.96	14.64	1.0	97.0
				gain	-4.38	13.59	-42.0	42.7
	29 N= 19	mid risk	247	Read02	44.64	17.32	6.7	93.3
				Read03	37.37	17.38	1.0	86.0
				gain	-7.26	15.08	-52.5	35.8
	11 N= 11	low risk	84	Read02	53.15	18.84	6.7	99.0
				Read03	49.08	18.92	2.0	99.0
				gain	-4.07	12.13	-29.9	32.3
subtotal	65	43	572					
total	679 teachers	76 schools	5,846 students					

Table 11

Results from teacher effect change model 1: OI vs. TI teachers

	Estimate	SE	95% interval	median
Fixed effect:				
1. Teachers' initial status (I.S.):				
In '00 (γ_{0000})	34.490	0.561	(33.400, 35.610)	34.490
Diff. OI vs. TI (γ_{0001})	-3.768	1.112	(-5.939, -1.559)	-3.778
Change in '00-'02 (θ_{0010})	3.784	0.442	(2.911, 4.630)	3.792
Change in '00-'02: TI vs. OI (θ_{0011})	2.892	0.779	(1.375, 4.449)	2.889
Change in '02-'03 (θ_{0020})	3.353	0.735	(1.927, 4.867)	3.338
Change in '02-'03: TI vs. OI (θ_{0021})	-3.632	1.532	(-6.709, -0.665)	-3.614
2. Teacher effect:				
In '00 (γ_{100})	2.249	0.273	(1.708, 2.784)	2.247
Change in '00-'02 (κ_{10100})	-0.309	0.313	(-0.925, 0.303)	-0.309
Change in '00-'02: TI vs. OI (θ_{1011})	0.038	0.317	(-0.581, 0.652)	0.038
Change in '02-'03 (κ_{10200})	-3.779	0.554	(-4.890, -2.713)	-3.773
Change in '02-'03: TI vs. OI (θ_{1021})	-0.313	0.929	(-2.216, 1.463)	-0.297
3. Gap parameter:				
In '00 (Bw_0)	-0.191	0.012	(-0.214, -0.168)	-0.191
Change in '00-'02 (Bw_{10})	-0.027	0.011	(-0.050, -0.005)	-0.027
Change in '00-'02: TI vs. OI (Bw_{11})	-0.013	0.012	(-0.036, 0.010)	-0.013
Change in '02-'03 (Bw_{20})	-0.081	0.020	(-0.120, -0.039)	-0.082
Change in '02-'03: TI vs. OI (Bw_{21})	-0.016	0.038	(-0.090, 0.058)	-0.016
4. Relation: Teachers' I.S and Teacher effects (Bc_1)				
	-0.028	0.022	(-0.070, 0.015)	-0.028
5. Relation: Teachers' I.S and Gap parameter (Bc_2)				
	0.000	0.001	(-0.002, 0.001)	0.000
6. School Characteristics Index effects on:				
Change in Teacher effect ('00-'02) (κ_{10101})	0.118	0.037	(0.046, 0.191)	0.118
Change in Teacher effect ('02-'03) (κ_{10201})	-0.124	0.079	(-0.277, 0.032)	-0.124
Change in Gap parameter ('00-'02) (Bw_{101})	0.000	0.001	(-0.003, 0.002)	0.000
Change in Gap parameter ('02-'03) (Bw_{201})	0.003	0.003	(-0.002, 0.009)	0.003
Variance Components:				
1. Level-3 (between-year & within teacher) Var.				
Teachers' I.S. ($\tau_{\beta 00}$)	32.360	4.230	(24.420, 41.150)	32.180
Teacher effect ($\tau_{\beta 10}$)	8.093	1.151	(5.983, 10.480)	8.053
Gap parameter (τ_{Bw})	0.002	0.001	(0.001, 0.003)	0.001
$Cov(U_{\beta 10jkl}, U_{Bwjkl})$	0.008	0.028	(-0.050, 0.060)	0.009
2. Level-4 (between-teacher & within-school) Var.				
Status in '00 ($\tau_{\gamma 000}$)	48.770	5.937	(37.430, 60.620)	48.680
Change in Teachers' I.S ('00-'02) ($\tau_{\gamma 001}$)	7.001	1.889	(3.855, 11.280)	6.797
Change in Teachers' I.S ('02-'03) ($\tau_{\gamma 002}$)	8.215	5.170	(2.226, 21.750)	6.864
Change in Teacher effect ('00-'02) ($\tau_{\gamma 101}$)	3.198	0.768	(1.850, 4.856)	3.148
Change in Teacher effect ('02-'03) ($\tau_{\gamma 102}$)	5.724	2.553	(1.983, 11.710)	5.307
Change in Gap par. ('00-'02) (τ_{Bw1})	0.001	0.000	(0.001, 0.002)	0.001
Change in Gap par. ('02-'03) (τ_{Bw2})	0.002	0.001	(0.000, 0.005)	0.001
3. Level-5 (between-school) Var.				
Teacher effect growth ('00-'02) ($\tau_{\theta 1010}$)	1.239	0.419	(0.641, 2.252)	1.165
Teacher effect growth ('02-'03) ($\tau_{\theta 1020}$)	3.757	1.702	(1.519, 7.984)	3.397
Change in gap parameter ('00-'02) (τ_{Bw1})	0.001	0.000	(0.000, 0.001)	0.001
Change in gap parameter ('02-'03) (τ_{Bw2})	0.002	0.002	(0.000, 0.006)	0.001

Table 12

Results from teacher effect change model 2: OI vs. TI Pathway

	Estimate	SE	95% interval	median
Fixed effect:				
1. Teachers' initial status (I.S.):				
Status In '00 (γ_{000})	34.080	0.488	(33.13, 35.05)	34.080
Diff. OI vs. ACT (θ_{0001})	-3.228	6.078	(-15.090, 8.702)	-3.221
Diff. OI vs. Intern (θ_{0002})	-9.795	5.489	(-20.470, 1.007)	-9.795
Diff. OI vs. Tradition (θ_{0003})	-0.781	2.455	(-5.560, 4.079)	-0.798
Diff. OI vs. TI (θ_{0004})	-3.337	1.229	(-5.744, -0.946)	-3.337
Change in '00-'02 (θ_{001})	3.902	0.430	(3.054, 4.743)	3.902
Diff. OI vs. ACT (θ_{0011})	-0.981	3.587	(-8.119, 5.854)	-0.981
Diff. OI vs. Intern (θ_{0012})	5.647	3.437	(-0.978, 12.560)	5.647
Diff. OI vs. Tradition (θ_{0013})	1.879	1.523	(-1.077, 4.864)	1.879
Diff. OI vs. TI (θ_{0014})	2.825	0.858	(1.141, 4.522)	2.825
Change in '02-'03 (θ_{002})	3.315	0.706	(1.917, 4.649)	3.315
Diff. OI vs. ACT (θ_{0021})	-2.060	7.381	(-16.710, 12.280)	-2.060
Diff. OI vs. Intern (θ_{0022})	-3.225	9.729	(-22.340, 16.160)	-3.225
Diff. OI vs. Tradition (θ_{0023})	-2.816	2.688	(-8.071, 2.406)	-2.816
Diff. OI vs. TI (θ_{0024})	-3.434	1.734	(-6.822, -0.016)	-3.434
2. Teacher effect:				
In '00 (γ_{100})	2.283	0.283	(1.722, 2.833)	2.283
Change in '00-'02 (κ_{10100})	-0.300	0.308	(-0.893, 0.309)	-0.300
Diff. OI vs. ACT (θ_{1011})	1.315	1.619	(-1.852, 4.463)	1.315
Diff. OI vs. Intern (θ_{1012})	1.005	1.398	(-1.759, 3.733)	1.005
Diff. OI vs. Tradition (θ_{1013})	0.086	0.562	(-1.031, 1.188)	0.086
Diff. OI vs. TI (θ_{1014})	-0.032	0.371	(-0.761, 0.695)	-0.032
Change in '02-'03 (κ_{10200})	-3.790	0.553	(-4.879, -2.700)	-3.790
Diff. OI vs. ACT (θ_{1021})	-0.960	4.309	(-9.575, 7.338)	-0.960
Diff. OI vs. Intern (θ_{1022})	-0.009	7.800	(-17.160, 13.880)	-0.009
Diff. OI vs. Tradition (θ_{1023})	-1.585	1.799	(-5.015, 1.953)	-1.585
Diff. OI vs. TI (θ_{1024})	0.170	1.117	(-1.997, 2.333)	0.170
3. Gap parameter:				
In '00 (Bw_0)	-0.222	0.011	(-0.244, -0.201)	-0.222
Change in '00-'02 (Bw_{100})	-0.028	0.012	(-0.048, -0.003)	-0.028
Diff. OI vs. ACT (Bw_{11})	0.023	0.056	(-0.091, 0.128)	0.023
Diff. OI vs. Intern (Bw_{12})	0.075	0.045	(-0.013, 0.161)	0.075
Diff. OI vs. Tradition (Bw_{13})	-0.017	0.021	(-0.058, 0.025)	-0.017
Diff. OI vs. TI (Bw_{14})	-0.017	0.014	(-0.044, 0.010)	-0.017
Change in '02-'03 (Bw_{200})	-0.078	0.023	(-0.124, -0.034)	-0.078
Diff. OI vs. ACT (Bw_{21})	-0.054	0.185	(-0.392, 0.314)	-0.054
Diff. OI vs. Intern (Bw_{22})	-0.285	0.315	(-0.915, 0.357)	-0.285
Diff. OI vs. Tradition (Bw_{23})	-0.024	0.086	(-0.194, 0.138)	-0.024
Diff. OI vs. TI (Bw_{24})	0.010	0.049	(-0.087, 0.104)	0.010
4. Relation: Teachers' I.S and Teacher effects (Bc_1)				
	-0.028	0.021	(-0.068, 0.014)	-0.028
5. Relation: Teachers' I.S and Gap parameter (Bc_2)				
	0.000	0.001	(-0.002, 0.002)	0.000
6. School Characteristics Index effects on:				
Change in Teacher effect ('00-'02) (κ_{10101})	0.121	0.036	(0.050, 0.192)	0.121
Change in Teacher effect ('02-'03) (κ_{10201})	-0.139	0.081	(-0.297, 0.017)	-0.139
Change in Gap parameter ('00-'02) (Bw_{101})	0.000	0.001	(-0.002, 0.002)	0.000

Change in Gap parameter ('02-'03) (B_{W201})	0.003	0.003	(-0.001 ,0.008)	0.003
Variance Components:				
1. Level-3 (between-year & within teacher) Var.				
Teachers' I.S. ($\tau_{\beta00}$)	32.320	4.230	(24.460 ,41.060)	32.320
Teacher effect ($\tau_{\beta10}$)	8.082	1.161	(5.905 ,10.470)	8.082
Gap parameter (τ_{Bw})	0.002	0.001	(0.000 ,0.004)	0.002
$Cov(U_{\beta10jkl}, U_{Bwjkl})$	0.008	0.027	(-0.046 ,0.059)	-0.008
2. Level-4 (between-teacher & within-school) Var.				
Status in '00 ($\tau_{\gamma000}$)	49.550	6.084	(37.940 ,61.740)	49.550
Change in Teachers' I.S ('00-'02) ($\tau_{\gamma001}$)	6.893	1.942	(3.576 ,11.150)	6.893
Change in Teachers' I.S.('02-'03) ($\tau_{\gamma002}$)	8.262	5.460	(2.258 ,22.700)	8.262
$Cov(V_{001kl}, V_{002kl})$	-1.848	2.380	(-7.664 ,1.629)	-1.848
Change in Teacher effect ('00-'02) ($\tau_{\gamma101}$)	3.363	0.781	(1.974 ,5.006)	3.363
Change in Teacher effect ('02-'03) ($\tau_{\gamma102}$)	6.493	2.846	(2.265 ,13.110)	6.493
Change in Gap par. ('00-'02) (τ_{Bw1})	0.001	0.000	(0.001 ,0.002)	0.001
Change in Gap par. ('02-'03) (τ_{Bw2})	0.002	0.002	(0.000 ,0.008)	0.002
3. Level-5 (between-school) Var.				
Teacher effect growth ('00-'02) ($\tau_{\theta1010}$)	1.255	0.425	(0.643 ,2.277)	1.255
Teacher effect growth ('02-'03) ($\tau_{\theta1020}$)	3.728	1.691	(1.499 ,8.045)	3.728
Change in gap parameter ('00-'02) (τ_{Bw1})	0.001	0.000	(0.000 ,0.001)	0.001
Change in gap parameter ('02-'03) (τ_{Bw2})	0.001	0.001	(0.000 ,0.004)	0.001

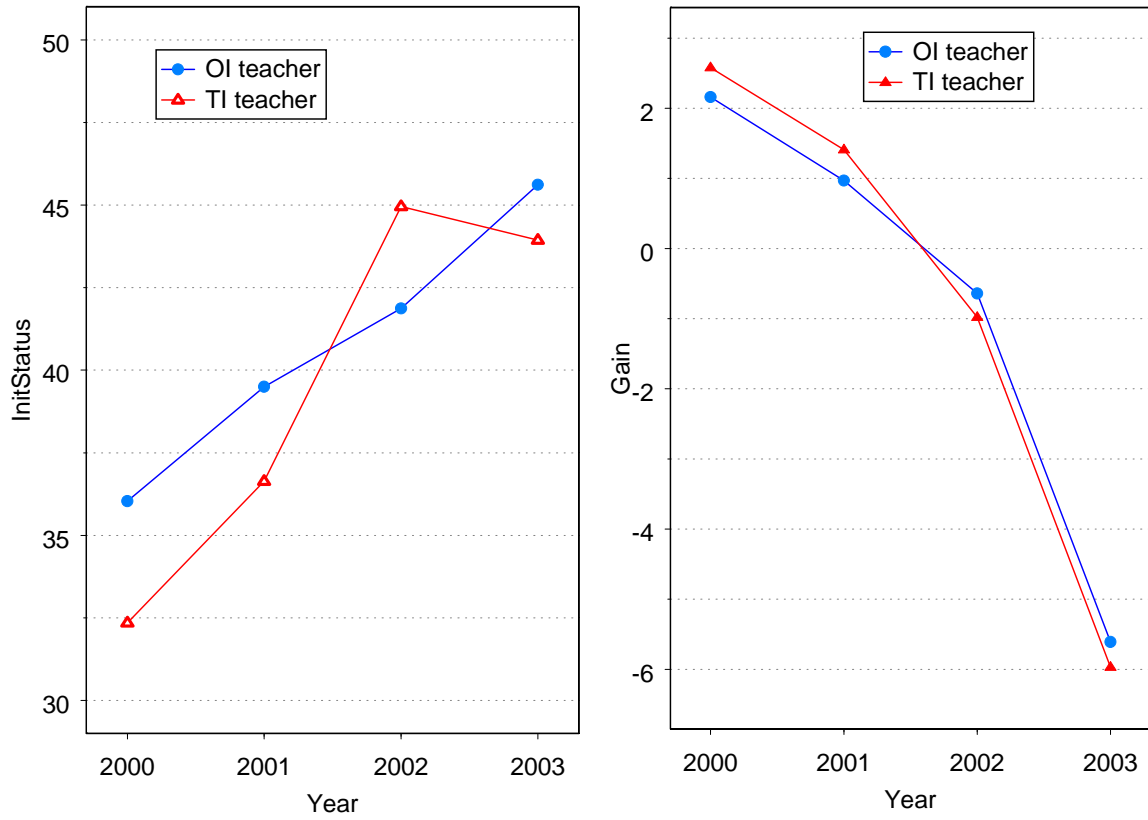


Figure 1. Average test scores in the previous years and average gains in each year: TI vs. OI teacher.

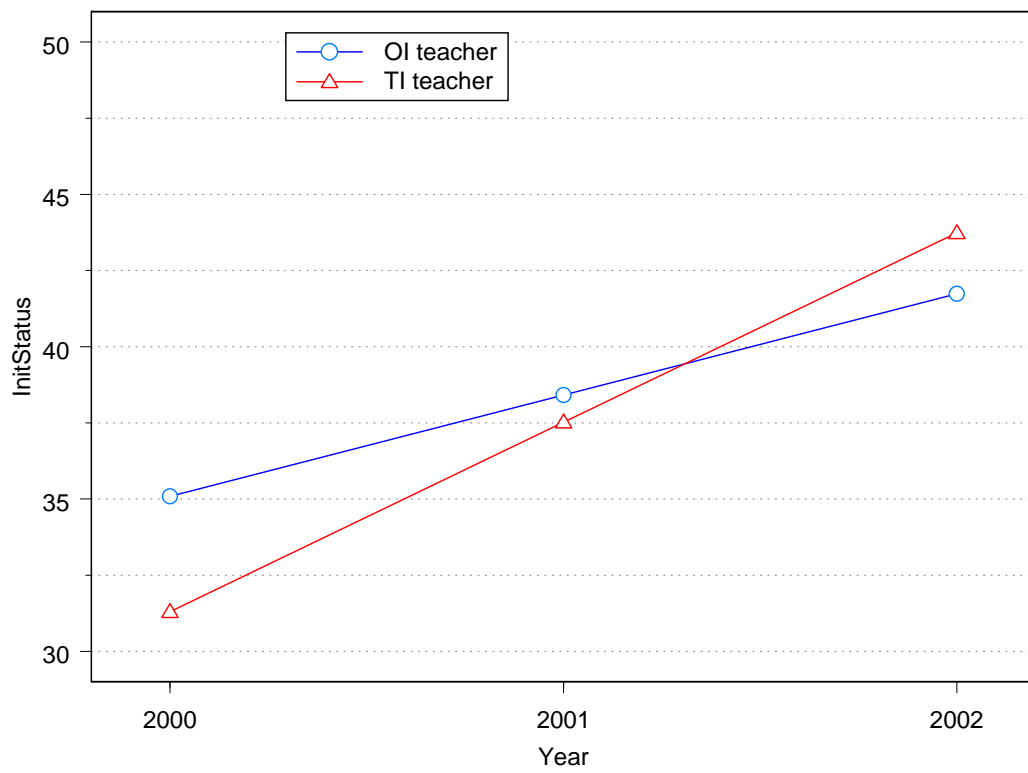


Figure 2. Fitted trajectories of teachers' initial status: TI vs. OI teachers (Results from Model 1).

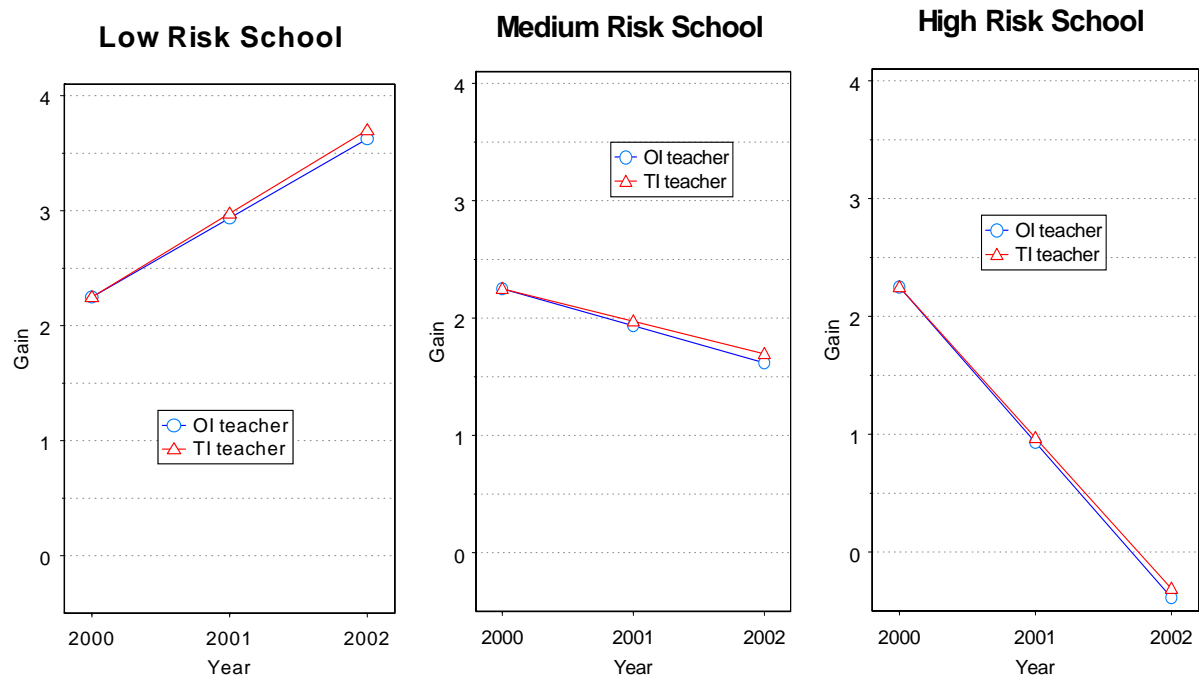


Figure 3. Fitted trajectories of teacher effects: TI vs. OI teachers in low, medium, and high risk schools (Results from Model 1).

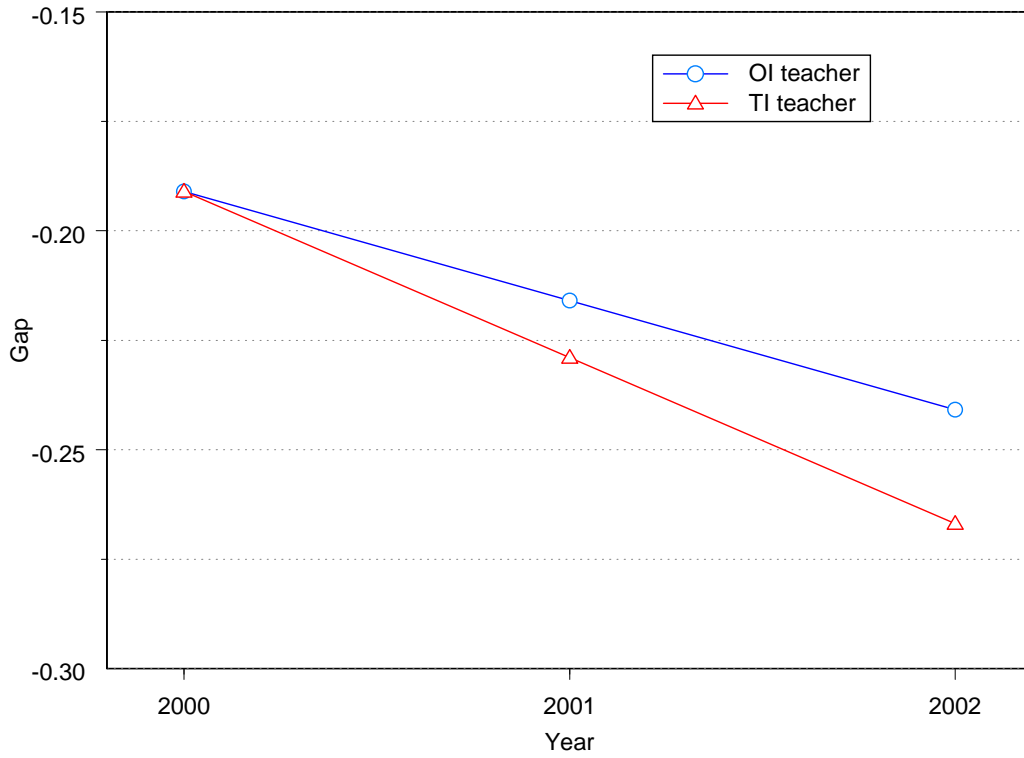


Figure 4. Fitted trajectories of Gap parameter: TI vs. OI teachers (Results from Model 1).