Within-School Teacher Quality: A Dynamic Model of Teacher Mobility

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Abstract

The allocation of quality teachers across schools is of interest because of both the importance and costliness of teachers as inputs in the education production process. This paper examines teacher mobility within the teaching profession utilizing a dynamic framework. Using longitudinal data on public schools in North Carolina, I jointly estimate teacher mobility outcomes with several endogenous teacher credential outcomes. The joint estimation uses a discrete factor random effects method to control for both individual permanent and time-varying unobserved heterogeneity. Preliminary results show that increasing the proportion of black students by 25 percentage points decreases the probability of a teacher staying at her current school by up to 2 percentage points. The results also show that teachers early in their career are more sensitive to changes in student characteristics and salary than more experienced teachers. The effect of changes in salary appear to be lower than the effect of changes in student demographics.

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1 Introduction

The effect of school resources on human capital accumulation is a topic that has been intensely studied over the past several decades across different disciplines. While research has shown that formal schooling is only one component of a complex production process that involves own ability, family, and peers, it is arguably the one most directly affected by government legislation and public funding. During the 2008 fiscal year average state spending on primary and secondary education comprised 23.6% of total state direct general expenditures.[1] Over the past 50 years, national real spending on public education has increased by an average of 7% annually.

Educational instruction is the most costly school resource by a large margin. In 2008 teacher salaries and benefits exceeded 55% of all public school expenditures.[2] Given the costliness of this resource, it is no surprise that teacher quality and its effect on the academic outcomes of students is of interest to school administrators, parents, taxpayers, and policy-makers. Beginning with the 1966 "Coleman Report", numerous studies have attempted to quantify the effect of school resources, with special attention to that of teacher quality. Although this literature is divided over which observable characteristics embody teacher quality, there is a consensus among recent studies that teacher quality is the most important resource used by public schools (Ehrenberg and Brewer, 1994; Hanushek, 1986; Rockoff, 2004).

Much of the current literature treats teacher quality as an exogenous, or randomly determined, characteristic within a school. However, unlike most other school resources, teachers have preferences over characteristics of their place of employment, hence the composition of teachers, and thus teacher quality, is not random across schools. Several studies show that teachers self-select across schools, oftentimes with more highly qualified teachers working at schools with better resources, lower poverty rates, and fewer minority students (Clotfelter, Ladd, and Vigdor, 2005; Lankford, Loeb, and Wyckoff, 2002). Studies that ignore this non-random sorting of teachers produce biased estimates of the effect of teacher quality on student achievement outcomes.

In this paper I examine the determinants of teacher mobility and its effect on observable teacher quality composition within a school. Specifically this study focuses on the student, school, and district characteristics that influence teacher movements between schools and school districts and, given these movements, the proportion of teachers with specific credentials within a school. This research adds to the current literature in two ways. First, I use a dynamic framework to jointly estimate the teacher mobility outcome along with

[1] National Center for Education Statistics: Digest of Education Statistics: 2010, Table 31

[2] National Center for Education Statistics: Digest of Education Statistics: 2010, Table A-26-2.

two endogenous teacher credential outcomes. These credentials, often associated with teacher quality, include outcomes for obtaining an advanced degree and becoming certified by the National Board for Professional Teaching Standards (NBPTS). Several studies in the literature have focused on these credentials as signals of, or contributions to, teacher quality. Because unobserved teacher characteristics may influence the decision to seek credentials, as well as affect school selection, recovery of unbiased effects requires joint estimation of these outcomes. In order to reduce possible bias due to unobserved characteristics in the joint estimation, I use a discrete factor random effects method that accounts for both individual (teacher) permanent and time-varying unobserved heterogeneity.

Second, the data I use are longitudinal administrative data on the North Carolina public school system which include unique information on the non-pecuniary benefits of teaching at a particular school. The existing literature in this area often uses student characteristics such as race and poverty level to proxy for poor working conditions. The data I use are supplemented with a working conditions survey administered to teachers. The survey contains teacher responses regarding topics such as school safety, administration relationships, and professional development opportunities. The inclusion of these data help mitigate the potential bias due to unobserved variables that are correlated with student race and poverty characteristics.

Preliminary results show that increasing the proportion of black students by 25 percentage points decreases the probability of a teacher staying at her current school by up to 2 percentage points. The results also show that teacher early in their career are more sensitive to changes in student characteristics and salary than more experience teachers.

2 Relevant Literature

There are two areas of the education economics literature that relate to my research. The first area covers teacher mobility. This literature examines the determinants of teacher movement into the profession, between schools, and attrition from teaching. The second area is teacher quality, which is concerned with identifying the characteristics that define or affect teacher quality, and the effect of these characteristics on student achievement.

2.1 Teacher Mobility

2.1.1 Teacher Attrition

Several studies focus on the retention of teachers in the teaching profession. Ingersoll and Smith (2003) argue that retaining quality teachers is a much more difficult task than recruiting new teachers. Stinebrickner (2001) uses the NLS-72 to estimate a structural dynamic discrete choice model of attrition from the teaching profession. He finds that changes in family characteristics such as marital status and number of children are the most important predictors of attrition. In addition, he finds that attrition is responsive to wage increases, and that teachers with better academic traits obtain higher wages in alternative professions. Using the same data and a competing risks duration specification, Stinebrickner (2002) again finds that attrition is highly correlated with changes in family structure. He also notes that exit rates out of the teaching profession are lower than those of non-teachers' first job. Exit rates out of the labor force entirely are similar for teachers and non-teachers. Using the NLS-72, van der Klaauw (1999) also finds salaries and alternative wages influence teacher retention rates. Dolton and van der Klaauw (1999) use a sample of UK university graduates to examine teacher career decisions for the first six years of their career. Using a competing risks model they find that a 10 percent increase in teacher salaries will increase the percentage of these teachers still in the profession by 5 percentage points.

2.1.2 Mobility within the Profession

Greenberg and McCall (1974), in one of the earliest economic studies to examine teacher mobility between schools, analyze the one-year (1971-1972) transition of teachers within the San Diego school system. Using an OLS linear probability model, they estimate the probability of a teacher leaving her current school. The probability of a teacher transferring from a school with below-average socio-economic status (SES) was approximately twice the probability of transferring from a school with average SES. They find that more experienced and more educated teachers tend to leave schools with low SES characteristics. Teachers moving between schools tend to move to schools with higher SES characteristics.

Lankford, Loeb, and Wyckoff (2002), Boyd, Lankford, Loeb, and Wyckoff (2005) and Boyd, Lankford, Loeb, and Wyckoff (2003) examine teacher sorting using administrative data from the state of New York. In their descriptive study, Lankford, Loeb, and Wyckoff (2002) summarize the variation in teacher characteristics across schools and regions from 1985-2000. They show that differences in teacher qualifications are most prominent at the school level rather than at the regional level. Among teachers who transition between schools after 1992, they find that the proportion of minority and poor students at the departing school is between 75 and 100 percent greater than that of the arrival school. They also find that, on average, teachers who move to a new school have a higher quality skill set than those who stay. Boyd, Lankford, Loeb, and Wyckoff (2005) use the same data to investigate teacher preferences over region. They observe that between the years 1999 - 2002 61 percent of teachers accepted their first teaching assignment within 15 miles of where they attended high school, and 85 percent within 40 miles. In addition, they found that teachers were likely to accept jobs in towns with characteristics similar to their hometown.

Boyd, Lankford, Loeb, and Wyckoff (2003) employ a two-sided matching model of teachers and schools using the initial assignments of teachers in five New York metropolitan areas. They find that teachers with higher qualifications are more likely to be matched with higher wages and schools with fewer minorities. Their model predicts that an increase in teacher salary of 1.3 standard deviations would be needed to offset the decrease in utility from a 0.46 standard deviation increase in minority students.

Using Texas administrative data on elementary school teachers, Hanushek, Kain, and Rivkin (2004) examine the probabilities of teachers moving within or outside of their current school district. They find that in order to keep a non-minority teacher from leaving, a 10 percent increase in minority students would require a 10 percent increase in salary. On average, a 10 percent increase in salary reduced the probability of leaving by approximately 3 percentage points for teachers with five or fewer years of experience. They also find that salary has a larger influence on switching within Texas schools than it does on leaving Texas schools.

In a similar study, Scafidi, Sjoquist, and Stinebrickner (2007) examine teachers in Georgia public elementary schools. Focusing on new teachers, they estimate a competing risks model with the options of switching schools/districts, taking an administrative job, taking a job within Georgia outside the public schools system, or leaving the Georgia labor force. They find that increasing the proportion of black students by one standard deviation increases the probability of a teacher leaving by 6.5 percentage points. They also find that black teachers are less likely to leave schools with a high proportion of minority students than white teachers. Furthermore, they find only a weak correlation between salary and the probability of leaving a school, contrasting the results of previous studies.

Jackson (2009) estimates the effect of changes in student demographics on the composition of teacher characteristics of a school using a natural experiment in one school district in North Carolina. In 2002, Charlotte-Mecklenburg schools ended their integration-based busing policy, leading to an immediate change in student demographics within each school. He uses a difference-in-differences technique along with similar school districts to uncover the causal effect of these changes on teacher composition. He finds that a 10 percentage point increase in black students results in a decrease in the average experience level of teachers of 0.8 years. He also finds that schools with a higher proportion of black students did not have higher teacher turnover, but did face teachers with lower quality measures.

2.2 Teacher Quality

One of the most often cited results of James Coleman's "Equality of Educational Opportunity" is that peer and family characteristics are far more important than school resources. The complexity of human capital accumulation combined with the lack of comprehensive data make valid estimation of each component's effect difficult (Todd and Wolpin, 2003). In light of this complexity, measuring the effect of teacher quality has led to a variety of conclusions in the literature. While the modern literature disagrees on which observable characteristics signify teacher quality, they do overwhelming agree that teacher quality is the most important school resource in predicting student outcomes. Hanushek (1986) articulates the inconclusive results of this literature when he writes that it is "difficult if not impossible to specify a few objective or subjective characteristics of teachers that capture the systematic differences of both backgrounds of teachers and their idiosyncratic choices of teaching styles and methods."

There are severable observable teacher characteristics that have been associated with teacher quality in the literature. These characteristics usually fall under the categories of pre-teaching human capital (quality of undergraduate institution, major, GPA, test scores) and human capital measures obtainable while teaching (experience, master's degree, nation board certification, licensure).

Summers and Wolfe (1977) examine a 1970-1971 randomly selected sample of schools and students from the Philadelphia Public School District. They find a positive correlation between the selectivity of a teacher's undergraduate institution and student achievement. Ehrenberg and Brewer (1994) also come to this conclusion using data from the 1980 *High School and Beyond* survey. Ferguson and Ladd (1996) examine the effect of teacher quality at both the student and aggregate school level. They use Alabama fourth grade students in the 1991 academic year. They find that a one standard deviation in teacher test scores increases student test scores by 0.1 standard deviations. Their results also show a one standard deviation increase in the percent of teachers with a masters degree increases student test scores by 0.026 standard deviations. They did not find a significant effect of experience on student test scores. Goldhaber and Brewer (1997) also find a positive relationship between teachers with a masters' degree in math and student math achievement. Kukla-Acevedo (2009) uses Kentucky data to analyze the effects of teacher preparation on student outcomes. She finds the teachers' undergraduate GPA is a significant predictor of student math scores, with a one standard deviation increase in math GPA resulting in a 0.385 standard deviation increase in math scores for minority students.

Several studies provide evidence of a positive correlation between teachers accredited with the National Board for Professional Teaching Standards (NBPTS) and student achievement. Goldhaber and Anthony (2007) examine data on NBPTS applicants in North Carolina from 1997 to 2000. They find that while the NBPTS accreditation process does not necessarily result in improved teacher quality, the process does successfully identify applicants who are higher quality teachers. Successful applicants to the process are shown to have a larger influence on student achievement than unsuccessful applicants. Using administrative data on a Florida school district, Cavalluzzo (2004) also found support for NBPTS certification as a signal of teaching quality. Vandevoort, Amrein-Beardsley, and Berliner (2004) find similar results, although their sample consists of Arizona teachers, of which only 35 were NBPTS certified.

The most common teacher characteristic found to be significant in the literature is teaching experience (Aaronson, Barrow, and Sander, 2007; Ballou and Podgursky, 1997; Kane, Rockoff, and Staiger, 2008; Loeb and Page, 2000; Rivkin, Hanushek, and Kain, 2005; Rockoff, 2004). Both Rivkin, Hanushek, and Kain (2005) and Rockoff (2004) find that the first few years of teaching experience have a significant effect on student achievement, with the positive effect diminishing as experience increases.

Several studies conclude that observable teacher characteristics other than experience are not correlated with student achievement. Aaronson, Barrow, and Sander (2007) estimate several value-added models using cross-sectional data from the Chicago Public School system. They find only a weak correlation between teacher observable characteristics such as an advanced degree and teaching certification with student achievement. Rivkin, Hanushek, and Kain (2005) find similar results using Texas administrative data. They find no significant correlation between a teacher's education credentials. They find a positive correlation between teaching experience and student achievement, with a larger effect during the first two years of teaching.

The effect of school resources on student achievement varies substantially across different data and methods. One noticeable difference is between studies using student-level data and studies aggregating at the school, district, or even state level. Studies that have used aggregate data tend to find more positive significant correlations between school resources and student achievement (Card and Krueger, 1992). These correlations tend to be larger than those found in studies using student level data. Loeb and Bound (1996) and Card and Krueger (1992) argue that aggregation can reduce measurement error commonly associated with test score data. Loeb and Bound (1996) also note that aggregation at the school level better accounts for the entirety of school resources over a students education. Aggregation may also help to mitigate endogenous sorting of resources between classrooms. If there are omitted variables at the level of aggregation, such as differences in state policies, aggregation can increase omitted-variable bias (Hanushek, Rivkin, and Taylor, 1996). Aggregation is likely to lead to greater bias in estimated marginal effects of inputs if those inputs are endogenous. For example, average teacher quality at a school is likely correlated with unobserved teacher preferences. None of these papers attempting to measure the effects take into account the endogeneity of teacher location.

3 Theoretical Motivation

3.1 Teacher Decisions

The theoretical framework described in this section provides the motivation for the empirical model to follow. This framework provides a description of the relationship and timing of teacher movements between schools as well as the teacher credential decisions. These credential decisions are important to model because teachers with a desire to move to a high quality school may also be more motivated to improve their credentials. In labor economic theory employee credentials such as degrees and certifications are observable traits that signal productivity to potential employers. In the labor market for teachers these credentials may serve as observable signals of teaching quality. Subsequently, teachers with a better portfolio of credentials may have greater access to better schools.

The literature identifies several teacher characteristics that are associated with teacher quality. Three of these characteristics are included in this model: education, NBPTS certification, and teaching experience. In each period teachers can become credentialed in the following areas: complete a master's degree (q_{1it}), and/or become NBPTS certified (q_{2it}). These credential decisions define the teacher's observed set of credentials: degreed (Q_{1it}) and national board certified (Q_{2it}) entering each period t.[3] The individual's teaching experience (Q_{3it}) entering period t is defined as the number of completed years taught.[4]

Consistent with labor economics theory, the representative teacher receives utility from both the pecuniary and non-pecuniary benefits of a teaching position. In this model teacher i derives utility in period t

[3]These stock variables are binary variables updated the year the credential is obtained and remain at that value for the duration of a teacher's career. For example $Q_{1it} = 1$ if the teacher obtained a master's degree in any previous period.

[4]Due to the nature of administrative data I have limited information on the timing of credential decisions. Because of this limitation I am unable to observe and model the length of time required to obtain teacher credentials. I am only able to observe the outcome of the decision. For example, I am unable to observe the accumulation of credits needed to obtain a master's degree or when the decision was made to begin a master's degree program. I only observe the successful outcome of the decision, which is the date the degree was completed. Similarly, I am unable to observe schools to which a teacher applies, job offers, or application rejections. I am only able to observe the outcome if a teacher does decide to move to another school.

from consumption (c_{it}), and leisure (ℓ_{it}), as well as the school characteristics (S_{it}) at the school she is employed. The contemporaneous utility is affected by preference shifters of observed exogenous time-invariant characteristics (X_i) and an unobserved component (u_{it}).

$$U_{it} = U(c_{it}, \ell_{it}, S_{it}, u_{it}; X_i) \tag{1}$$

Total consumption (c_{it}) is constrained by income (I_{it}) when teaching ($h_{it} > 0$) minus the price (p) of completing a master's degree.[5]

$$c_{it} = \mathbb{1}[h_{it} > 0] * I_{it} - p_t * q_{1it} \tag{2}$$

Teaching income is a function of a teacher's credentials (Q_{it}) and current school characteristics (S_{it}).

$$I_{it} = I(Q_{it}, S_{it}) \tag{3}$$

A teacher's total time in each period (Ω) is divided between hours teaching (h_{it}), leisure (ℓ_{it}), and time required to obtain credentials (τ_{q_1}, τ_{q_2}).

$$\Omega = h_{it} + \ell_{it} + \tau_{q_1} q_{1it} + \tau_{q_2} q_{2it} \tag{4}$$

Given the constraint on consumption and time, the utility for period t becomes:

$$U_{it} = \ U(\ I(Q_{it}, S_{it}) - p_t q_{1it},\ \Omega - h_{it} - \tau_{q_1} q_{1it} - \tau_{q_2} q_{2it}, S_{it}, u_{it};\ X_i) \tag{5}$$

The traditional academic school year defines one period in this model. In North Carolina, as in many other states, employment opportunities and transitions between schools are made almost uniformly based on the academic year. This framework, summarized in Figure 1, uses the following timing assumptions:

1. The teacher enters the period with knowledge of her credentials (Q_{it}), individual characteristics (X_i), current school characteristics (S_{it}), non-school community characteristics (P_t^s), the price and prevalence of credentials (P_t^Q) and preference shifter u_{it}.

2. In the first stage of the period, she chooses whether or not to obtain the following credentials: complete a master's degree (q_{1it}) and become NBPTS certified (q_{2it}). These decisions, along with current

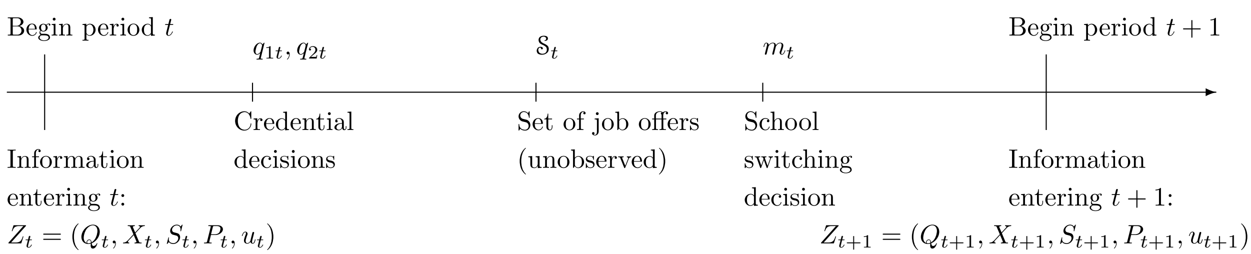
[5] I do not include other forms of income because they are not observable in the data.

experience, update her stock of credentials.

3. Given the updated credentials, the teacher receives a set of employment offers ($\mathcal{S}_t$) containing offers from n schools. This set of offers is unobserved by the researcher.

4. At the end of the period, the teacher makes a decision (m_{it}) of whether to leave her current school for a different school within her set of offers ($m_{it} = 1$) or to stay at her current school ($m_{it} = 0$).

Figure 1: Timing of behavior



The outside option contained in the offer set $\mathcal{S}_t$ represents possible teaching or non-teaching employment opportunities outside of North Carolina public schools or leaving the labor the labor force altogether. The probability of a teacher facing an offer set of $\mathcal{S}_t$ is a function of a teacher's updated credentials and experience (Q_{t+1}), as well as the current school of employment and its characteristics. This set of offers, while a function of observable credentials, is not deterministic. At the beginning of the period, the teacher does not know with certainty the offer set she will receive until after she makes the credential decisions. The probability of receiving a set of offers $\mathcal{S}_t$ is denoted $\pi^{S_n}(Z_{t+1}, S_t)$. The offer set is realized only after the credential decisions are made. There is also a probability of being laid-off in the next period. Let the probability of being laid-off in the next period be denoted γ_{t+1}.

Upon receiving a set of job offers $\mathcal{S}_t$ the teacher makes the decision whether to stay or leave her current school. In this paper, I only consider the following alternatives: stay in current school, move to new school in same district, move to new district, or select the outside option (i.e. attrit from sample). In another paper, I consider the set of alternatives to include movement to particular schools, rather than focusing on district moves only (Cook, 2011). The lifetime value of choosing a particular credentials combination $q = (q_1, q_2)$ at the beginning of period t condition on being in school s is:

$$V^s_q(Z_t, \epsilon_t) = U_{it} + \beta W(Z_{t+1}) \quad \forall t \tag{6}$$

where

$$W(Z_{t+1}) = \gamma_{t+1} \sum \pi_{t+1} E_t[\max_{s'} V^{s'}(Z_{t+1}|S'_{nt})] + (1-\gamma_{t+1}) \sum \pi^{s''}_{t+1} E_t[\max_{s''} V^{s''}(Z_{t+1}|S''_{nt})] \quad \forall t \tag{7}$$

and

$$V^s(Z_{t+1}|S_{nt}) = E_t[\max_q V^s_q(Z_{t+1}, \epsilon_{t+1}|m_t = s)] \quad \forall s, \forall t \tag{8}$$

is the maximal expected value of lifetime utility at the beginning of period $t+1$, unconditional on the subsequent credentials decision but conditional on the employment decision. Note that expression (7) captures both the uncertainty of layoff as well as the optimal employment decision among a set of uncertain potential offers. The set of offers S'_{nt+1} would exclude continuation at one's current school s; The set of offers S'_{nt+1} would include the option to stay at school s. Both sets include the outside option. The value function in equation (6) signifies that when the teacher makes certification decisions at the beginning of each period there is uncertainty about the future value of those decisions because of the stochastic nature of the employment offers.

Teacher decisions of credentials and school choice determine the composition of teacher characteristics at a given school in two ways. First, teachers that stay at the current school could update their credentials, changing the composition of teacher characteristics. Second, the flow of teachers in and out of a school changes the composition of teacher characteristics at that school.

4 Empirical Model

4.1 Teacher Outcomes

Using the theoretical framework, I form approximations of the demand functions for the two credential decisions made at the beginning of the period, along with the end-of-period employment decision, using the theory to inform the arguments of those functions. The credential outcomes are the result of the decisions to complete a master's degree (q_{1it}), and/or become national board certified (q_{2it}). The probabilities of each of these outcomes are specified as discrete-time hazard models, where a teacher-year observation is included in estimation of the probabilities every period until the specific certification is obtained.[6] Once a teacher acquires the credential her stock of that credential is updated, and that specific credential is no longer a decision in future periods.

Each of these certification probabilities is a function of vectors describing the credentials history (Q_{it}) of a teacher entering the period. This vector includes certification outcomes observed in the previous period as well as the stock of certifications a teacher has when entering the current period. The certification probabilities are also a function of a vector of exogenous teacher characteristics (X_{it}), a vector of school-level and district-level characteristics (S_{it}), exogenous community variables (P_{it}^S) that describe the non-school characteristics of the community and exogenous credential variables (P_t^Q) that describe the costs of obtaining a credential and prevalence of the credential.

In the empirical model, I decompose the error term u_{it} for each equation into three components: individual permanent heterogeneity (μ_t), individual time-varying heterogeneity (ν_{it}), and an identical and independently distributed type I extreme value component (ϵ_{it}). That is,

$$u_{it} = \mu_i + \nu_{it} + \epsilon_{it} \tag{9}$$

Conditional on the correlated error components, the i.i.d. error component (ϵ_{it}) produces logit probabilities of the credential outcomes. Equations (10) and (11) express the probabilities of the observed credential outcomes that are simultaneously made during the period.

The log odds ratio of obtaining a master's degree:

$$\begin{aligned}\ln\left[\frac{Pr(q_{1it}=1 \mid Q_{1it}=0)}{Pr(q_{1it}=0 \mid Q_{1it}=0)}\right] &= \beta_0 + \beta_1 Q_{2it} + \beta_2 Q_{3it} + \beta_3 X_{it} \\ &\quad + \beta_4 S_{it} + \beta_5 P_{it}^Q + \beta_6 P_{it}^S + \mu_{1i} + \nu_{1it}\end{aligned} \tag{10}$$

The log odds ratio of becoming national board certified:

$$\begin{aligned}\ln\left[\frac{Pr(q_{2it}=1 \mid Q_{2it}=0,\ Q_{3it}\geq 3)}{Pr(q_{2it}=0 \mid Q_{2it}=0,\ Q_{3it}\geq 3)}\right] &= \delta_0 + \delta_1 Q_{1it} + \delta_2 Q_{3it} + \delta_3 X_{it} \\ &\quad + \delta_4 S_{it} + \delta_5 P_{it}^Q + \delta_6 P_{it}^S + \mu_{2i} + \nu_{2it}\end{aligned} \tag{11}$$

Each of these probabilities are estimated as discrete-time duration models. Note that each equation is

[6] Applicants for NBPTS certification are required to have at least three years of teaching experience. Accordingly, individuals with less than three years of experience are excluded from the NBPTS hazard model.

conditional upon not having previously obtained that credential. The vector containing the history of that credential is omitted due to absence of variation. For example, the degree equation is estimated for only those individuals who do not already have an advanced degree, meaning their history of that credential would be zero for all observations.

As outlined with the theoretical motivation in the previous section, the beginning-of-period credential decisions update the teacher's stock of credentials. These updated credentials could influence the movement of teachers between schools in two ways. First, teachers aspiring to achieve these credentials may be more inclined to seek out "better" schools at which to teach. Second, these credentials are observable signals of teacher quality and may influence the quality of job offers received by a teacher. Given this influence, the end-of-period school employment decision (m_{it}) is a function of these updated stock variables (Q_{it+1}). I define the end-of-period employment decision, conditional on not attritting to include three options. It is also conditional on not choosing the outside option, which in these data equate with attrition from the sample. [7]

$$m = \begin{cases} 0 & \text{stay at current school,} \\ 1 & \text{move to different school in same district,} \\ 2 & \text{move to different school in different district.} \end{cases}$$

The log odds ratio of changing schools relative to staying at the current school is

$$\begin{aligned} \ln\left[\frac{Pr(m_{it}=m)}{Pr(m_{it}=0)}\right] &= \lambda_0^m + \lambda_1^m Q_{1it+1} + \lambda_2^m Q_{2it+1} + \lambda_3^m Q_{3it+1} + \lambda_4^m X_{it} \\ &\quad + \lambda_5^m S_{it} + \lambda_6^m P_{it}^S + \mu_{4i}^m + \nu_{4it}^m \qquad m = 1, 2 \end{aligned} \tag{12}$$

Note that the vector of exogenous supply shifting variables (P_{it}^Q) is not included in equation (12) because they affect the moving decision only through the updated credential stock variables (i.e. they have an independent effect on the employment decision given the updated stock of credentials).

4.2 Estimation Technique

I jointly estimate equations (10) through (12) by allowing these equations to be correlated through the permanent (μ_i) and time-varying (ν_{it}) error components. Researchers commonly allow for this correlation to exist through distributional assumptions, such as joint normality, about the error terms. If the distributional assumptions are incorrect the resulting parameters will be biased. I use a more flexible semi-parametric es-

[7] This attrition is discussed in section 4.3 below.

timation method that relaxes these distributional assumptions. The discrete factor random effects method (DFRE), based on Heckman and Singer (1984), approximates the joint cumulative distribution of the unobserved heterogeneity components using a discrete step-wise function (Mroz, 1999; Mroz and Guillkey, 1995). This method determines the points of support along the distribution as well as the probability of being at each point. The location and probabilities of these mass points are parametrically estimated along with the other model coefficients in the likelihood function.

The DFRE method is preferred to other common panel data approaches such as first differences or fixed effects for several reasons. First, the DFRE controls for two types of unobserved heterogeneity: individual permanent and time-varying heterogeneity, whereas common methods only capture individual permanent heterogeneity. Secondly, unlike fixed effects methods, the DFRE method allows for the use of time-invariant regressors. Thirdly, within estimators rely heavily on within individual variation of time-varying regressors. Because of this reliance, lack of variation or the presence of measurement error can increase attenuation bias when using these other estimators (Angeles, Guilkey, and Mroz, 1998). Mroz and Guillkey (1995) show using Monte Carlo simulations that the DFRE outperforms parametric maximum likelihood methods when the distributional assumptions of the econometrician are incorrect.

4.3 Identification and Initial Conditions

The empirical equations set forth are estimated as a system of equations, with the the endogenous outcomes of the credential decisions used as regressors in the moving decisions. The empirical model attains identification from theoretical exclusion restrictions and the nonlinear dynamic nature of the equations.

Valid exclusion restrictions need to influence the endogenous outcomes of master's degree and NBPTS certification without affecting the moving decision, conditional on the credentials obtained in the period. The North Carolina DPI sets a salary schedule each year that determines the salary of a teacher given her experience and credentials. While districts may choose to pay teacher salaries above this schedule, these levels are the minimum amounts that must be paid to teachers set forth by the state. Based upon these state salary schedules a teacher increases her income based on her education attainment and NBPTS status. The additional amount earned based on these two credentials vary across the experience level of a teacher. In each period experience level varies across teacher, and subsequently these increases in income vary across both teacher and time. Because these salary increases are set at the state level and apply to all school districts, they should influence the credential decision but not the moving decision. I use these state salary schedule differentials to help identify the per-period decisions of whether to obtain a master's degree and

NBPTS certification. Additionally, I use average in-state tuition levels within the county for identification. In-state tuition levels vary across time and across individuals in different counties.

Identification of parameters also comes through the dynamic nature and functional form of the model. Bhargava (1991) shows that, under weak conditions in linear dynamic models, each lag of the exogenous time-varying variables has an effect on the current endogenous variable. The degree of identification has been shown to be even greater in nonlinear dynamic models (Mroz and Savage, 2006; Mroz and Surette, 1998). In this sense, the entire history of exogenous time-varying variables act as instruments for endogenous variables in the current period.[8]

The administrative data are left-censored in regards to teachers being at different points in their career in the first year a teacher is observed. The first year of observed data, 1995, has teachers with a range of teacher experience, and levels of credentials. Also, teachers observed in later years can enter the sample from a position outside of the public schools system, and have a range of experience and levels of credentials. These initial levels in the first observed period for an individual cannot be modeled in a dynamic framework because there are no observed lagged values available as regressors. This leads to the problem of endogenous initial conditions. In order to explain the variation in these initial levels I model these endogenous variables with reduced form equations.

Identification of these reduced form equations comes through variables that explain these initial levels but do not influence the per-period outcomes. Reduced form equations are estimated for four initial conditions: master's degree, national board certification, teaching experience, and the quality of school at which a teacher is initially observed. The exclusion restrictions used need to influence these initial levels without influencing the later outcomes conditioned on the initial endogenous value.

Identification for initial master's degree and initial national board certification status comes from historic salary schedules for teachers in North Carolina. Initial teaching experience is identified by the unemployment rate at the time an individual received her first bachelor's degree. The unemployment rate captures economic variation that may influence teaching opportunities as well as opportunities outside the teaching profession. Identification also comes from changes in teaching license requirements in North Carolina beginning in 1959.[9] Based upon the year an individual received her first bachelor's degree the teaching requirements such as required testing, required scoring, and specialization are different. I categorize teachers into eight different time periods based on these changing requirements. In order to model the initial school quality of

[8]Cameron and Trivedi (2005) also show how these exogenous variables from other periods serve as instruments in their discussion on GMM estimation of panel models.

[9]License Certification Requirements, all Fifty States, [serial] 1959-2008.

a teacher I create a trichotomous index of low, medium, and high quality based on observable school quality characteristics. Identification of this initial condition comes from indicators from the region in which an individual received her first bachelor's degree. The rational for this identification variable is that teachers from colleges outside of North Carolina may have fewer connections within the North Carolina public school system. Table 9 contains summaries for these variables.

The set of variables that is excluded from the per-period questions are included in each of the initial condition equations. In order to correctly model the distribution of unobserved heterogeneity the five reduced form initial condition equations are jointly estimated with the per-period equations. Accordingly, the individual permanent component of the unobserved heterogeneity (μ_i) is allowed to be correlated across the initial conditions as well as the per-period equations. The individual time-varying component of the unobserved heterogeneity (ν_{it}) is not included in the initial conditions.

In each period some teachers leave the sample. The data do not contain information on the reason for an individual leaving the data. An individual observed in the data one year and not observered in the data the next year could leave the public school system for a variety of unidentified reasons. For example, a teacher could retire, leave the state, leave the teaching profession, or leave public schools for a position at a private school. In order to account for the possibility of nonrandom attrition, I model this attrition with a binary variable indicating the last period an individual is observed. This attrition equation is jointly modeled with the other per-period decisions, allowing the unobserved heterogenity to be correlated across these equations.

4.4 The Likelihood Function

The discrete factor random effects method approximates the continuous distributions of the unobserved heterogeneity components using K mass points for μ_k and G mass points for ν_{gt}. The method estimates ρ_k which is the joint probability of the k^{th} permanent mass point and ψ_g which is the joint probability of the g^{th} time-varying mass point.

The unconditional contribution of individual i to the likelihood function for the per-period, initial conditions, and attrition outcomes is:

$$
\begin{aligned}
\mathcal{L}_i(\Theta,\rho,\psi) = \sum_{k=1}^{K} \rho_k \Bigg\{ & \prod_{q_1=0}^{1} Pr(Q_{11}=q_1 \mid \mu_{4k})^{\mathbb{1}\{Q_{1i1}=q_1\}} \prod_{q_2=0}^{1} Pr(Q_{21}=q_2 \mid \mu_{5k})^{\mathbb{1}\{Q_{2i1}=q_2\}\mathbb{1}\{Q_{3i1}>3\}} \\
& \frac{1}{\sigma}\Phi(\ln Q_{31} \mid \mu_{6k}) \prod_{s=1}^{3} Pr(S_1=s \mid \mu_{7k}^{s})^{\mathbb{1}\{S_{it}=s\}} \\
& \prod_{t=1}^{T}\sum_{g=1}^{G} \psi_g \Bigg[\prod_{q_1=0}^{1} Pr(q_{1t}=q_1 \mid \mu_{1k},\nu_{1tg},Q_{1it}=0)^{\mathbb{1}\{Q_{1it}=q_1\}\mathbb{1}\{Q_{1it}=0\}} \\
& \prod_{q_2=0}^{1} Pr(q_{2t}=q_2 \mid \mu_{2k},\nu_{2tg},Q_{2it}=0)^{\mathbb{1}\{q_{2it}=q_2\}\mathbb{1}\{Q_{2it}=0\}\mathbb{1}\{Q_{3it}>3\}} \\
& \prod_{a=0}^{1} Pr(a_t=a \mid \mu_{8k},\nu_{8tg})^{\mathbb{1}\{a_{it}=a\}} \Bigg] \prod_{m=0}^{2} Pr(m_t=m \mid \mu_{3k}^{m},\nu_{3tg}^{m})^{\mathbb{1}\{m_{it}=m\}\mathbb{1}\{a_{it}\neq 0\}} \Bigg\}
\end{aligned} \tag{13}
$$

The respective joint probabilities of the permanent and time-varying mass points are given by equations (14) and (15):

$$
\begin{aligned}
\rho_k = Pr(&\mu_1=\mu_{1k},\mu_2=\mu_{2k},\mu_3^0=\mu_{3k}^0,\mu_3^1=\mu_{3k}^1,\mu_3^2=\mu_{3k}^2,\mu_4=\mu_{4k},\mu_5=\mu_{5k},\mu_6=\mu_{6k}, \\
&\mu_7^1=\mu_{7k}^1,\mu_7^2=\mu_{7k}^2,\mu_7^3=\mu_{7k}^3,\mu_8=\mu_{8k})
\end{aligned} \tag{14}
$$

$$
\psi_g = Pr(\nu_1=\nu_{1g},\nu_2=\nu_{2g},\nu_3^0=\nu_{3g}^0,\nu_3^1=\nu_{3g}^1,\nu_3^2=\nu_{3g}^2,\nu_8=\nu_{8g}) \tag{15}
$$

The joint likelihood function over all individuals is given by:

$$
L(\Theta) = \prod_{i=1}^{N} \mathcal{L}_i(\Theta,\rho,\psi) \tag{16}
$$

The likelihood function is maximized with respect to the parameters in the outcome equations, as well as the unobserved heterogeneity components μ_k, ν_g, ρ_k, and ψ_g.

5 Data

5.1 Description

The data I use are from the North Carolina Education Research Data Center (NCERDC). These data are compiled annually from the administrative records of the North Carolina Department of Public Instruction

(DPI). The DPI records include data on the universe of districts, schools, teachers, and students in the North Carolina public school system from 1995 to 2007. These data provide a comprehensive view of the public school system, allowing teachers to be followed throughout their transition within the system.

Information on teachers includes gender, race, educational attainment, college and graduation year, teaching licenses, NBPTS certification, state-based salary and total teaching experience. The licensure data include the date the license was obtained and the type of license. The NBPTS data includes information on the date the certification is awarded.

In order to supplement the NCERDC information on teachers I use additional data describing the undergraduate institution of the teacher from the Integrated Postsecondary Education Data System by the National Center for Education Statistics (NCES) of the U.S. Department of Education. These variables include indicators for the Carnegie classifications of whether a college is privately funded, a Research I institution, offers graduate degrees, and is a historically black college. I also use supplemental data on the selectivity of the teacher's undergraduate institution. The Barrons' Admissions Competitiveness Index from the NCES provide indicators for the competitiveness of undergraduate institutions in the U.S. This index is represented by indicators for the competitiveness category of the institution. From these data I use indicators for the categories "most competitive", "highly competitive", and "very competitive". The NCES provides this index for years 1972, 1982, 1992, and 2004. I merge this index with the teacher data using the year closest to that of the teacher's year of undergraduate completion. Table 10 summarizes the variables describing teachers. The collective data on a teacher's undergraduate institution provide an approximation of academic ability as well as controls for different types of individuals.[10]

Data on schools include standard demographics of students such as race, students eligible for free or reduced lunch, size of the student body, and student-teacher ratio. The data also include geographic indicators for urban or rural classification. In addition to data from the DPI, the NCERDC also houses survey results from the North Carolina Professional Teaching Standards Commission (NCPTSC). Beginning in 2002, the NCPTSC biennially administers a working conditions survey to all certified school personnel in the state. These surveys are anonymously administered within schools, which eliminates the possibility of linking them with specific teacher data. Although these survey results are subjective teacher perceptions of school quality, they provide a unique measure of the non-pecuniary benefits that are difficult to observe in standard administrative data used in the existing literature. I use responses from eight questions pertaining to the non-pecuniary benefits of working at a school. These questions include topics such as school safety, work

[10]In reality, the competitiveness of an undergraduate institution is endogenous. Modeling this endogeneity is not feasible in the model, and since I am only using this index to proxy for ability, I argue that modeling this endogeneity is not needed.

load, and professional development. Table 9 contains descriptions of these questions. Each question used is a five-point Likert item with possible responses ranging from "strongly disagree" to "strongly agree". I average these responses within schools and then classify schools into quartiles, with a higher quartile representing a more positive average response.

The NCERDC data contain financial information at the district level. From these data I construct variables for the percent of total revenue that comes from local sources, local revenue per student, expenditures per student, average teacher salary supplement, and the percentage of teachers receiving salary supplements. Based on the observed data, I create variables for the number of school openings and school closings within a district. The addition or subtraction of schools within an area provides opportunities for teacher transitions. I also create indicator variables for districts on the border of the state. These border states include South Carolina, Georgia, Tennessee, and Virginia. Teachers working in school districts on the border may be more affected by policy changes or school employment opportunities in border states, thus having a higher attrition rate from the data. School, district, community characteristics, and exclusion restrictions are summarized in Table 11.

5.2 Sample Selection

The focus of my analysis is on the outcomes of the standard classroom teacher. The NCERDC Personnel Files include all classroom and non-classroom activities for public school employees with direct contact with students. I use these records to identify employees with a teaching assignment involving classroom activity. I further limit the sample by keeping only full-time teachers that are observed in the data to be matched with only one school each year. Full-time teachers with classroom activity that are observed at multiple schools during a single academic year are dropped from the sample.[11]

Due to the nature of administrative data, the NCERDC data only provide a snapshot of the North Carolina public school system over a set amount of time. The individuals observed in the data have self-selected into the teaching profession, and specifically, into the North Carolina public school system. I cannot observe prior labor force behavior, or the labor force outcomes after an individual leaves the sample. For example, if an individual is in the data one year and then absent the next year, I cannot determine if that individual chose to work in education at a private school or in a different state, left the field of education, or left the labor force altogether. Accordingly, this analysis does not attempt to explain teacher outcomes

[11] These individuals represent less than 3% of all teachers in the data. This figure oftentimes represent teachers with specialty assignments. For example, a school district may have a science teacher that teaches a science module at several middle schools within the district.

once they leave North Carolina public schools. A similar problem involves individuals who leave the sample and then reenter in a later year. I do not want to drop these observations once the individual initially exits because I need to characterize the endogenous quality of teachers within a school. Hence, I need to retain, in estimation, their observations after re-entry to the North Carolina public school system. Due to the complications of modeling reentry, I treat each spell of these individuals as a different individual. Table 12 in the appendix summarizes the entry and attrition of the sample each year. In 1995, I initially observe 59,399 individuals. In subsequent years, the sample grows steadily, with more individual entering than leaving the sample. Overall, my sample contains 205,875 individuals providing 907,259 person-year observations. Table 13 in the appendix provides a summary of length of spell for individuals. Approximately 59.2 percent of individuals have spells of three years or longer.

Table 1 compares the average school characteristics of the departing school and arrival school for teachers that switch schools. The table shows, at a descriptive level, that teachers tend to move to schools with fewer black students, fewer poor students, and more desirable conditions. Looking at the mean for urban and rural geography, it appears that teachers also tend to move to more suburban areas. The differences between the means were found to be statistically different from zero at the 1 percent level using paired t-tests.

Table 1: Selected School Characteristics of Switching Teachers

	Departing School		**Arrival School**	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Pct. black	35.53	24.38	31.20	22.92
Pct. lunch	36.08	20.93	29.74	20.92
Urban	0.32	0.46	0.29	0.45
Rural	0.20	0.40	0.18	0.39
WCS: Safe school	2.15	1.17	2.42	1.14
WCS: Teachers respect	2.13	1.15	2.38	1.11
WCS: Teachers shielded	2.14	1.17	2.37	1.13
WCS: Prof. devel.	2.23	1.16	2.37	1.09
WCS: Class load	2.24	1.16	2.31	1.09
WCS: Interference	2.19	1.17	2.37	1.11
WCS: High standards	2.15	1.15	2.36	1.11
WCS: Inv. w/decisions	2.03	1.19	2.12	1.19
Avg. supplement (1000's)	2.43	3.25	2.56	2.88
Pct. w/supplement	96.91	16.15	97.38	14.77

All differences between means are found to be significant at the 1% level using paired t-tests.
Descriptions of Working Conditions Survey (WCS) variables are in Table 9 of the appendix.

6 Preliminary Results

Preliminary estimates of the parameters of the credential equations and employment outcome are presented in Table 14 and Table 15 of the appendix.[12] These equations are estimated jointly using a discrete factor random effects method allowing the equations to be correlated across the both the individual permanent (μ) and time-varying (ν_t) unobserved components. The distributions for the individual permanent and time-varying unobserved heterogeneity components are approximated using five and three mass points, respectively. The probability weights and factor loadings for each mass point are presented in Table 16 of the appendix.

Table 2 allows for evaluation of the accuracy of the model by comparing the predicted outcomes of the model with the outcome means from the data. The first column in Table 2 contains the proportions found in the data for each outcome in the model, while the second column contains the predicted outcome from the jointly estimated equations. The predicted outcomes from the model are determined using the estimated coefficients from the model in addition to integrating over the unobserved heterogeneity components and a random draw representing the idiosyncratic error component. As shown in the table, the model does well in predicting the credential and employment outcomes, on average.

Table 2: Model Fit

	Actual	Predicted
Adv. degree	0.016	0.015
NBPTS	0.014	0.014
Stay at current school	0.927	0.935
Switch within district	0.045	0.039
Switch outside district	0.027	0.026
Attrit	0.153	0.176

6.1 Marginal Effects

Using the coefficients from the jointly estimated equations, I calculate the marginal effects for changes in three variables: percent of students on free or reduced lunch, percent of black students, and teacher salary. These marginal effects are determined by first simulating the baseline outcome and then subtracting this outcome from the simulated outcomes from the change in the specified variable. Both outcomes are simulated by integrating over the individual permanent and time-varying heterogeneity components, as well as an idiosyncratic error draw. These differences are then averaged across teachers based on the credentials

[12]Estimated coefficients for the reduced form initial condition equations are available upon request.

of experience, advanced degree, and NBPTS certification. All marginal effects are one-period effects average over these groups of teachers. Standard errors for these marginal effects are semi-parametrically bootstrapped using 100 replications. Table 3 provides the baseline simulated probabilities from which the marginal effects are calculated. At baseline, teachers with fewer years of experience have a higher probability of switching to a different school or attritting, relative to teachers with more experience. Specifically, teachers within their first three years of teaching are almost seven percentage points more likely to leave the public school system, compared to all teachers. Teachers with more experience generally have a high probability of staying at their current school. Teachers holding an advanced degree, although having a similar probability of staying at their current school, have a higher probability of attritting compared to all teachers. Teachers who are NBPTS certified have a higher probability of staying at their current school, and lower probability of attritting than the average teacher. This difference may represent NBPTS teachers being more invested in teaching than average teacher and teachers with advanced degrees.

Table 3: Baseline Probabilities

	Probability			
Teacher Characteristics	Stay	Switch within District	Switch outside of District	Attrit
Years of experience:				
0 to 2	68.10	4.60	4.70	24.62
3 to 5	72.11	4.42	3.68	20.00
6 to 10	76.86	4.22	2.80	16.26
11 plus	80.96	3.21	1.52	14.91
Advanced degree	76.86	3.63	2.15	19.30
NBPTS	80.58	2.74	1.47	15.35
All teachers	76.95	3.77	2.56	17.63

Table 4 displays the marginal effects of a 25 percentage point increase in the proportion of students eligible for free or reduced lunch within a school. All figures in the table are changes in percentage points from the baseline values in Table 3. Based on these preliminary results, this increase decreases the probability a teacher will stay at her current school for all teacher groups evaluated. This effect is largest for teachers with less than six years of experience, with a decrease in the probability of staying by 1.13 percentage points. Given a teacher leaving her current school, the results show that the increase in eligible students for free lunch has a larger effect on the probability of moving within the same district than moving to a new district or leaving the public schools system. This trend is consistent across all groups with the exception of NBPTS teachers, with the change in the probability of leaving NC public schools being 0.11 percentage points larger than the change in probability of moving to a new schools within the same district.

Table 4: Marginal Effects of Increased Students on Free/Reduced Lunch

Teacher Characteristics	Percentage Point Change in Probability: Stay		Switch within District		Switch outside of District		Attrit	
Years of experience:								
0 to 2	-1.13	***	0.61	***	0.27	***	0.26	***
	(0.03)		(0.02)		(0.03)		(0.02)	
3 to 5	-1.13	***	0.64	***	0.21	***	0.26	***
	(0.03)		(0.02)		(0.03)		(0.02)	
6 to 10	-1.01	***	0.58	***	0.24	***	0.19	***
	(0.03)		(0.02)		(0.02)		(0.02)	
11 plus	-0.82	***	0.50	***	0.16	***	0.16	***
	(0.02)		(0.01)		(0.01)		(0.01)	
Advanced degree	-0.88	***	0.53	***	0.19	***	0.16	***
	(0.02)		(0.01)		(0.02)		(0.02)	
NBPTS	-0.92	***	0.35	***	0.09	***	0.46	***
	(0.03)		(0.01)		(0.02)		(0.03)	
All teachers	-0.94	***	0.55	***	0.20	***	0.20	***
	(0.02)		(0.01)		(0.02)		(0.02)	

Standard errors are bootstrapped using 100 replications.

*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

Table 5 presents the marginal effects of a 25 percentage point (approximately one standard deviation) increase in the proportion of black students at the current school. Across all defined teacher groups, there is a decrease in the probability a teacher stays at her current school. This decrease is the largest for teachers with fewer years of experience with approximately a two percentage point decrease in the probability of staying. However, unlike the effect of increasing the proportion of free lunch students, the change in proportion of black students has a larger effect on attritting than it does on switching schools within the public schools system. Given a teacher stays within the NC public school system, there is a larger change in probability that a teacher switches to a school in a different district relative to switching within the district, across all teacher groups. These results suggest that, in addition to specific schools having trouble keeping teachers, the public school system in general face difficulties in retaining these teachers.

Table 5: Marginal Effects of Increased Black Students

Teacher Characteristics	Percentage Point Change in Probability: Stay		Switch within District		Switch outside of District		Attrit	
Years of experience:								
0 to 2	-2.02	***	0.15	***	0.65	***	1.27	***
	(0.02)		(0.02)		(0.03)		(0.01)	
3 to 5	-2.00	***	0.19	***	0.51	***	1.33	***
	(0.02)		(0.01)		(0.03)		(0.01)	
6 to 10	-1.93	***	0.24	***	0.48	***	1.23	***
	(0.02)		(0.01)		(0.02)		(0.01)	
11 plus	-1.65	***	0.28	***	0.34	***	1.03	***
	(0.02)		(0.01)		(0.02)		(0.01)	
Advanced degree	-1.78	***	0.23	***	0.40	***	1.15	***
	(0.02)		(0.01)		(0.02)		(0.01)	
NBPTS	-1.79	***	0.26	***	0.39	***	1.08	***
	(0.02)		(0.02)		(0.02)		(0.02)	
All teachers	-1.81	***	0.24	***	0.44	***	1.14	***
	(0.02)		(0.01)		(0.02)		(0.01)	

Standard errors are bootstrapped using 100 replications.

*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

The marginal effects of a $5,000 increase in teacher salary (approximately 15% of the mean salary observed in the sample) are provided in Tables 6 through 8. Table 6 contains these effects for teachers at all schools within the sample. Table 7 displays results for teachers at school with greater than 50% of student eligible for free or reduced lunch. Table 8 displays results for teachers at schools with greater than 50% black students. Approximately 25% of all schools in the sample meet either criteria. Table 6 shows that, averaged over all schools, the increase in salary has a small positive increase on the probability of a teacher staying at her current school. This effect is largest for inexperienced teachers with a $5,000 increase in salary associated with an increase in the probability of staying of approximately four tenths of a percentage point. The effect of this salary change on attrition has the largest effect on teachers with an advanced degree or NBPTS certification, with a decrease in the the probability of attritting by 0.32 and 0.37 percentage points, respectively.

Table 6: Marginal Effects of Increased Salary

Teacher Characteristics	Percentage Point Change in Probability: Stay		Switch within District		Switch outside of District		Attrit	
Years of experience:								
0 to 2	0.40	***	0.02	**	-0.19	***	-0.25	***
	(0.02)		(0.01)		(0.01)		(0.02)	
3 to 5	0.26	***	0.05	***	-0.19	***	-0.12	***
	(0.02)		(0.01)		(0.01)		(0.02)	
6 to 10	0.29	***	-0.00		-0.13	***	-0.15	***
	(0.02)		(0.01)		(0.01)		(0.02)	
11 plus	0.34	***	-0.03	***	-0.10	***	-0.21	***
	(0.01)		(0.01)		(0.01)		(0.01)	
Advanced degree	0.31	***	0.06	***	-0.05	***	-0.32	***
	(0.02)		(0.01)		(0.01)		(0.02)	
NBPTS	0.37	***	0.06	***	-0.07	***	-0.37	***
	(0.02)		(0.01)		(0.01)		(0.02)	
All teachers	0.33	***	-0.01		-0.13	***	-0.20	***
	(0.01)		(0.01)		(0.01)		(0.01)	

Standard errors are bootstrapped using 100 replications.

*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

Table 7 provides the effect of the income increase for teachers at schools with greater than 50% of students eligible for free or reduced lunch. The marginal effects for teachers at these schools are similar to the effects for all schools (Table 6). For this subset of schools, teachers with an advanced degree or NBPTS certification have a smaller change in probability of staying relative to teachers of the same certification at all schools. This comparison suggests that teachers with higher credentials at these schools are less responsive to changes in salary than similar teachers at different schools.

Lastly, Table 8 displays the marginal effects of the increase in salary for teachers at schools with greater than 50% black students. In each experience group, the effect of this increase in salary on the probability of staying is slightly larger for teachers at these schools relative to similar teachers at all schools. For teachers with an advanced degree or NBPTS certification, the marginal effect of this increase on the probability of staying is slightly smaller than for similar teachers at all schools. These findings suggest that generally, teachers across different experience levels at schools with a higher proportion of black students are slightly more responsive to changes in salary compared to similar teachers at all schools. Teachers with higher credentials at this type of school appear to be less responsive when compared with similar teachers at all schools.

Table 7: Marginal Effects of Increased Salary at Schools with 50% Students Free Lunch

Teacher Characteristics	Percentage Point Change in Probability							
	Stay		Switch within District		Switch outside of District		Attrit	
Years of experience:								
0 to 2	0.43	***	-0.03	***	-0.19	***	-0.20	***
	(0.02)		(0.01)		(0.01)		(0.02)	
3 to 5	0.22	***	0.05	***	-0.19	***	-0.08	***
	(0.02)		(0.01)		(0.01)		(0.02)	
6 to 10	0.26	***	0.03	***	-.016	***	-0.14	***
	(0.02)		(0.01)		(0.01)		(0.02)	
11 plus	0.36	***	-0.03	***	-0.12	***	-0.21	***
	(0.01)		(0.01)		(0.01)		(0.02)	
Advanced degree	0.16	***	0.14	***	-0.06	***	-0.24	***
	(0.02)		(0.01)		(0.01)		(0.02)	
NBPTS	0.31	***	0.23	***	-0.08	***	-0.46	***
	(0.02)		(0.01)		(0.01)		(0.02)	

Standard errors are bootstrapped using 100 replications.

*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

Table 8: Marginal Effects of Increased Salary at Schools with 50% Black Students

Teacher Characteristics	Percentage Point Change in Probability							
	Stay		Switch within District		Switch outside of District		Attrit	
Years of experience:								
0 to 2	0.42	***	0.04	***	-0.22	***	-0.24	***
	(0.02)		(0.01)		(0.01)		(0.02)	
3 to 5	0.30	***	0.08	***	-0.21	***	-0.17	***
	(0.02)		(0.01)		(0.01)		(0.02)	
6 to 10	0.35	***	0.06	***	-0.18	***	-0.23	***
	(0.02)		(0.01)		(0.01)		(0.02)	
11 plus	0.38	***	-0.06	***	-0.13	***	-0.22	***
	(0.01)		(0.01)		(0.01)		(0.01)	
Advanced degree	0.30	***	0.13	***	-0.12	***	-0.31	***
	(0.02)		(0.01)		(0.01)		(0.02)	
NBPTS	0.35	***	0.15	***	-0.11	***	-0.39	***
	(0.02)		(0.01)		(0.01)		(0.02)	

Standard errors are bootstrapped using 100 replications.

*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

7 Discussion

With teacher quality being both an important and expensive school resource, understanding the employment outcome of teachers may have important policy implications. In this research, I add to the current literature by estimating teacher mobility outcomes, along with several endogenous teacher credential outcomes, using longitudinal data on North Carolina public schools. I jointly estimate these outcomes using a discrete factor random effects method that reduces potential bias by controlling for individual permanent and time-varying unobserved heterogeneity.

Preliminary results show that, on average, teacher mobility outcomes are more sensitive to changes in student demographic makeup, relative to changes in salary. These results suggest that schools with a higher proportion of black students and students eligible for free or reduced lunch will experience higher teacher turnover, and may have trouble retaining teachers with characteristics associated with teacher quality. These results also suggest that substantial increases in salary may be needed in order to induce desirable teacher movement outcomes. Given the working condition variables I use as control variables for non-pecuniary benefits at a school, these estimates may be more accurate depictions of the true effects of student and salary changes. Controlling for unobserved heterogeneity may also help to isolate the true marginal effects of these variables.

Although these one-period marginal effects seem relatively small in magnitude, over time the dynamic effects of these changing school characteristics may have larger implications for the composition of teachers within specific types of schools. The direction of this research involves steps toward analyzing the long run effect of different policies on teacher mobility. These steps include analyzing the fit of the dynamic model over time, with simulated outcomes being updated across periods. Once the fit of the model is validated, I plan to implement different policy simulations to estimate the effect of policies over time. For example, this model can be used to simulate the long term effects of student and salary changes on the proportion of new teachers still in the public school system after ten years.

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8 Appendix

8.1 Data Summaries

Table 9: Description of Variables

Variable	Description
Teacher Characteristics	
Male	Teacher is male.
Black	Teacher is black.
Asian	Teacher is asian.
Hispanic	Teacher is hispanic.
Other race	Teacher is race other than black, asian, hispanic, or white.
Elementary	Teaches at an elementary school.
Middle School	Teaches at a middle school.
High School	Teaches at a high school.
College: Private	Teacher graduated from a private college.
College: Research I	Teacher graduated from a Research I institution.
College: Urban	Undergraduate institution located in urban area.
College: Rural	Undergraduate institution located in rural area.
College: Has grad courses	Undergraduate institution offers graduate coursework.
College: Historically black	Undergraduate institution is a historically black college.
College: Most comp.	Barron's Selectivity Index: most competitive institution.
College: Highly comp.	Barron's Selectivity Index: highly competitive institution.
College: Very comp.	Barron's Selectivity Index: very competitive institution.
College: In NC	Undergraduate institution is located in North Carolina.
College: In SC, TN, VA, or GA	Undergraduate institution located in SC, TN, VA, or GA.
College: Not in NC, SC, TN, VA, GA	Undergraduate institution not in NC, SC, TN, VA, or GA.
NC ed. license	Teacher received license through an approved NC education program.
Salary (1000's)	Teacher's base salary from state salary records.
NBPTS certified	Indicator variable for if a teacher is NBPTS certified.
Advance degree	Indicator variable for if a teacher has an advanced degree.
Experience	Years of teaching experience defined from payroll.
School & District Characteristics	
Students per teacher	Number of students per instructional staff.
Total students (100's)	Number of students in the school.
Pct. black	Percent of students who are black.
Pct. lunch	Percent of students eligible for free or reduced lunch.
Urban	Location classified as urban.
Rural	Location classified as rural.
WCS: Safe school	Teacher working condition survey: School is safe.
WCS: Teachers respect	Teacher working condition survey: Teachers are trusted and respected.
WCS: Teachers shielded	Teacher working condition survey: Leadership shields teachers from disruptions.
WCS: Prof. devel.	Teacher working condition survey: Teachers have resources for professional development.

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Table 9 continuing from previous page

Variable	Description
WCS: Class load	Teacher working condition survey: Teachers have reasonable student/class loads.
WCS: Interference	Teacher working condition survey: Teachers are protected from interfering duties.
WCS: High standards	Teacher working condition survey: Teachers are held to high standards.
WCS: Inv. w/decisions	Teacher working condition survey: Teachers are involved in school decisions.
Local rev. pct	Percent of total revenue that is provided by local sources (local revenue).
Local rev/pupil (1000's)	Local revenue per student.
Expenditures/pupil (1000's)	Total expenditures per student.
Closings	Number of school openings in the district.
Openings	Number of school closings in the district.
Avg. supplement (1000's)	Average teacher salary supplement within the district.
Pct. w/supplement	Percent of teachers receiving salary supplement.
SC border	School district borders South Carolina.
GA border	School district borders Georgia.
TN border	School district borders Tennessee.
VA border	School district borders Virginia.
Community Characteristics & Exclusion Restrictions	
Non-ag empl. (1000's)	County nonagricultural employment level.
Med. income	County median family income.
UE	County unemployment rate.
Pop. dens. (100's)	County population density (individuals/sq. mile).
UG completions (1000's)	County undergraduate-level education graduates.
Grad completions (100's)	County graduate-level education graduates.
Colleges county	Number of colleges in county.
Schools county	Number of primary and secondary schools in county.
Students county (1000's)	Number of primary and secondary students in county.
NBPTS salary	State monthly salary differential for being NBPTS certified.
Master's salary	State monthly salary schedule differential for having an advanced degree.
Grad tuition (1000's)	Average in-state graduate tuition.
Per-Period Dependent Variables	
Degree decision	Indicator for completing advanced degree in current period.
NBPTS decision	Indicator for becoming NBPTS certified in current period.
Switch decision	Multinomial indicator for staying at current school, or leaving for a different school in same district, or different school in different district.
Attrit	Indicator for last period teacher is observed in data.

Table 10: Teacher Summary Statistics

	Initially Observed		**All Years**	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Male	0.20	0.40	0.20	0.40
Black	0.15	0.36	0.14	0.35
Asian	0.00	0.07	0.00	0.05
Hispanic	0.01	0.11	0.01	0.09
Other race	0.01	0.09	0.01	0.09
College: Private	0.30	0.46	0.29	0.45
College: Research I	0.11	0.31	0.10	0.30
College: Urban	0.49	0.50	0.47	0.50
College: Rural	0.26	0.44	0.29	0.45
College: Has grad courses	0.79	0.40	0.82	0.39
College: Historically black	0.11	0.31	0.11	0.31
College: Most comp.	0.01	0.09	0.00	0.07
College: Highly comp.	0.03	0.17	0.02	0.15
College: Very comp.	0.10	0.30	0.09	0.28
College: In NC	0.63	0.48	0.71	0.45
NC ed. license	0.53	0.50	0.65	0.48
Elementary	0.39	0.49	0.43	0.50
Middle School	0.35	0.48	0.40	0.49
High School	0.34	0.47	0.36	0.48
Experience	8.19	9.35	12.65	9.68
Salary (1000's)	29.00	9.26	34.24	9.12
NBPTS certified	0.01	0.09	0.04	0.20
Advance degree	0.25	0.44	0.28	0.46

Table 11: School and Community Summary Statistics

	All Years	
Variable	Mean	Std. Dev.
Students per teacher	14.45	5.60
Total students (100's)	6.33	3.47
Pct. black	0.32	0.25
Pct. lunch	0.36	0.21
Urban	0.25	0.44
Rural	0.27	0.44
WCS: Safe school	2.42	1.15
WCS: Teachers respect	2.42	1.14
WCS: Teachers shielded	2.42	1.15
WCS: Prof. devel.	2.44	1.14
WCS: Class load	2.38	1.14
WCS: Interference	2.40	1.14
WCS: High standards	2.41	1.13
WCS: Inv. w/decisions	2.31	1.19
Local rev. pct	0.29	0.09
Local rev/pupil (1000's)	2.14	1.08
Expenditures/pupil (1000's)	7.24	1.50
Closings	1.05	1.98
Openings	0.23	0.87
Avg. supplement (1000's)	2.19	3.21
Pct. w/supplement	0.95	0.21
SC border	0.21	0.41
GA border	0.02	0.12
TN border	0.04	0.20
VA border	0.08	0.26
NBPTS salary	205.08	156.16
Master's salary	300.91	221.58
Grad tuition (1000's)	1.18	1.82
Non-ag empl. (1000's)	122.23	153.56
UE	4.98	2.07
Pop. dens. (100's)	4.01	3.84
UG completions (1000's)	0.44	0.92
Grad completions (100's)	0.38	0.73
Colleges county	3.04	3.67
Schools county	50.72	44.51
Students county (1000's)	34.90	35.80

Table 12: Sample Entry and Attrition

	Persons		
Year	Entry	Attrition	Total
1995	59,399	8,911	59,399
1996	8,825	7,846	59,313
1997	11,672	8,559	63,139
1998	10,747	9,614	65,327
1999	10,972	9,783	66,685
2000	11,532	10,736	68,434
2001	12,060	10,660	69,758
2002	12,754	11,073	71,852
2003	12,408	11,362	73,187
2004	12,888	11,563	74,713
2005	13,531	12,647	76,681
2006	14,202	12,586	78,236
2007	14,885	13,761	80,535
Total	205,875	139,101	907,259

Table 13: Length in Sample

	Persons			Person-Years		
Years Observed	No.	Col %	Cum %	No.	Col %	Cum %
1	47,741	23.2	23.2	47,741	5.3	5.3
2	36,333	17.6	40.8	61,707	6.8	12.1
3	24,231	11.8	52.6	64,461	7.1	19.2
4	17,800	8.6	61.3	64,802	7.1	26.3
5	13,987	6.8	68.0	64,738	7.1	33.4
6	10,967	5.3	73.4	61,477	6.8	40.2
7	9,180	4.5	77.8	60,373	6.7	46.9
8	7,698	3.7	81.6	58,200	6.4	53.3
9	6,671	3.2	84.8	57,146	6.3	59.6
10	5,532	2.7	87.5	52,784	5.8	65.4
11	5,058	2.5	90.0	53,380	5.9	71.3
12	4,366	2.1	92.1	50,088	5.5	76.8
13	3,591	1.7	93.8	45,002	5.0	81.8
14	12,720	6.2	100.0	165,360	18.2	100.0
Total	205,875	100.0		907,259	100.0	

8.2 Preliminary Model Results

Table 14: Credential Decision Results (jointly estimated)

	Advanced Degree			**NBPTS**		
Variable	Coefficient		S.E.	Coefficient		S.E.
Male	-0.302	**	(0.145)	-1.152	***	(0.181)
Black	0.408	**	(0.159)	-1.253	***	(0.278)
Asian	-0.103		(0.285)	-0.016		(0.196)
Hispanic	-0.202		(0.173)	-0.455	***	(0.156)
Other race	0.003		(0.136)	-0.385	**	(0.156)
Experience	-0.217	***	(0.036)	-0.240	***	(0.025)
Experience sq.	-0.645	***	(0.196)	0.752	***	(0.155)
Experience cu.	1.355	***	(0.420)	-1.723	***	(0.320)
Missing experience	0.222		(0.320)	-0.665	***	(0.176)
Male × Exper.	-0.024		(0.043)	0.132	***	(0.043)
Male × Exper. sq.	0.351		(0.398)	-0.943	***	(0.299)
Male × Exper. cu.	-0.986		(0.990)	1.907	***	(0.604)
Black × Exper.	-0.157	***	(0.044)	0.161	***	(0.060)
Black × Exper. sq.	1.502	***	(0.390)	-1.020	**	(0.407)
Black × Exper. cu.	-3.364	***	(0.952)	1.956	**	(0.807)
Advance degree	-		-	0.197	**	(0.097)
Lagged degree decision	-		-	0.046		(0.072)
NBPTS certified	0.144		(0.137)	-		-
Lagged NBPTS decision	-0.978	***	(0.113)	-		-
Lagged switch decision	0.074	*	(0.045)	-0.461	***	(0.050)
Salary (1000's)	0.275	***	(0.027)	0.021	***	(0.003)
Pct. black	-0.295	**	(0.116)	0.002		(0.086)
Male × Pct black	0.188		(0.216)	-0.495	**	(0.205)
Black × Pct black	0.185		(0.225)	-0.436	*	(0.241)
Pct. lunch	0.164		(0.119)	-0.805	***	(0.094)
Pct. lunch missing	-0.175		(0.133)	-0.378	***	(0.111)
Male × Pct lunch	-0.159		(0.233)	0.005		(0.261)
Black Pct free lunch	-0.126		(0.213)	0.038		(0.245)
Students per teacher	0.039	*	(0.024)	0.010		(0.027)
Total students (100's)	0.007		(0.005)	-0.002		(0.004)
WCS: Safe school	0.034	**	(0.017)	0.037	***	(0.014)
WCS: Teachers respect	0.021		(0.020)	0.035	**	(0.017)
WCS: Teachers shielded	-0.039	*	(0.020)	0.008		(0.017)
WCS: Prof. devel.	-0.032	**	(0.015)	-0.044	***	(0.013)
WCS: Class load	0.010		(0.015)	0.028	**	(0.013)
WCS: Interference	0.019		(0.016)	0.005		(0.014)
WCS: High standards	-0.041	**	(0.018)	-0.009		(0.016)
WCS: Inv. w/decisions	0.043	***	(0.016)	-0.003		(0.016)
WCS: Missing	-0.181		(0.185)	0.536	***	(0.169)
Middle School	0.050		(0.036)	-0.092	***	(0.030)
High School	-0.044		(0.052)	0.121	***	(0.040)
Urban	0.083	**	(0.042)	0.073	**	(0.032)

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Table 14 continuing from previous page

	Advanced Degree			**NBPTS**		
Variable	Coefficient		S.E.	Coefficient		S.E.
Coefficient		S.E.				
Rural	0.076	**	(0.038)	-0.086	***	(0.033)
Local rev. pct	-1.012		(0.703)	0.024		(0.509)
Local rev/pupil (1000's)	0.066		(0.063)	-0.001		(0.045)
Expenditures/pupil (1000's)	-0.044	*	(0.025)	0.052	***	(0.019)
Avg. supplement (1000's)	-0.008		(0.006)	0.020	***	(0.005)
Avg. supp. missing	-0.119		(0.143)	0.039		(0.128)
Pct. w/supplement	-0.381	***	(0.136)	0.072		(0.122)
Pct. w/supp. missing	-0.487	***	(0.173)	-0.228		(0.168)
Closings	-0.005		(0.007)	-0.002		(0.008)
Openings	0.027	**	(0.013)	-0.010		(0.012)
SC border	0.206	***	(0.043)	0.022		(0.035)
GA border	0.033		(0.144)	-0.088		(0.125)
TN border	0.088		(0.086)	-0.070		(0.073)
VA border	0.153	**	(0.062)	-0.028		(0.050)
School closed	0.046		(0.228)	0.064		(0.197)
NBPTS salary	0.020	***	(0.002)	0.124	***	(0.005)
Master's salary	0.029	***	(0.007)	0.000		(0.003)
Grad tuition (1000's)	0.030	***	(0.009)	-0.011		(0.008)
Non-ag empl. (1000's)	-0.030	***	(0.007)	0.038	***	(0.006)
Med. income	-0.010	***	(0.003)	-0.007	***	(0.002)
UE	-0.039	***	(0.010)	-0.024	***	(0.009)
Pop. dens. (100's)	0.010		(0.015)	0.010		(0.012)
UG completions (1000's)	-0.068	*	(0.040)	0.028		(0.034)
Grad completions (100's)	0.194	***	(0.054)	0.090	*	(0.047)
Colleges county	0.019		(0.012)	-0.045	***	(0.010)
Schools county	-0.051	*	(0.030)	-0.124	***	(0.025)
Students county (1000's)	0.173	***	(0.047)	0.022		(0.039)
College: Private	-0.079	**	(0.037)	-0.113	***	(0.028)
College: Research I	0.001		(0.061)	0.185	***	(0.044)
College: Urban	0.022		(0.040)	0.015		(0.030)
College: Rural	0.097	**	(0.042)	-0.085	***	(0.032)
NC ed. license	0.352	***	(0.036)	0.258	***	(0.026)
College: Has grad courses	0.178	***	(0.048)	0.008		(0.036)
College: Historically black	-0.049		(0.067)	-0.326	***	(0.067)
College: Most comp.	0.231		(0.199)	0.524	***	(0.145)
College: Highly comp.	0.290	***	(0.091)	0.316	***	(0.070)
College: Very comp.	0.057		(0.057)	0.121	***	(0.044)
Time trend	-1.921	***	(0.125)	0.495	***	(0.146)
Time trend sq.	22.668	***	(1.713)	0.298		(1.928)
Time trend cu.	-7.634	***	(0.700)	-1.694	**	(0.810)
Constant	-7.080	***	(0.515)	-12.065	***	(0.478)

*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

Table 15: Employment Decision Results (jointly estimated)

	Switch Within District			**Switch Outside District**			**Attrit**		
Variable	Coefficient		S.E.	Coefficient		S.E.	Coefficient		S.E.
Male	-0.062		(0.049)	-0.032		(0.111)	-0.063		(0.050)
Black	-0.103	*	(0.062)	0.533	***	(0.153)	0.617	***	(0.061)
Asian	-0.148		(0.104)	-0.078		(0.256)	0.413	***	(0.129)
Hispanic	0.215	***	(0.061)	-0.370	**	(0.175)	0.540	***	(0.082)
Other race	0.007		(0.065)	-0.858	***	(0.176)	-0.013		(0.068)
Experience	0.015	**	(0.006)	-0.253	***	(0.019)	0.034	***	(0.008)
Experience sq.	-0.171	***	(0.049)	0.964	***	(0.135)	-1.887	***	(0.070)
Experience cu.	0.018		(0.109)	-1.617	***	(0.282)	6.548	***	(0.175)
Male × Exper.	0.010		(0.012)	0.135	***	(0.027)	-0.129	***	(0.015)
Male × Exper. sq.	-0.061		(0.089)	-0.821	***	(0.201)	0.984	***	(0.134)
Male × Exper. cu.	0.192		(0.190)	1.450	***	(0.414)	-2.022	***	(0.326)
Black × Exper.	0.040	***	(0.013)	0.107	***	(0.031)	-0.128	***	(0.016)
Black × Exper. sq.	-0.253	***	(0.095)	-0.788	***	(0.228)	1.136	***	(0.135)
Black × Exper. cu.	0.518	***	(0.195)	1.402	***	(0.463)	-2.814	***	(0.315)
Advance degree	0.100	***	(0.016)	0.372	***	(0.043)	0.595	***	(0.023)
NBPTS certified	-0.203	***	(0.068)	-0.222		(0.360)	0.521		(0.504)
Lagged degree decision	-0.084		(0.059)	-0.286	*	(0.148)	0.310	***	(0.063)
Lagged NBPTS decision	0.331	***	(0.055)	0.515	***	(0.146)	-0.452	***	(0.064)
Lagged switch decision	0.148	***	(0.025)	0.712	***	(0.069)	-0.247	***	(0.029)
Salary (1000's)	-0.002		(0.002)	-0.027	***	(0.005)	-0.009	***	(0.003)
Pct. black	0.500	***	(0.049)	1.816	***	(0.115)	0.899	***	(0.052)
Male × Pct black	-0.380	***	(0.086)	-0.362	*	(0.192)	-0.178	**	(0.083)
Black × Pct black	-0.232	**	(0.094)	-2.475	***	(0.230)	-0.129		(0.093)
Pct. lunch	0.620	***	(0.055)	0.730	***	(0.133)	0.025		(0.056)
Pct. lunch missing	0.282	***	(0.060)	0.050		(0.143)	0.187	***	(0.058)
Male × Pct lunch	0.428	***	(0.098)	-0.135		(0.240)	0.998	***	(0.105)
Black Pct free lunch	-0.223	**	(0.094)	0.339		(0.240)	-0.464	***	(0.096)
Students per teacher	0.047	***	(0.010)	0.115	***	(0.024)	-0.020		(0.013)
Total students (100's)	0.021	***	(0.002)	0.004		(0.005)	-0.014	***	(0.002)
WCS: Safe school	-0.001		(0.008)	0.007		(0.018)	0.041	***	(0.008)
WCS: Teachers respect	-0.097	***	(0.009)	-0.157	***	(0.022)	-0.069	***	(0.009)
WCS: Teachers shielded	-0.028	***	(0.009)	-0.044	**	(0.022)	-0.027	***	(0.009)
WCS: Prof. devel.	-0.016	**	(0.007)	-0.030	*	(0.017)	0.015	**	(0.007)

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Table 15 continuing from previous page

	Switch Within District			**Switch Outside District**			**Attrit**		
Variable	Coefficient		S.E.	Coefficient		S.E.	Coefficient		S.E.
WCS: Class load	0.070	***	(0.007)	-0.002		(0.016)	0.018	***	(0.007)
WCS: Interference	-0.015	*	(0.008)	0.004		(0.018)	0.001		(0.008)
WCS: High standards	0.054	***	(0.008)	0.063	***	(0.020)	0.010		(0.009)
WCS: Inv. w/decisions	0.005		(0.008)	-0.011		(0.019)	0.002		(0.008)
WCS: Missing	0.229	***	(0.060)	-0.248	**	(0.117)	0.219	***	(0.073)
Middle School	0.165	***	(0.015)	0.473	***	(0.038)	0.105	***	(0.016)
High School	-0.549	***	(0.025)	0.503	***	(0.051)	0.073	***	(0.022)
Urban	0.036	**	(0.017)	-0.116	***	(0.043)	0.001		(0.018)
Rural	0.045	**	(0.019)	-0.092	**	(0.039)	-0.028	*	(0.017)
Local rev. pct	3.420	***	(0.371)	-3.741	***	(0.694)	-1.154	***	(0.308)
Local rev/pupil (1000's)	-0.352	***	(0.038)	0.186	***	(0.066)	0.142	***	(0.030)
Expenditures/pupil (1000's)	0.188	***	(0.011)	-0.136	***	(0.025)	0.000		(0.011)
Avg. supplement (1000's)	-0.006	***	(0.002)	-0.018	***	(0.005)	-0.004	*	(0.002)
Avg. supp. missing	-0.028		(0.069)	-0.293	*	(0.154)	-0.143	**	(0.068)
Pct. w/supplement	0.227	***	(0.071)	0.186		(0.151)	0.154	**	(0.067)
Pct. w/supp. missing	0.160	*	(0.082)	0.433	**	(0.174)	0.284	***	(0.077)
Closings	0.005	***	(0.001)	-0.004	**	(0.002)	0.018	***	(0.001)
Openings	0.043	***	(0.006)	0.394	***	(0.023)	-0.007		(0.007)
SC border	0.105	***	(0.018)	-0.219	***	(0.043)	-0.003		(0.019)
GA border	0.087		(0.077)	-0.087		(0.174)	0.093		(0.072)
TN border	0.124	**	(0.049)	-0.729	***	(0.107)	0.052		(0.044)
VA border	-0.040		(0.033)	-0.057		(0.059)	0.026		(0.026)
School closed	312.305	***	(0.144)	313.336	***	(0.144)	0.426	***	(0.103)
Non-ag empl. (1000's)	-0.053	***	(0.003)	0.010		(0.007)	-0.002		(0.003)
Med. income	0.008	***	(0.001)	0.023	***	(0.003)	0.005	***	(0.001)
UE	0.001		(0.005)	-0.014		(0.010)	-0.026	***	(0.004)
Pop. dens. (100's)	0.013	**	(0.006)	0.032	**	(0.015)	0.040	***	(0.006)
UG completions (1000's)	0.041	***	(0.015)	-0.279	***	(0.037)	-0.022		(0.017)
Grad completions (100's)	-0.103	***	(0.024)	0.601	***	(0.056)	0.076	***	(0.026)
Colleges county	0.038	***	(0.005)	-0.058	***	(0.013)	-0.028	***	(0.005)
Schools county	0.147	***	(0.013)	-0.236	***	(0.032)	0.004		(0.014)
Students county (1000's)	0.007		(0.019)	0.102	**	(0.048)	0.005		(0.021)
College: Private	-0.033	**	(0.015)	0.024		(0.037)	0.010		(0.015)
College: Research I	-0.015		(0.025)	-0.114	*	(0.063)	0.050	*	(0.027)

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Table 15 continuing from previous page

	Switch Within District			Switch Outside District			Attrit		
Variable	Coefficient		S.E.	Coefficient		S.E.	Coefficient		S.E.
College: Urban	0.020		(0.016)	0.052		(0.041)	-0.005		(0.017)
College: Rural	0.051	***	(0.018)	0.098	**	(0.043)	-0.076	***	(0.018)
NC ed. license	-0.044	***	(0.013)	-0.002		(0.036)	-0.561	***	(0.015)
College: Has grad courses	0.023		(0.018)	0.117	**	(0.046)	0.000		(0.019)
College: Historically black	0.007		(0.029)	-0.147	**	(0.073)	-0.073	**	(0.029)
College: Most comp.	-0.206	**	(0.089)	-0.621	***	(0.201)	0.824	***	(0.104)
College: Highly comp.	-0.142	***	(0.044)	0.203	**	(0.102)	0.360	***	(0.045)
College: Very comp.	-0.023		(0.024)	0.206	***	(0.061)	0.096	***	(0.026)
Time trend	0.241	***	(0.028)	0.195	***	(0.067)	0.446	***	(0.029)
Time trend sq.	-4.300	***	(0.441)	-1.399		(1.034)	-5.358	***	(0.439)
Time trend cu.	1.984	***	(0.203)	0.486		(0.474)	2.141	***	(0.201)
Constant	-13.509	***	(0.190)	-12.987	***	(0.459)	-1.505	***	(0.148)

*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

Table 16: Unobserved Heterogeneity Parameters for Per-Period Equations

		Beginning of Period Decision		**End of Period Decision**		
Point of Support	Probability Weight	Adv. Degree	NBPTS	Switch Within District	Switch Outside District	Attrit
Permanent						
1	0.080		———	Normalized to zero	———	
2	0.436	0.819	1.290	0.570	0.341	-2.530
		(0.086)	(0.229)	(0.075)	(0.084)	(0.032)
3	0.081	0.636	1.178	1.130	0.888	-2.198
		(0.166)	(0.311)	(0.135)	(0.151)	(0.052)
4	0.144	0.414	0.871	0.386	0.005	-2.158
		(0.086)	(0.227)	(0.075)	(0.082)	(0.034)
5	0.259	-4.920	0.346	1.965	3.177	2.835
		(0.229)	(0.735)	(0.210)	(0.462)	(0.411)
Time-varying						
1	0.367		———	Normalized to zero	———	
2	0.559	-0.473	-1.494	-2.628	-1.277	-83.38
		(0.077)	(0.306)	(0.204)	(0.159)	(1.5754)
3	0.073	-0.235	0.480	3.734	3.827	-78.32
		(0.084)	(0.295)	(0.176)	(0.1724)	(1.6987)