Essays on Teacher Mobility

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Economics.

Chapel Hill
2012

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Abstract

JEREMY A. COOK: Essays on Teacher Mobility.
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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. Furthermore, because teachers have preferences over their workplace characteristics, this allocation across schools is nonrandom. This research examines teacher mobility within the school system by focusing on the school characteristics that affect the probability of teachers leaving their current schools. Using longitudinal data on public schools in North Carolina, I estimate teacher mobility probabilities using empirical specifications that incorporate current school characteristics, as well as characteristics of other potential schools.

I jointly estimate these teacher mobility probabilities with two 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. Results show that changes in student demographics have significant effects on one-year mobility probabilities. These changes in demographics have different effects across teachers of different experience levels, with teachers early in their careers being more sensitive to changes in student characteristics and salary than more experienced teachers. Long run results suggest that providing beginning teachers with preferred school characteristics may result in a substantial increase in the number of these teachers remaining in the public school system after five years.

Acknowledgments

I am very grateful for the opportunity to pursue a graduate degree at the University of North Carolina at Chapel Hill. I would like to thank the members of my dissertation committee for their influence and helpful comments at many stages of this research. Most notably, I am indebted to my dissertation advisor, Donna Gilleskie, for taking me on as an advisee. Her feedback and encouragement made a significant contribution to my experience, especially during this past year.

My cohort of economics graduate students at UNC-CH made this experience more enjoyable and memorable. I am appreciative of the camaraderie we shared that eased the burden of the various challenges of a doctoral program.

I am most thankful for my faithful friends and family. Their prayers and encouragement provided me with a renewed perspective during the tougher times. This dissertation is dedicated to my family. I am deeply grateful for their unwavering love and support, especially that of my parents who have sacrificed so much for their children, and my brother, for always lifting my spirits. Finally, I am exceptionally thankful for Abigail and her encouragement, patience, and steadfastness through the daily details.

Table of Contents

List of Tables

List of Figures

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 component 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 expense 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 (Hanushek, 1986; Ehrenberg and Brewer, 1994; 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

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[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.

teachers self-select across schools, oftentimes with more highly qualified teachers working at schools with better resources, lower poverty rates, and fewer minority students (Lankford, Loeb, and Wyckoff, 2002; Clotfelter, Ladd, and Vigdor, 2005). Studies that ignore this non-random sorting of teachers produce biased estimates of the effect of teacher quality on student achievement outcomes.

Based on evidence that teachers are important, expensive, and non-randomly placed inputs, their mobility between schools is worth studying. The primary goal of this research is to examine the determinants of teacher mobility. Specifically this study focuses on the student, school, and district characteristics that influence teacher movements between schools and school districts. I use three empirical approaches to examine this mobility. My first approach uses a multinomial logit model to estimate the mobility probability. This "district level" analysis restricts the mobility outcome to either stay in the current school, switch to another school within the same district, switch to another school in a different district, or leave the school system.

The second and third empirical approaches expand the mobility outcome to include specific school selection. These "school level" analyses use a conditional logit framework with specific schools in the set of mobility alternatives. With these models, regressors vary by alternative, allowing the characteristics of potential schools to affect the probability of leaving a teacher's current school. The second empirical approach uses the entire sample of teachers and does not allow for unobserved heterogeneity. The third empirical approach controls for unobserved heterogeneity and uses a subsample of high school teachers from the Piedmont region of North Carolina. In this model, the set of alternatives includes all high schools in this region.

This research adds to the current literature in several ways. First, I use a dynamic framework to jointly estimate the teacher mobility outcome along with endogenous teacher credential outcomes over time. 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). Teaching experience is also modeled through mobility and attrition outcomes. 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, by using a conditional logit framework this research presents a more comprehensive examination of the determinants of teacher mobility. If teachers are voluntarily leaving their current school for another school, the arrival school characteristics may play an important role in that outcome. Specifying the probability of leaving the current school as a function of both current school characteristics as well as possible future school characteristics introduces a measure of the "pull" aspect of the arrival school characteristics.

Third, 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.

The results of this research show that changes in student demographics have significant effects on teacher mobility, and that these effects vary across teachers with different levels of teaching experience. For example, the results from one model show that an increase in the proportion of black students of 25 percentage points decreases the probability of a teacher staying at her current school by up to 2.8 percentage points for teachers with five or fewer years of experience, compared to 1.4 percentage points for more experienced teachers. These changes in teacher mobility are one-year transition rates. Over time, these changes in school characteristics can have a much larger effect on teacher mobility and attrition.

Potentially, biases still remain in the results of this research. These biases arise from the assumed exogeneity of demand side features of this labor market. In this research I assume that a teacher's employment opportunities, reflected by the discrete alternatives of the mobility equations, are exogenous. Realistically, the mobility of an individual is constrained by the set of offers an individual receives. Ignoring these restrictions may result in biased estimates of mobility probabilities. The potential biases from this assumption are discussed further in Chapter 7.

The remainder of this dissertation is organized in the following structure. Chapter 2 discusses the literature related to teacher mobility and teacher quality. Chapter 3 introduces the general theoretical motivation for the empirical models. Chapter 4 discusses each of the empirical specifications used in estimation. Chapter 5 describes the North Carolina data and the sample of teachers used in the analyses. Chapter 6 presents the estimation results from these different models. Finally, Chapter 7 provides a discussion of this research, including its limitations and the potential biases that may be present. It also discusses the direction of future research. Additional data summaries and all estimated coefficients are included in the appendix.

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 (Kane, Rockoff, and Staiger, 2008; Aaronson, Barrow, and Sander, 2007; Rivkin, Hanushek, and Kain, 2005; Ballou and Podgursky, 1997; Loeb and Page, 2000; 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.[1] The individual's teaching experience (Q_{3it}) entering period t is defined as the number of completed years taught.[2]

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[1]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.

[2]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.

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 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}).

$$U_{it} = U(c_{it}, \ell_{it}, S_{it}, u_{it}; X_i) \tag{3.1}$$

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.[3]

$$c_{it} = \mathbb{I}[h_{it} > 0] * I_{it} - p_t * q_{1it} \tag{3.2}$$

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

$$I_{it} = I(Q_{it}, S_{it}) \tag{3.3}$$

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}).

$$\Omega = h_{it} + \ell_{it} + \tau_{q_1} q_{1it} + \tau_{q_2} q_{2it} \tag{3.4}$$

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

$$U_{it} = \ U(\ I(Q_{it}, S_{it}) - p_t q_{1it},\ \Omega - h_{it} - \tau_{q_1} q_{1it} - \tau_{q_2} q_{2it}, S_{it}, u_{it};\ X_i) \tag{3.5}$$

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 for teacher i in

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

Figure 1, uses the following timing assumptions:

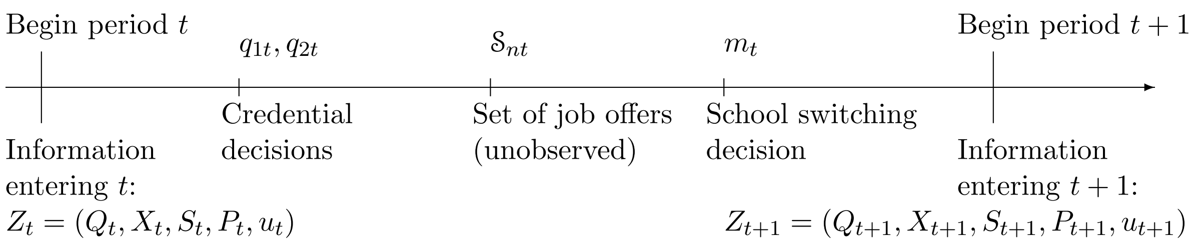
1. The teacher enters the period with knowledge of the state variables (Z_{it}) which include her credentials (Q_{it}), individual characteristics (X_i), current school characteristics (S_{it}), non-school community characteristics (P_t^s), the price and prevalence of credentials (P_t^Q) and preference 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 experience, update her stock of credentials.

3. Given the updated credentials, the teacher receives a set of employment offers ($\mathcal{S}_{nt}$) from the set of all possible offer sets ($\mathcal{S}_t$). 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 3.1: Timing of Behavior



The set of offers, denoted $\mathcal{S}_{nt}$, is the n^{th} offer set from the set of all possible offer sets, $\mathcal{S}_t$. The outside option contained in the offer set $\mathcal{S}_{nt}$ 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 $\mathcal{S}_{nt}$ 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 $\mathcal{S}_{nt} \in \mathcal{S}_t$ is denoted $\pi_t^{\mathcal{S}}$. 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 $\mathcal{S}_{nt}$ the teacher makes the decision whether to stay or leave her current school. The individual makes this decision each period until she chooses the outside option (i.e. attrit from the sample). The lifetime value of choosing a particular credentials combination $q = (q_1, q_2)$ at the beginning of period t conditional on being in school s is:

$$V_q^s(Z_t, \epsilon_t) = U_{it} + \beta W(Z_{t+1}) \quad \forall t \tag{3.6}$$

where

$$W(Z_{t+1}) = \gamma_{t+1} \sum_{\mathcal{S}'_n \in \mathcal{S}'} \pi_{t+1}^{\mathcal{S}'} E_t[\max_{s' \in \mathcal{S}'_{nt+1}} V^{s'}(Z_{t+1})] + (1-\gamma_{t+1}) \sum_{\mathcal{S}''_n \in \mathcal{S}''} \pi_{t+1}^{\mathcal{S}''} E_t[\max_{s'' \in \mathcal{S}''_{nt+1}} V^{s''}(Z_{t+1})] \quad \forall t \tag{3.7}$$

and

$$V^s(Z_{t+1}) = E_t[\max_q V_q^s(Z_{t+1}, \epsilon_{t+1})] \quad \forall s, \forall t \tag{3.8}$$

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 (3.7) captures both the uncertainty of layoff as well as the optimal employment decision among a set of uncertain potential offers. The set of offers $\mathcal{S}'_{nt}$ would exclude continuation at one's current school s; The set of offers $\mathcal{S}''_{nt}$ would include the option to stay at school s. Both sets include the outside option. The value function in equation (3.6) 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. This chapter outlines the empirical specifications of three different approaches to the treatment of the end-of-period mobility decision. The first approach analyzes the mobility outcome at the district level, while the second and third approaches use a school-specific mobility outcome. In each of these approaches, the set of offers ($\mathcal{S}$) described in the previous chapter is assumed to be exogenous. In other words, the empirical estimation does not explicitly model the possibility that many teachers may not be able to move to a school with their preferred characteristics due to demand side restrictions. Chapter 7 includes further discussion of the limitations of this assumption, as well as possible ways future research may alleviate the biases resulting from this assumption.

4.2 District Level Mobility

This empirical specification is motivated by the teacher decision outlined in the theoretical framework. These decisions produce two credential outcomes as well as the mobility outcome at the end of the period.

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.[1] 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}), a vector of exogenous community variables (P_{it}^S) that describe the non-school characteristics of the community and a vector of exogenous credential variables (P_{it}^Q) that describe the costs and incentives related to obtaining these credentials.

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,

$$u_{it} = \mu_i + \nu_{it} + \epsilon_{it} \tag{4.1}$$

Conditional on the correlated error components, the i.i.d. error component (ϵ_{it}) produces logit probabilities of the credential outcomes. Equations (4.2) and (4.3) 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:

$$\begin{aligned} \ln\left[\frac{Pr(q_{1it}=1 \mid Q_{1it}=0)}{Pr(q_{1it}=0 \mid Q_{1it}=0)}\right] &= \beta_0 + \beta_1 Q_{2it} + \beta_2 Q_{3it} + \beta_3 X_{it} \\ &\quad + \beta_4 S_{it} + \beta_5 P_{it}^Q + \beta_6 P_{it}^S + \mu_{1i} + \nu_{1it} \end{aligned} \tag{4.2}$$

[1] 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.

The log odds ratio of becoming national board certified:

$$\ln\left[\frac{Pr(q_{2it}=1 \mid Q_{2it}=0,\ Q_{3it}\geq 3)}{Pr(q_{2it}=0 \mid Q_{2it}=0,\ Q_{3it}\geq 3)}\right] = \delta_0 + \delta_1 Q_{1it} + \delta_2 Q_{3it} + \delta_3 X_{it} + \delta_4 S_{it} + \delta_5 P^Q_{it} + \delta_6 P^S_{it} + \mu_{2i} + \nu_{2it} \tag{4.3}$$

Each of these probabilities is estimated as a discrete-time duration model. Note that each equation is 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 chapter, 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}). It is also conditional on not choosing the outside option, which in these data equate with attrition from 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 (a_{it}) indicating the last period an individual is observed. The log odds ratio of attrition at the end of period t is

$$\ln\left[\frac{Pr(a_{it}=1)}{Pr(a_{it}=0)}\right] = \eta_0 + \eta_1 Q_{1it+1} + \eta_2 Q_{2it+1} + \eta_3 Q_{3it+1} + \eta_4 X_{it} + \eta_5 S_{it} + \eta_6 P^S_{it} + \mu_{3i} + \nu_{3it} \tag{4.4}$$

I define the end-of-period employment decision (m_{it}), conditional on not attritting ($a_{it} = 0$),to include three options:

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

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

$$\begin{aligned} \ln\left[\frac{Pr(m_{it} = m) \mid a_{it} = 0}{Pr(m_{it} = 0) \mid a_{it} = 0}\right] &= \lambda_0^m + \lambda_1^m Q_{1it+1} + \lambda_2^m Q_{2it+1} + \lambda_3^m Q_{3it+1} + \lambda_4^m X_{it} \\ &+ \lambda_5^m S_{it} + \lambda_6^m P_{it}^S + \mu_{4i}^m + \nu_{4it}^m \qquad m = 1, 2 \end{aligned} \tag{4.5}$$

Note that the vector of exogenous variables (P_{it}^Q) that shift demand for credentials is not included in equations (4.4) and (4.5). I assume that the current level (period t) of these variables affect the mobility outcome only through the updated credential stock variables (i.e., P_{it}^Q has no effect on the employment decision conditional upon the updated stock of credentials).

4.3 Estimation Technique

I jointly estimate equations (4.2) through (4.5) 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 estimation 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 and Guillkey, 1995; Mroz, 1999). 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.

4.4 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. [2]

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 Surette, 1998; Mroz and Savage, 2006). In this sense, the entire history of exogenous time-varying variables act as instruments for endogenous variables in the current period.[3]

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 school 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. In order to model the initial school quality of a teacher I create a trichotomous index of low, medium, and high quality based on observable school quality characteristics. The exclusion restrictions used need to influence these initial levels without influencing the later outcomes conditioned on the initial

[2] As evident in the appendix, these instruments are statistically significant in the credential equations. Furthermore, when included in the mobility equation, a likelhood ratio test failed to reject the null hypothesis of joint significance at the 10% level.

[3] 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.

endogenous value.

Identification for initially observed values for master's degree, national board certification status, experience, and school quality comes from several variables. These variables include historic salary schedules for teachers in North Carolina that identify differentials in salary across certifications and 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.[4] 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. Identification of these initial conditions also comes from indicator variables representing the region in which an individual received her first bachelor's degree. The rationale for this identification variable is that teachers from colleges outside of North Carolina may have different barriers to obtaining a position within the North Carolina public school system.[5]

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.

4.5 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}.

[4]License Certification Requirements, All Fifty States, [serial] 1959-2008.

[5]Conditional upon the initial endogenous value, these exclusion restrictions were found to be jointly insignifiant in the per-period equations using a likelihood ratio test.

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:

$$
\begin{aligned}
\mathcal{L}_i(\Theta, \rho, \psi) = \sum_{k=1}^{K} \rho_k \Bigg\{ & \prod_{q_1=0}^{1} Pr(Q_{11} = q_1 \mid \mu_{5k})^{\mathbb{1}\{Q_{1i1}=q_1\}} \prod_{q_2=0}^{1} Pr(Q_{21} = q_2 \mid \mu_{6k})^{\mathbb{1}\{Q_{2i1}=q_2\}\mathbb{1}\{Q_{3i1}>3\}} \\
& \frac{1}{\sigma}\Phi(\ln Q_{31} \mid \mu_{7k}) \prod_{s=1}^{3} Pr(S_1 = s \mid \mu_{8k}^{s})^{\mathbb{1}\{S_{i1}=s\}} \\
& \prod_{t=1}^{T} \sum_{g=1}^{G} \psi_g \Bigg[\prod_{q_1=0}^{1} Pr(q_{1t} = q_1 \mid \mu_{1k}, \nu_{1tg}, Q_{1it} = 0)^{\mathbb{1}\{q_{1it}=q_1\}\mathbb{1}\{Q_{1it}=0\}} \\
& \prod_{q_2=0}^{1} Pr(q_{2t} = q_2 \mid \mu_{2k}, \nu_{2tg}, Q_{2it} = 0)^{\mathbb{1}\{q_{2it}=q_2\}\mathbb{1}\{Q_{2it}=0\}\mathbb{1}\{Q_{3it}>3\}} \\
& \prod_{a=0}^{1} Pr(a_t = a \mid \mu_{3k}, \nu_{3tg})^{\mathbb{1}\{a_{it}=a\}} \\
& \prod_{m=0}^{2} Pr(m_t = m \mid \mu_{4k}^{m}, \nu_{4tg}^{m})^{\mathbb{1}\{m_{it}=m\}\mathbb{1}\{a_{it}=0\}} \Bigg] \Bigg\}
\end{aligned}
\tag{4.6}
$$

The respective joint probabilities of the permanent and time-varying mass points are given by equations (4.7) and (4.8):

$$
\begin{aligned}
\rho_k = Pr(&\mu_1 = \mu_{1k}, \mu_2 = \mu_{2k}, \mu_3 = \mu_{3k}, \mu_4^0 = \mu_{4k}^0, \mu_4^1 = \mu_{4k}^1, \mu_4^2 = \mu_{4k}^2, \mu_5 = \mu_{5k}, \\
&\mu_6 = \mu_{6k}, \mu_7 = \mu_{7k}, \mu_8^1 = \mu_{8k}^1, \mu_8^2 = \mu_{8k}^2, \mu_8^3 = \mu_{8k}^3)
\end{aligned}
\tag{4.7}
$$

$$
\psi_g = Pr(\nu_1 = \nu_{1g}, \nu_2 = \nu_{2g}, \nu_3 = \nu_{3g}, \nu_4^0 = \nu_{4g}^0, \nu_4^1 = \nu_{4g}^1, \nu_4^2 = \nu_{4g}^2) \tag{4.8}
$$

The joint likelihood function over all individuals is given by:

$$
\mathcal{L}(\Theta) = \prod_{i=1}^{N} \mathcal{L}_i(\Theta, \rho, \psi) \tag{4.9}
$$

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.

4.6 School Level Mobility

The empirical model presented in the previous section of this chapter treats the mobility outcome of the teacher as a function of current school characteristics. Specifically, the outcome of the mobility equation (4.5) has a multinomial logit specification. This trichotomous outcome indicating the mobility of a teacher restricts the categories to whether the teacher stays at her current school, moves to a new school in the same district, or moves to a new school in a different district. At this level of analysis, the characteristics of the departing school are used, while the arrival school characteristics are not used. Since only the current school characteristics enter the equation as regressors, the estimated probability of switching schools is not a function of employment opportunities at other schools. Effectually, this specification captures only the "push" aspect of current school characteristics.

Inherently, when an individual contemplates the decision to leave a job, he/she weighs the utility received at the current job versus the utility at a potential new job. Analogously, the teacher considers the characteristics of the potential future school when deciding whether to leave his/her current school. Incorporating this "pull" aspect of other schools requires the probability of switching schools be a function of the characteristics of those other schools.

A conditional logit model is a more appropriate empirical specification when the choice of an individual is dependent upon the characteristics of each alternative. This model differs from the standard multinomial logit model in that conditional model regressors vary by alternative. Also, unlike a multinomial logit model where each regressor has a different coefficient for each outcome, the conditional logit outcomes share a common parameter for each characteristic. [6]

The timeline of Figure (3.1) has an individual making a mobility decision (m_t) at the end of the period. Let this decision be a choice of school s among $\mathcal{S}$ schools. Consider a conditional logit specification with each discrete outcome representing a specific school. The probability of selecting school s_j is a function of school s_j characteristics, as well as the characteristics of all other schools in $\mathcal{S}$. Let S_j represent a vector of school characteristics for school s_j, and

[6] See Wooldridge (2001) or Cameron and Trivedi (2005) for further discussion regarding these discrete outcome models.

$X_i^{S_j}$ represent a vector of alternative-invariant individual characteristics of teacher i interacted with school characteristics S_j. These individual characteristics include the credential stock and personal characteristics in the previous specification. In addition to the school characteristics used in the previous specification, the vector of alternative-varying characteristics includes an indicator variable representing the current school of the teacher. This vector also includes the distance in miles from the teacher's current school to each alternative. These two variables are used to assist in explaining the barrier of leaving the current school for another alternative. The average salary at each school is used as an approximation of the salary a teacher could potentially earn if that school alternative were selected by the teacher. An i.i.d. extreme value error component produces the logit probability of choosing a specific school s_j from a set of alternatives $\mathcal{S}$:

$$Pr(m_{it} = s_j) = \frac{\exp\left(\alpha_1 S_j + \alpha_2 X_i^{S_j}\right)}{\sum_{h \in \mathcal{S}} \exp\left(\alpha_1 S_h + \alpha_2 X_i^{S_h}\right)} \tag{4.10}$$

The relative probabilities of choosing one school over another can also be expressed as a log odds ratio. Note that the relative probability of choosing one school over another school is a function of the differences in alternative characteristics. The empirical equation in log odds of choosing school s_j relative to another school s_k:

$$\ln\left[\frac{Pr(m_{it} = s_j)}{Pr(m_{it} = s_k)}\right] = \alpha_1(S_j - S_k) + \alpha_2(X_i^{S_j} - X_i^{S_k}) \tag{4.11}$$

Estimating equation (4.10) for each school in the sample would require a model with approximately 2000 discrete outcomes for each individual. Given this large number of alternatives, and the number of individuals in the sample, estimating (4.10) is computationally burdensome. One method of reducing the computational cost of this model is to reduce the number of alternatives in the choice set of individuals. The following two empirical approaches of this research use difference specifications to reduce this burden.

4.6.1 Random Sampling of Alternatives

McFadden (1978) describes a method to randomly sample a choice set when using the entire set of alternatives is infeasible. This random sampling approach has been used in discrete choice applications involving recreational sites, utility demand, and residential location (Parsons and Kealy, 1992; Train, McFadden, and Ben-Akiva, 1987; Liu, Mroz, and van der Klaauw, 2010). Let $K \subseteq \mathcal{S}$, where K is a subset of schools in the full set of schools $\mathcal{S}$. Let $q(K|s_j)$ represent the probability that subset K is drawn given that alternative s_j is selected.

If the researcher assigns an unequal probability for each subset of alternatives given the selected alternative then the choice probability is altered to include an alternative-specific correction term added to the representative utility. This correction term accounts for the bias caused by the random sampling of alternatives. During estimation the parameter for this term is constrained to one. Letting V_j represent the indirect utility of choosing s_j, McFadden (1978) shows that under the Independence of Irrelevant Alternatives (IIA) property the probability of choosing alternative s_j given the choice set K becomes:

$$Pr(m_i = s_j \mid K) = \frac{exp(V_j + \ln q(K \mid s_j))}{\sum_{k \in K} exp(V_k + \ln q(K \mid s_k))} \tag{4.12}$$

When the the probability of entering the choice set is equal for each of the non-chosen alternatives, McFadden (1978) shows that under the uniform conditioning property the alternative specific correction terms cancel in the choice probability. This property leads to estimation that is the same as the standard conditional logit.[7]

The specification in equation (4.11) contains only regressors which vary by alternative. A specification which includes both alternative-varying and alternative-invariant regressors is commonly referred to as a mixed logit model. Similar to a multinomial logit model, the alternative-invariant regressors of a mixed logit model have a unique coefficient for each alternative. Each of these coefficients represent the different effect the alternative-invariant regressor has on the probability of each specific alternative. For example, teacher gender would have a

[7]Ben-Akiva and Lerman (1985) and Train (2003) provide a more thorough discussion of McFadden (1978) and applications.

unique coefficient for each school alternative, which represents the different effect on the probability of selecting each school alternative. In the context of random sampling a set of alternatives, the interpretation of alternative-specific parameters for alternative-invariant regressors is less clear. The coefficients, although consistent, are determined from the randomly sampled set of alternatives. In this case, there is not a specific coefficient estimated for each specific alternative from the entire set of alternatives, but rather, the randomly sampled alternative sets which vary across individuals. In estimation, the k^{th} alternative for individual i could be different from the k^{th} alternative for individual j. The resulting coefficient for alternative k cannot be associated with a specific school, but rather only the k^{th} alternative. Therefore, alternative-invariant regressors are avoided by interacting these alternative-invariant regressors with alternative-varying regressors. Likewise, estimating a conditional logit equation jointly with other equations using a DFRE method with alternative-invariant unobserved heterogeneity components produces unintuitive effects of these components for each randomly sampled alternative. For this reason, I estimate the choice probabilities from equation (4.10) with a conditional logit model that is not jointly estimated with the credential equations outlined in the previous section. Without modeling the unobserved heterogeneity, I only recover biased estimates of the effect of endogenous credentials. With this model, estimation uses 20 randomly selected schools for the set of alternatives, including the school chosen by the teacher. The probability of entering the choice set is equal for each non-chosen alternative.

4.6.2 Subsample of Teachers

In order to allow for unobserved heterogeneity, the final empirical approach of this dissertation reduces the computational burden of a conditional logit model through limiting the sample of individuals, and subsequently, reducing the set of alternatives. For this specification, I use a regionally-specific sample of teachers who move only within this regional set of schools. Each teacher faces the same set of alternatives, and I assume they consistently choose from this set of alternatives each period. This subsample of individuals consists of teachers from 70 high schools in the central Piedmont region of North Carolina. Further description of this sample is included in the next chapter.

I estimate the conditional logit equation jointly with the credential, attrition, and initial conditions equations using the DFRE method each described in section 4.3. With this approach, the computational burden is reduced, and the equivocal interpretation of heterogeneity terms for randomly sampled alternatives is avoided. The mobility probability equation at the end of the period includes the 70 schools as discrete alternatives. Accordingly, the mobility outcome established in equation (4.5) is altered to include the subset of alternatives.

$$\ln\left[\frac{Pr(m_{it}=s_j)}{Pr(m_{it}=s_k)}\right] = \gamma_1(S_j - S_k) + \gamma_2(X_i^{S_j} - X_i^{S_k}) + \mu_{3i}^j + \nu_{3it}^j \quad j \neq k, j = 1, ..., 70 \tag{4.13}$$

Equation (4.13) is correlated with equations (4.2) through (4.3) through the individual permanent (μ_{4i}^j) and time-varying (ν_{4it}^j) heterogeneity components. As in the previous specification, the joint distribution of μ and ν is estimated using a discrete factor random effects method. In equation (4.13) the unobserved heterogeneity type is allowed to enter with a different marginal effect for each alternative. In this respect, the specification contains both alternative-invariant parameters for the regressors (S_j, X^{S_j}) as well as alternative-varying parameters representing the marginal effect of each unobserved type on the probability of choosing an alternative.

The segment of the likelihood function of equation (4.6) representing the contribution of the mobility outcome is altered to include the choice of school from the subset of 70 alternatives as follows:

$$\prod_{j=1}^{70} Pr(m_t = s_j \mid \mu_{3k}^j, \nu_{3tg}^j)^{\mathbb{1}\{m_{it}=s_j\}} \tag{4.14}$$

Estimation results using these specifications are discussed in Chapter 6.

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, NBPTS certification, state-based salary and total teaching experience. The education and certification data include information on the date the degree or certification was 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 university, 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 B.1 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.[1]

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 load, and professional development. Table A.1 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

[1] 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.

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 B.2.

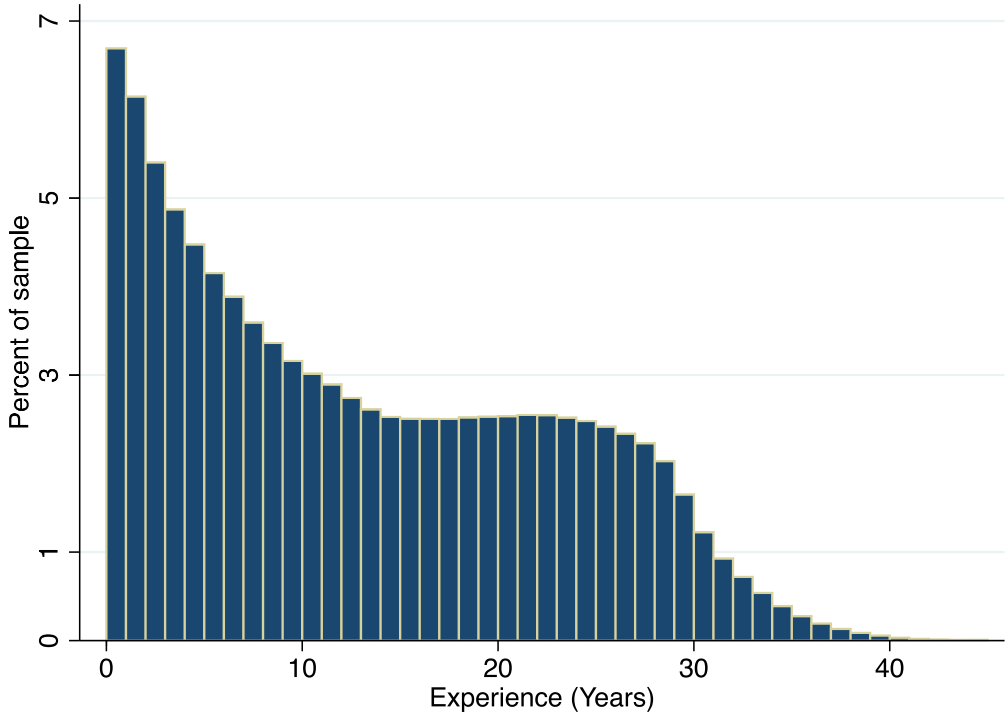
5.2 Sample Selection

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.[2]

Figure 5.1 represents a histogram of years of teaching experience in the sample. Although this histogram provides a description of the school system over a specific period of time, the decreasing height of the bins roughly measures the rate of attrition across teaching experience. There is a large mass of teachers with fewer than five years of teaching experience. The large drop in teaching experience suggests high attrition within the first few years teaching. This attrition decreases near 15 years of experience, where we see a constant percentage of teachers across these middle years of experience. The proportion of individuals in the sample with 28 or more years of experience decreases substantially at each additional year of experience. This decrease is most likely due to the range of retirement benefit age requirements based on an individual's age and state employment history.

[2]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.

Figure 5.1: Teaching Experience



Figures 5.2 and 5.3 display the teacher outcomes across years of experience for the credentials and mobility, respectively. Teachers with fewer years of experience obtain an advanced degree at a greater frequency than other teachers. This percentage peaks at four years of experience with 3.7% of teachers obtaining an advanced degree. The percentage steadily declines across years of experience. The percentage of outcomes across experience for NBPTS are similar to that of an advanced degree. The percentage of teachers obtaining NBPTS certification peaks at five years of experience with 2.6% of teachers with that experience. This percentage decreases steadily across years of experience, with a larger percentage of experienced teachers obtaining NBPTS certification than those obtaining an advanced degree.

Figure 5.3 contains the mobility outcomes across years of experience for moving to a new school within the same district, moving to a new school outside of the current district, and attritting from the school system. Teachers within the first few years of teaching have a high attrition rate. As shown, over 40% of teachers in their first year of teaching leave their current school by either switching to a different school or attritting. The percentage of teachers attritting decreases significantly over the first several years of experience. This rate of attrition is relatively constant over mid-career teachers, and then increases significantly as teachers reach retirement age. Teachers switching schools more often move to a school within the same district, compared to moving to a new district.

Figure 5.2: Credential Outcomes

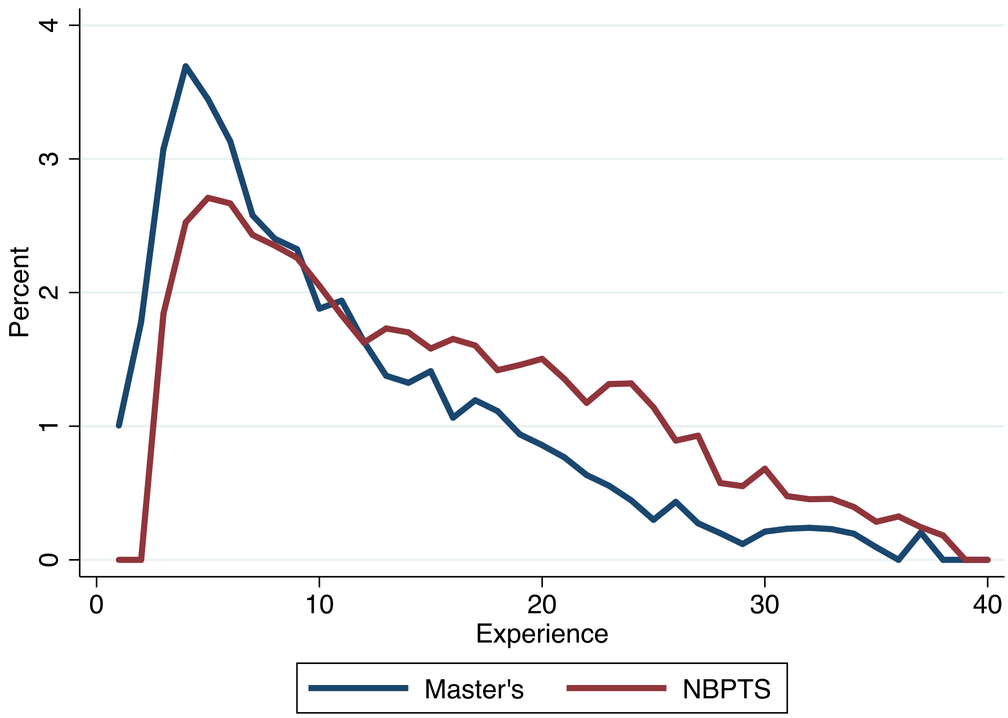
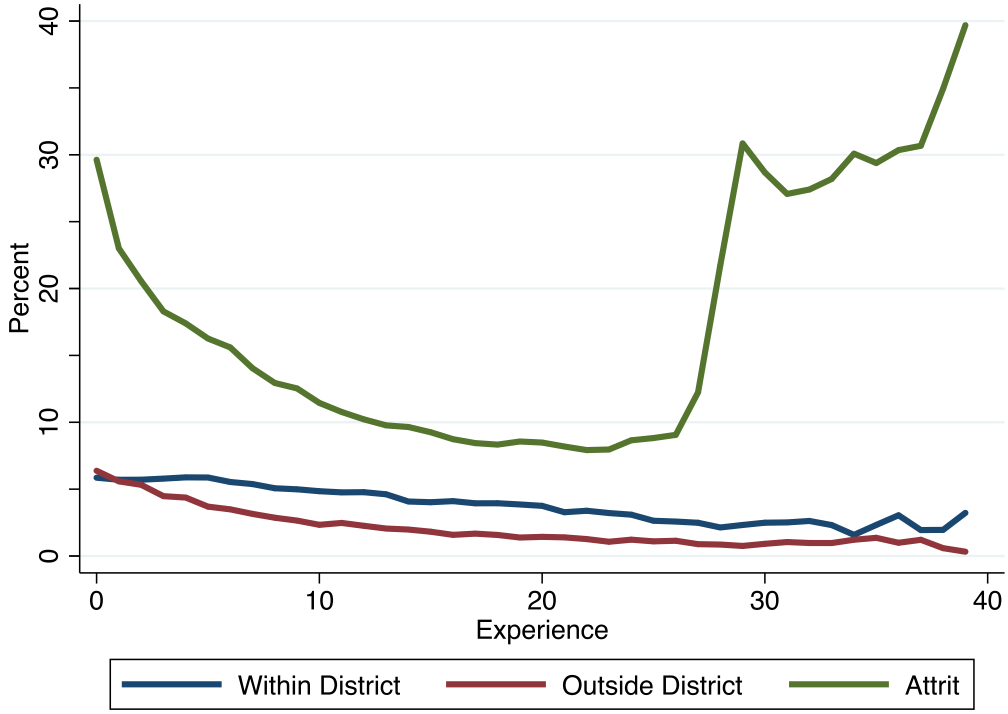


Figure 5.3: Mobility Outcomes



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 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 B.3 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 individuals entering than leaving the sample. Overall, my sample contains 205,875 individuals providing 907,259 person-year observations. Table B.4 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 5.1 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 5.1: 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: School is safe	2.15	1.17	2.42	1.14
WCS: Teachers respected	2.13	1.15	2.38	1.11
WCS:Teachers shielded from disruptions	2.14	1.17	2.37	1.13
Professional development	2.23	1.16	2.37	1.09
Reasonable class load	2.24	1.16	2.31	1.09
Low interfering duties	2.19	1.17	2.37	1.11
High standards for teachers	2.15	1.15	2.36	1.11
Teachers involved w/decisions	2.03	1.19	2.12	1.19

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 A.1 of the appendix.

5.3 Subsample of Teachers

The third empirical approach of this dissertation uses a subsample of teachers and schools in order to reduce the size of the set of alternatives. The subsample includes high school teachers in the central Piedmont region of North Carolina. North Carolina's Piedmont region is generally considered to be the 35 counties in the region between the foothills of the Appalachian Mountains and the coastal plain.[3] The subsample includes 14 counties within the central area of the Piedmont region, excluding counties on the border of either Virginia or South Carolina. In choosing a subsample of schools, border counties are excluded considering teachers near state borders may more frequently appear to have attritted from the data, when in actuality they are moving to a school in another state. The sample from this region includes 11,519 teachers from schools in Alamance, Chatham, Davidson, Davie, Durham, Forsyth, Guilford, Lee, Montgomery, Moore, Orange, Randolph, Wake, and Yadkin counties. A total of 18 school districts are within this sample of counties, including 70 high schools. Several large school districts are included in this sample from metropolitan areas such as Durham, Raleigh, Greensboro, and Winston-Salem, as well as their more rural surroundings.

[3] North Carolina Department of the Secretary of State, 2012.

6 Results

6.1 District Level Model Results

Estimates of the parameters for the credential and mobility equations are presented in Table C.1 and Table C.2 of the appendix. These equations are estimated jointly using a discrete factor random effects method allowing the equations to be correlated across 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 optimal number of mass points was determined by adding additional mass points until the log-likelihood failed to improve as determined using a likelihood ratio test. The probability weights and mass point are presented in Table C.3 of the appendix.

Table 6.1 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 6.1 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.

6.1.1 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

Table 6.1: District Level Model Fit: Predicted Outcomes versus Observed Outcomes

	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

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 of experience, advanced degree, and NBPTS certification. All marginal effects are one-period effects averaged over these groups of teachers. Standard errors for these marginal effects are semi-parametrically bootstrapped using 100 replications. Table 6.2 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 higher 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 the average teacher and teachers with advanced degrees.

Table 6.3 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 6.2. Based on these results, this

Table 6.2: Baseline Probabilities

Teacher Characteristics	Probability			
	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

increase decreases the probability a teacher will stay at her current school for all teacher groups evaluated, with the exception of teachers with fiver or fewer years of experience. This effect is largest for teachers with eleven or more years of experience, with a decrease in the probability of staying by 1.47 percentage points. Given a teacher stays within the public school system, the results show that the increase in eligible students for free lunch has a positive effect on both the probability of moving within the same district or moving to a new district.

Table 6.4 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 2.8 percentage point decrease in the probability of staying. In addition, inexperienced teachers switching schools tend to move to a new school district, as opposed to switching within the same district. These results suggest that, in addition to specific schools having trouble keeping teachers, the public school system in general faces difficulties in retaining these teachers.

Table 6.3: 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	0.54	***	0.62	***	0.34	***	-1.51	***
	(0.03)		(0.02)		(0.03)		(0.02)	
3 to 5	0.15	***	0.64	***	0.31	***	-1.11	***
	(0.03)		(0.02)		(0.03)		(0.02)	
6 to 10	-0.40	***	0.59	***	0.20	***	-0.39	***
	(0.03)		(0.02)		(0.02)		(0.02)	
11 plus	-1.47	***	0.38	***	0.59	***	0.49	***
	(0.02)		(0.01)		(0.01)		(0.01)	
Advanced degree	-1.03	***	0.48	***	0.13	***	0.42	***
	(0.02)		(0.01)		(0.02)		(0.02)	
NBPTS	-0.96	***	0.37	***	0.09	***	0.53	***
	(0.03)		(0.01)		(0.02)		(0.03)	
All teachers	-0.97	***	0.47	***	0.15	***	0.36	***
	(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 6.4: 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	-2.77	***	-0.25	***	0.41	***	2.59	***
	(0.02)		(0.02)		(0.03)		(0.01)	
3 to 5	-2.78	***	-0.27	***	0.39	***	2.64	***
	(0.02)		(0.01)		(0.03)		(0.01)	
6 to 10	-2.38	***	-0.18	***	0.24	***	2.30	***
	(0.02)		(0.01)		(0.02)		(0.01)	
11 plus	-1.44	***	0.44	***	0.09	***	0.88	***
	(0.02)		(0.01)		(0.02)		(0.01)	
Advanced degree	-2.29	***	-0.13	***	0.19	***	2.23	***
	(0.02)		(0.01)		(0.02)		(0.01)	
NBPTS	-0.80	***	-0.14	***	0.20	***	0.77	***
	(0.02)		(0.02)		(0.02)		(0.02)	
All teachers	-2.19	***	-0.15	***	0.23	***	2.12	***
	(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 Table 6.5. Table 6.5 shows that, averaged over all teachers, 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 1.58 percentage points. While this increase in salary has the same effect on the probability of staying at the current school for NBPTS teachers as it does all teachers, this effect is almost twice as large for teachers with an advanced degree. The increase in salary is associated with a decrease in the attrition probability averaged over all teachers. However, there is a positive and significant effect of this increase of salary on the attrition of teachers with three to ten years of experience. This result is puzzling due to its inconsistency with traditional labor supply theory. Considering that it is difficult to imagine a scenario where individuals dislike a higher salary, other causes, including the demand side assumptions discussed earlier, are plausible. Further discussion of potential biases are included in Chapter 7.

Table 6.5: 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	1.58	***	-0.13	**	-0.28	***	-1.20	***
	(0.02)		(0.01)		(0.01)		(0.02)	
3 to 5	0.36	***	-0.19	***	-0.26	***	0.09	***
	(0.02)		(0.01)		(0.01)		(0.02)	
6 to 10	-0.16	***	-0.08		-0.20	***	0.44	***
	(0.02)		(0.01)		(0.01)		(0.02)	
11 plus	0.27	***	0.06	***	-0.11	***	-0.23	***
	(0.01)		(0.01)		(0.01)		(0.01)	
Advanced degree	0.61	***	-0.00	***	-0.13	***	-0.47	***
	(0.02)		(0.01)		(0.01)		(0.02)	
NBPTS	0.33	***	-0.01	***	-0.08	***	-0.23	***
	(0.02)		(0.01)		(0.01)		(0.02)	
All teachers	0.34	***	-0.01		-0.15	***	-0.18	***
	(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.

Figures 6.1 through 6.6 present the marginal effects across the full range of teaching experience. Figure 6.1 shows the relatively constant effect across experience level of the increase in free lunch students on switching schools. This change in student composition has a much larger, and varying, effect on attrition across experience levels. This increase decreases the probability of attrition for teaching with less than ten years of experience. Figures 6.4 through 6.6 compare the marginal effects of the select school characteristics on attrition across teachers with different credentials. The change in percentage of free lunch students generally has a similar effect on attrition for teachers with NBPTS certification or a master's degree as it does to all teachers. As shown in Figure 6.5, the effect of a change in the percentage of black students has a much lower effect on attrition for NBPTS certified teachers than teachers with a master's degree and teachers without these certifications. The effect of the $5,000 increase in salary has a similar pattern across experience for teachers with different credentials, however, this change in salary has a larger decrease in attrition for NBPTS and master's degree teachers.

Figure 6.1: Effect of 25 Percentage Point Increase in Pct. Lunch on Mobility

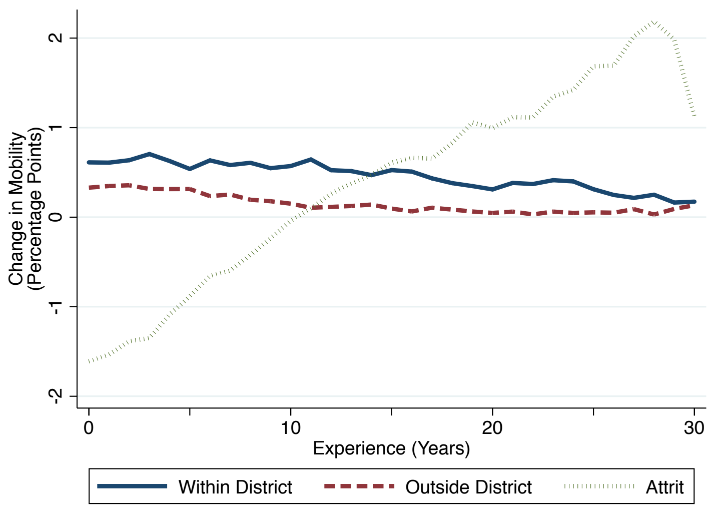


Figure 6.2: Effect of 25 Percentage Point Increase in Pct. Black on Mobility

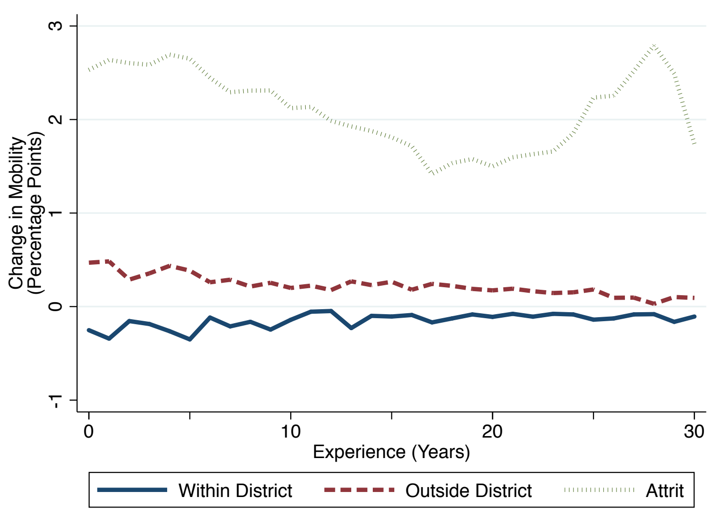


Figure 6.3: Effect of $5,000 Increase in Salary on Mobility

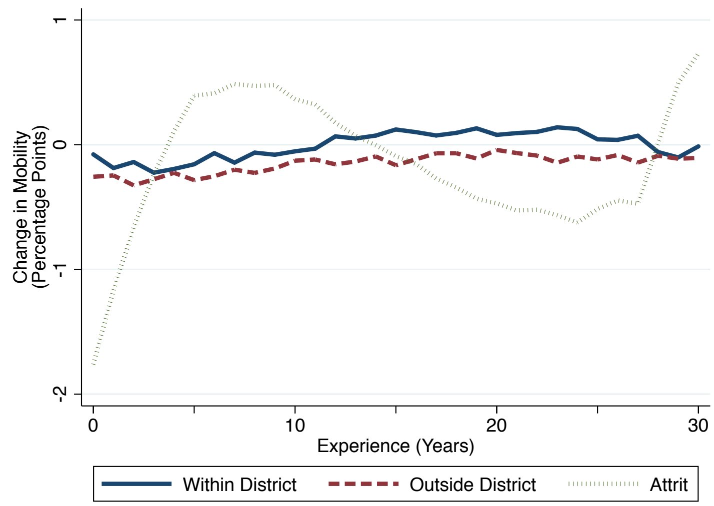


Figure 6.4: Effect of 25 Percentage Point Increase in Pct. Lunch on Attrition
Comparison Across Teacher Groups

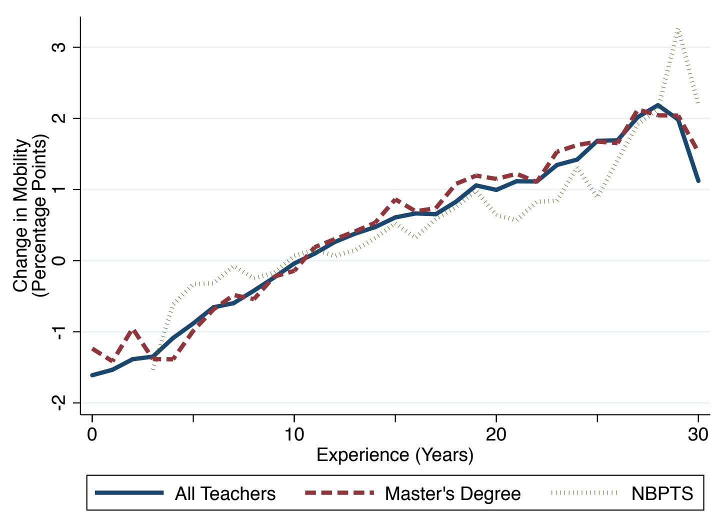


Figure 6.5: Effect of 25 Percentage Point Increase in Pct. Black on Attrition
Comparison Across Teacher Groups

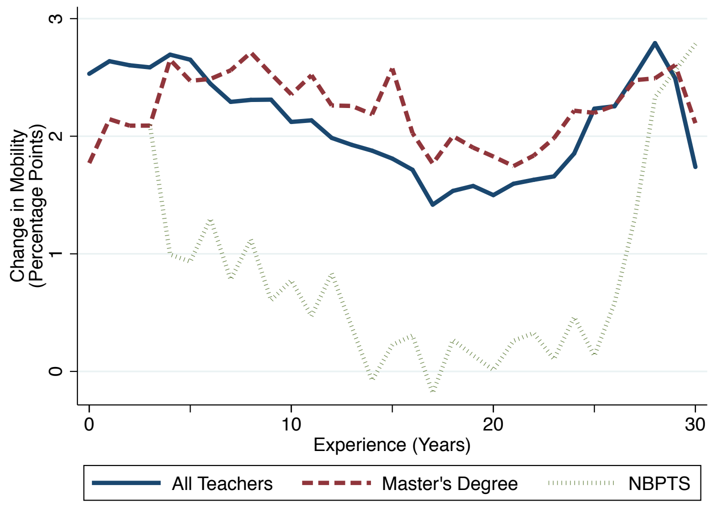
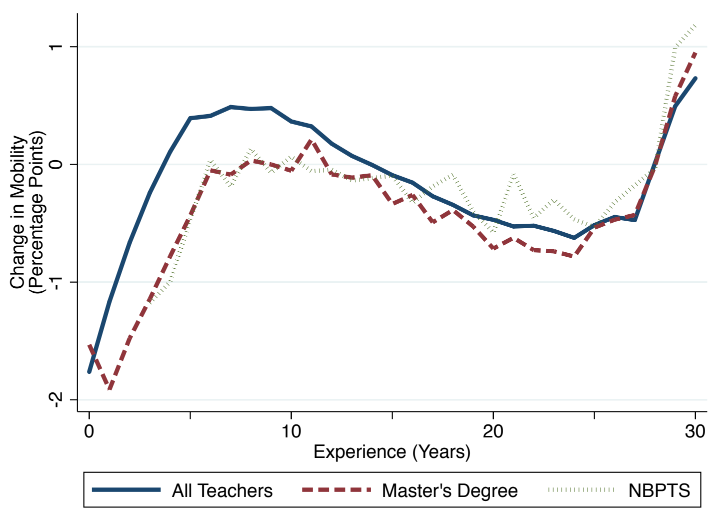


Figure 6.6: Effect of $5,000 Increase in Salary on Attrition
Comparison Across Teacher Groups



6.1.2 Long Run Effects

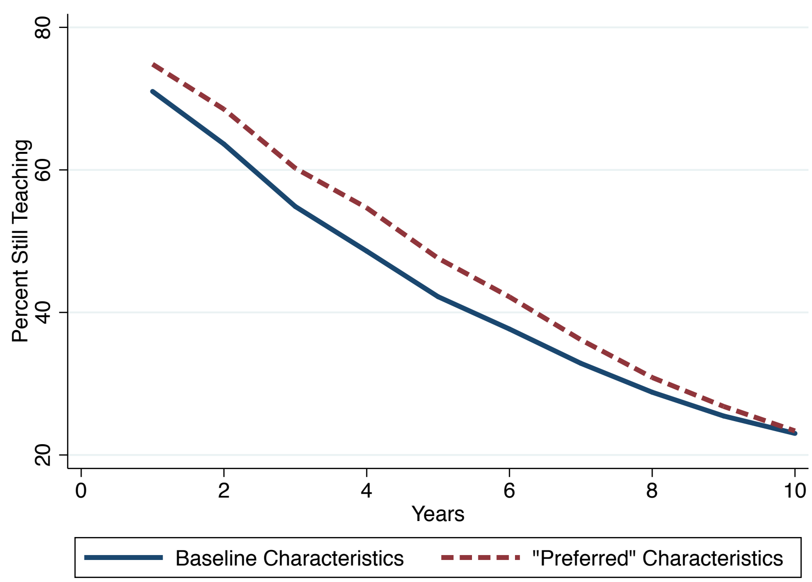
One of the features of this study is the modeling of the mobility and credential outcomes dynamically. This attribute allows for the ability to capture long run marginal effects. While the short-run, within-period, effects may appear small, the effects of some characteristics may be greater in the long run. When informing policy, it is useful to consider potential effects beyond the current period.

Given the high rates of attrition of inexperienced teachers, policy makers and school administrators may be interested in the long run effects of school characteristics on the size of a teacher cohort. For example, they may consider providing new or inexperienced teachers an environment that limits stress and is conducive for professional development. This improved environment may come through programs to alleviate the school characteristics that are correlated with teacher attrition, or even programs to place new teachers in schools with established environments. Once a teacher accumulates teaching experience, she may be more apt to handle the challenges of teaching and remain in the public school system longer.

In order to evaluate the potential effects of these policies on inexperienced teachers, I use the dynamic model to simulate teacher attrition outcomes. For this simulation, I start with teachers with zero years of teaching experience in 1995 (approximately 4,000 teachers). In order to provide teachers with an improved environment, I change the school characteristics of these teachers to be in the top decile of the characteristics shown to be "preferred" by teachers. These characteristics include percent of students eligible for free or reduced lunch, percent of black students, and the working conditions characterizing factors such as school safety, professional development opportunities, and administrative support. The credential outcomes, as well as the attrition outcomes, are simulated forward across periods, while integrating over the distribution of unobserved heterogeneity.

Figure 6.7 contains the results of this policy simulation. The results of the baseline characteristics represents the simulated attrition of teachers at schools with characteristics as observed in the data. The results of the "preferred" characteristics represents the simulated attrition of these teachers if they were placed in environments with the preferred characteristics as described above. The simulated results show the percentage of these inexperienced teachers remaining in the public school system in the years following. The difference between these two lines represents the additional percent of teachers remaining in the public school system due to the changes in preferred characteristics. For example, after one year of teaching, an additional four percent of the new teachers remain in public schools. This difference peaks at four years of experience, with approximately an additional seven percent of new teachers still in the public school system. After the fourth year of teaching, the effects of the policy diminish, and, at approximately ten years of experience, there is no distinguishable difference in the percent of these teachers remaining in public schools.

Figure 6.7: Policy Simulation, Providing New Teachers with “Preferred” School Characteristics



6.2 School Level Model Results

6.2.1 Random Sampling of Alternatives

The second empirical approach of this dissertation, outlined in Chapter 4, uses a random sample of alternatives in the choice set of each teacher. As described earlier, this equation is not jointly estimated with the credential or attrition equations. This model includes 20 randomly sampled alternatives from the universe of schools in the sample. Estimated coefficients for this single equation conditional logit model with random sampling of alternatives are displayed in table C.7 of the appendix.

Based on these coefficients, the percentage of students eligible for free or reduced lunch at a school has a negative and significant effect on the probability a teacher chooses that school. This negative effect increases in magnitude for male teachers, as well as those with a master's degree or NBPTS certification. The coefficient on percent of black students is negative, but statistically insignificant. However, the interactions of this variable with indicators for a male teacher, black teacher, experience, and master's degree are all significant. Male teachers, black teachers, and teachers with a master's degree are more likely to select a school with a higher percentage of black students. The interactions between each credential stock and the percentage of teachers at a school with those credentials are both positive and significant. This may indicate that teachers are drawn to schools with similar teachers in terms of credentials, or that certain schools systematically hire teachers with these credentials.

Given the number of interaction variables and the nonlinear nature of a condition logit model, the marginal effects of changes in school characteristics are determined through simulation, and averaged over the sample. Figures 6.8 through 6.13 include plots of the marginal effects of three school characteristics: percentage of students eligible for free or reduced lunch, percentage of black students, and average teacher salary at the school. Of these figures, the first three represent changes in these characteristics for the school at which a teacher currently teaches. These represent the "push" effects of current school characteristics when a teacher evaluates switching schools. The last three represent changes in these characteristics for all schools in the set of alternatives, with the exception of the current school. These changes in other school characteristics represent the “pull” aspect of possible alternatives when a teacher is considering leaving her current school. Each of these marginal effects and their 95% confidence intervals are simulated using 100 bootstrap replications using the estimated coefficients and covariance matrix.

Figure 6.8 displays the marginal effect on switching school of a 25 percentage point increase in students eligible for free or reduced lunch. This effect is positive and statistically significant. The change in the probability of leaving the current school is greater than 1.5% for inexperienced teachers. This change remains positive, but steadily declines across experience.

Figure 6.9 displays the marginal effect of a 25 percentage point increase in black students on switching schools. The change in student demographics has the largest effect for teachers with less than five years of experience. This effect is not statistically different from zero for teachers with experience between five and 20 years.

The marginal effects across experience of a $5,000 increase in salary on the probability of switching school are shown Figure 6.10. This increase in salary decreases the probability of a teacher switching schools, with the largest effect on inexperience teachers. This statistically significant effect diminishes over the range of experience.

Figure 6.8: "Push Effect" of 25 Percentage Point Increase in Pct. Lunch at Current School

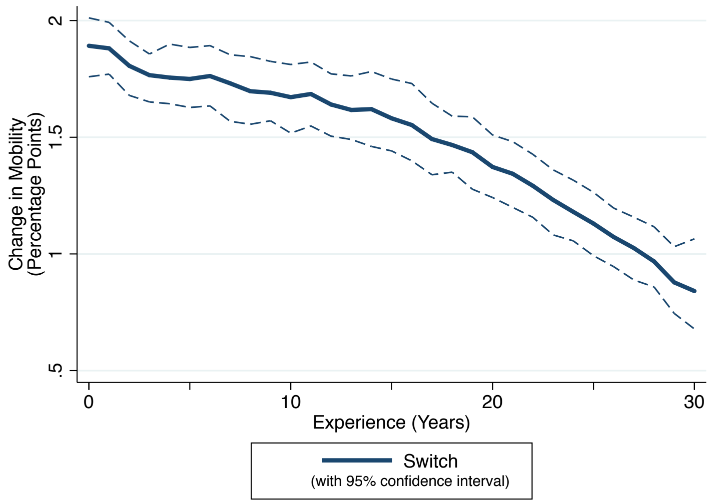


Figure 6.9: "Push Effect" of 25 Percentage Point Increase in Pct. Black at Current School

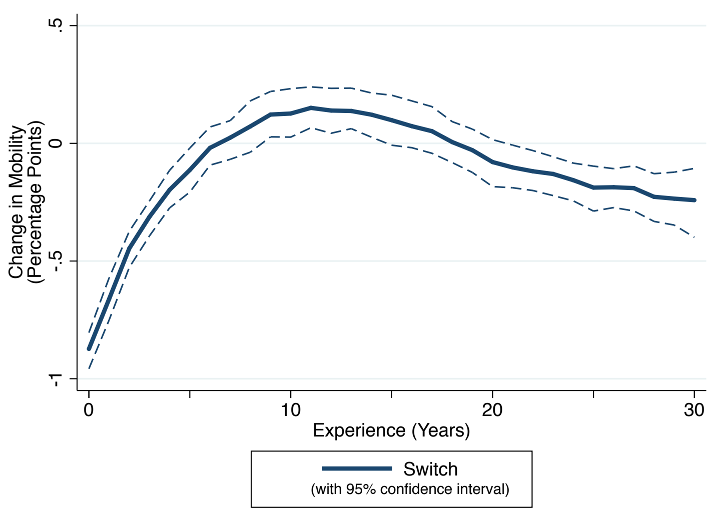
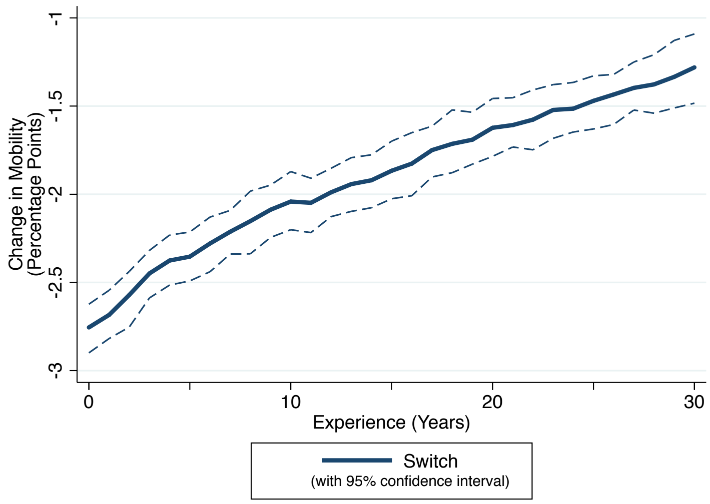


Figure 6.10: "Push Effect" of $5,000 Increase in Salary at Current School



Figures 6.11 through 6.13 show the marginal effects of these changes in percent of free lunch students, percent of black students, and average salary for all other schools excluding the current school of the teacher. The trend across experience for these effects generally mirror those found in Figures 6.8 through 6.10, although there exist slight differences in magnitude. The effect of the increase in percentage of free lunch students (Figure 6.11) is negative and statistically significant across teachers of every experience level. This magnitude of this effect is greatest for first year teachers at -1.5%, and steadily become smaller as experience increases.

Figure 6.12 shows that an increase in the percentage of black students at other schools increases the probability that a teacher leaves the current school. This effect is statistically significant, and larger across the range of experience when compared with the same change in students at the current school.

Finally, Figure 6.13 displays the marginal effect of a $5,000 increase in salary. This effect is positive and significant across the range of experience, with its largest magnitude at lower levels of teaching experience.

Figure 6.11: “Pull Effect” of 25 Percentage Point Increase in Pct. Lunch at All Other Schools

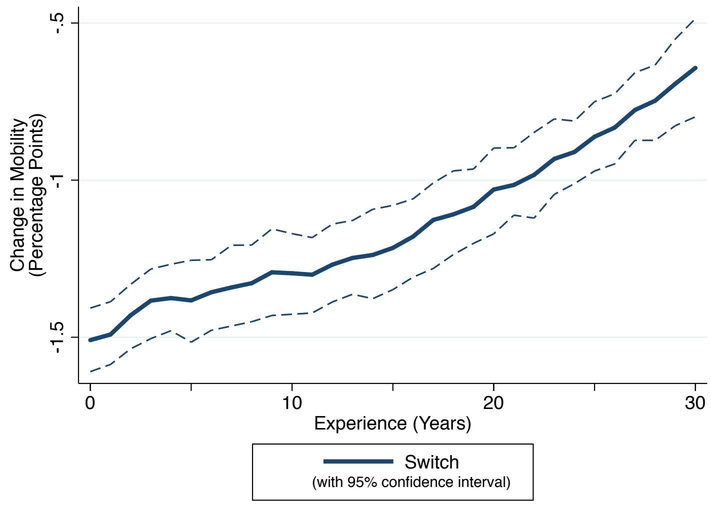


Figure 6.12: “Pull Effect” of 25 Percentage Point Increase in Pct. Black at All Other Schools

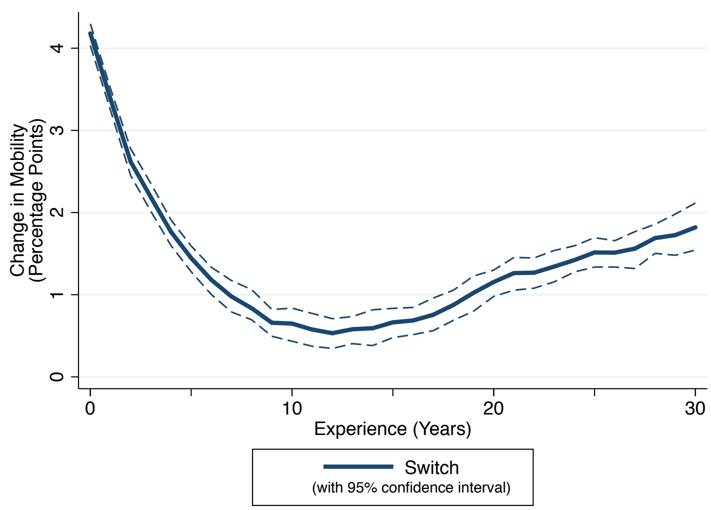
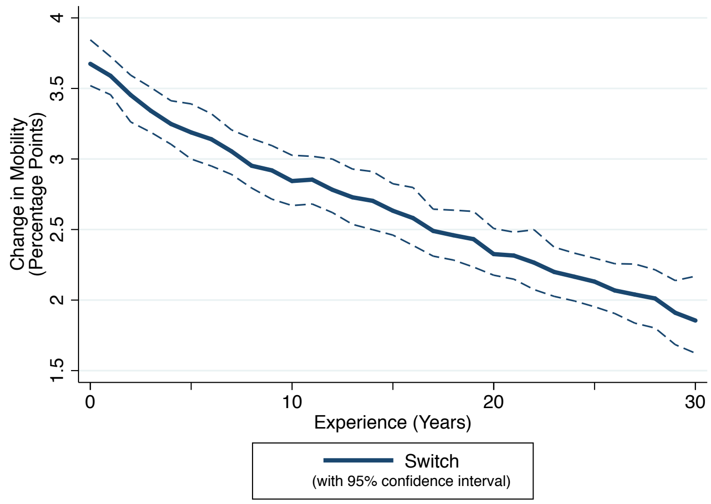


Figure 6.13: "Pull Effect" of $5,000 Increase in Salary at All Other Schools



6.2.2 Subsample of Teachers

The empirical model in Section 4.6.2 includes the credential, attrition, and mobility equations for a sample of high school teachers in the Piedmont region of North Carolina. These equations are jointly estimated using the DFRE method described in Section 4.3. Tables C.9 through C.11 display the coefficients for these equations. I use eight points of support for the individual permanent heterogeneity and four points of support for individual time-varying heterogeneity. The marginal effects of these mass points are allowed to vary across equation, as well as across outcomes within discrete equations. This attribute results in unique effects across mass points for all 70 outcomes of the mobility equation. Table C.12 of the appendix displays the coefficients for these points of support. Permanent and time-varying mass points were added to the specification until the likelihood function failed to improve significantly, using a likelihood ratio test. The likelihood failed to improve beyond eight permanent points and four time-varying points.

I evaluate the fit of the model by comparing the predicted outcomes from the equations with the actual outcomes observed in the data. These predicted outcomes are determined using the estimated coefficients and integrating over the unobserved heterogeneity components to calculate the outcome probabilities. Along with a random draw, representing the idiosyncratic error component, the outcome probabilities are used in calculating the predicted outcome. The comparison of these predicted and actual outcomes, provided in Table C.8, show a relatively accurate fit of the model.

The coefficients in Table C.11 show a positive, but insignificant effect of percentage of black students and percent of free lunch students on the school choice of teachers. The interaction between percentage of black students and the indicator for black teacher is both positive and significant. The interactions of both black students and free lunch students with each of the credential stock variables are not found to be significantly different from zero.

Figures 6.14 through 6.19 display the simulated marginal effects of select school characteristics on the mobility of teachers. These marginal effects are short-run results of changes in school characteristics. These changes include increases in percent of students on free or reduced lunch, percent of black students, and teacher salary. These marginal effects are calculated by taking the difference between predicted outcomes before and after the specified school characteristic is changed. The simulated outcomes use the coefficients from the jointly estimated equations and integration over the unobserved heterogeneity components.

The first set of marginal effect simulations, found in tables 6.14 to 6.16, represent the results of changes in the current school characteristics of a teacher. The choice probabilities produced by the conditional logit model of equation (4.13) are a function of the characteristics of every alternative. The effect on mobility of changing a characteristic of the current school represents a “push” effect of that characteristic.

The marginal effects for a 25 percentage point increase in the number of students eligible for free or reduced lunch at the teacher’s current school are presented in figure 6.14. Although statistically significant, the effect of this increase on the probability of a teaching leaving her school for another school is small and positive. This increase in probability of switching schools is relatively constant across years of experience. The magnitude of this demographic change is larger for attrition, and steadily increases across years of experience. This effect on attrition changes sign from a negative effect for teachers with less than 15 years of experience to a positive effect for more experienced teachers.

Figure 6.15 displays the marginal effects for a 25 percentage point increase in the number of black students at the teacher's current school. This change in student composition has a negative, statistically significant effect for teachers in their first few years of teaching. The effect becomes insignificant for teachers between four and twenty years of experience before becoming negative for teachers later in their teaching careers. This change in demographics has a positive effect on teacher attrition. For more inexperienced teachers, increasing the percent of black students is associated with up to a three percent increase in attrition.

Figure 6.16 presents the effects of a $5,000 increase in average salary at the current school. Surprisingly, an increase in average salary at the current school is associated with a positive and statistically significant increase in the probability a teacher moves to another school. One possible explanation for this seemingly counterintuitive result is that the average salary does not accurately represent the potential salary a teacher would earn at a school. Another reason could be the bias caused from ignoring the demand side restrictions mentioned previously. The bias from these restrictions may be accentuated in this subsample of teacher due to the regional constraint of the sample. The assumptions regarding demand restrictions and the subsequent potential bias are discussed further in the next chapter. The effect of this increase in salary on attrition is more intuitive. The increase in salary decreases the probability a teacher leaves the school system. This effect is larger for teachers at the beginning and end of their teaching careers than it is for teachers in the middle range of teaching experience.

Figure 6.14: "Push Effect" of 25 Percentage Point Increase in Pct. Lunch at Current School

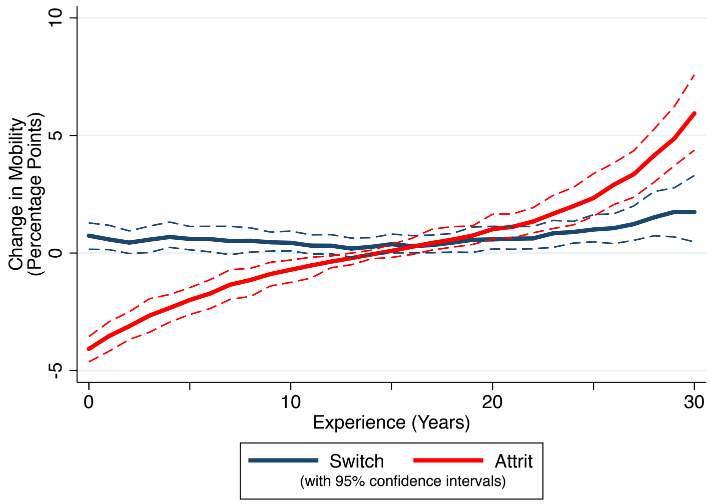


Figure 6.15: "Push Effect" of 25 Percentage Point Increase in Pct. Black at Current School

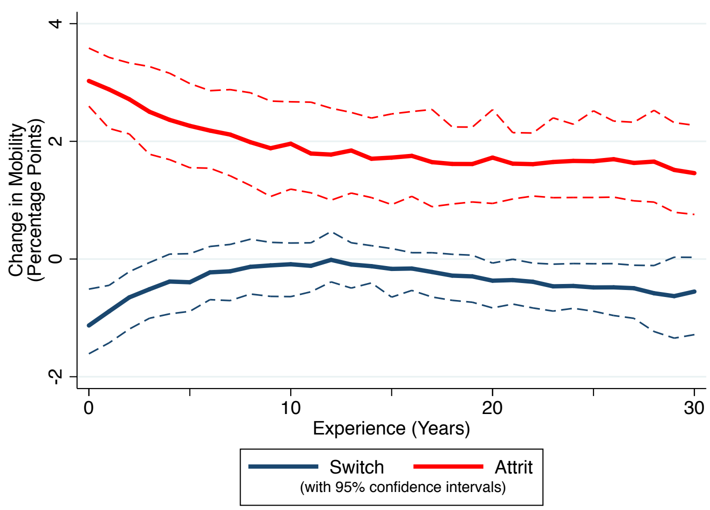
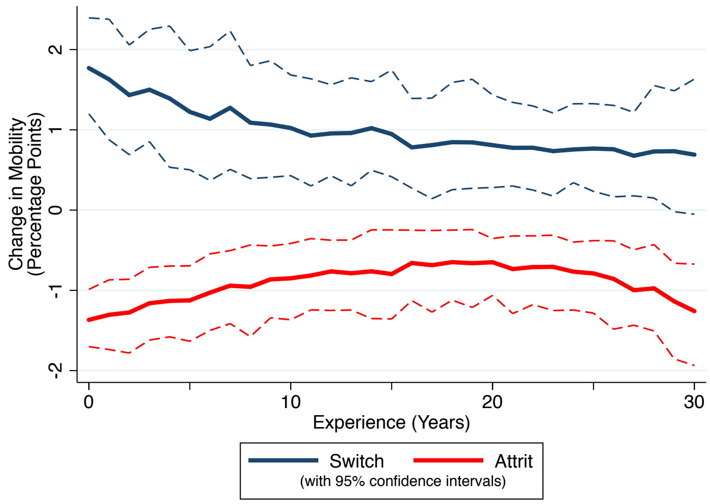


Figure 6.16: "Push Effect" of $5,000 Increase in Salary at Current School



The second set of marginal effects, displayed in figures 6.17 through 6.19, represents the results of characteristics at schools other than the one at which a teacher works. These "pull" effects capture the draw of characteristics of other schools. The marginal effects are calculated by increasing the selected characteristic at every alternative except the current school of the teacher.

Figure 6.17 displays the effect of a 25 percentage point decrease in the number of students on free or reduced lunch. For teachers in their first two years of teaching, this effect is positive and statistically significant. Beyond three years of experience, the effect is positive, but not statistically significant for teachers with less than 27 years of experience.

The marginal effects in figure 6.18 represent the effect of a 25 percentage point decrease in the number of black students on the probability a teacher leaves her school for another. The results show a negative effect on the probability a teacher switches schools. This effect is statistically insignificant, with the exception of teachers with fewer than three years of experience or greater than 22 years of experience.

Figure 6.19 presents the marginal effect of a $5000 decrease in average salary at all other alternatives on the probability a teacher switches schools. Similar to the effects of figure 6.16, the results of this effect have an unexpected positive sign. These effects are statistically significant over the range of experience. This change in demographics has the largest effect for inexperienced teachers at 1.7% increase in the probability of switching schools.

Figure 6.17: "Pull Effect" of 25 Percentage Point Increase in Pct. Lunch at All Other Schools

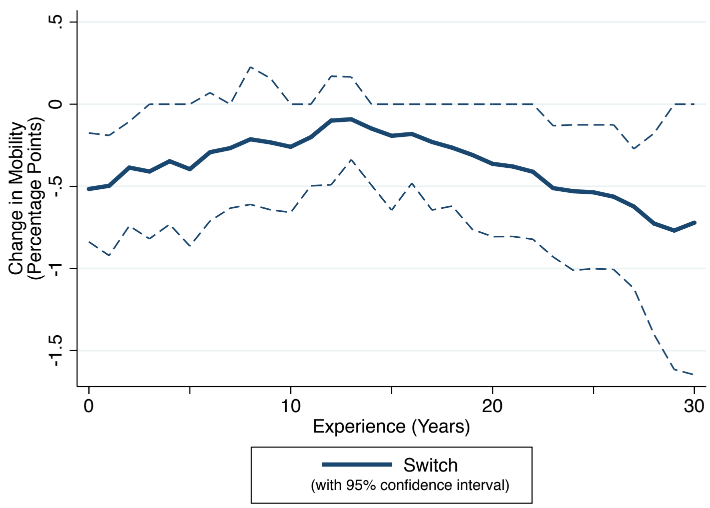


Figure 6.18: "Pull Effect" of 25 Percentage Point Increase in Pct. Black at All Other Schools

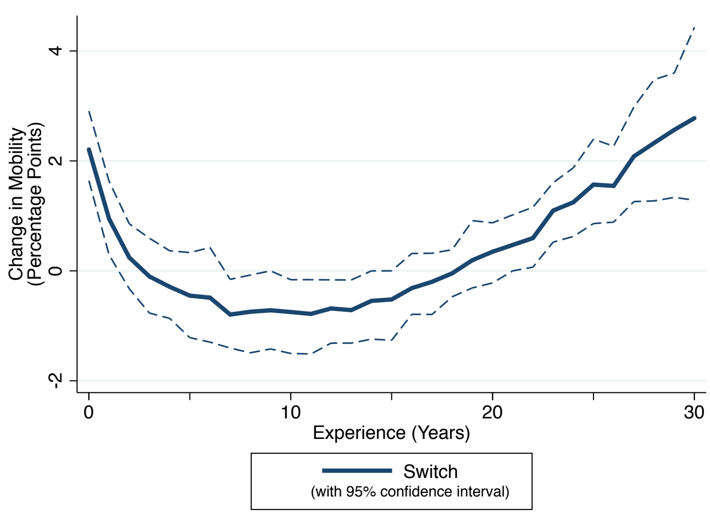
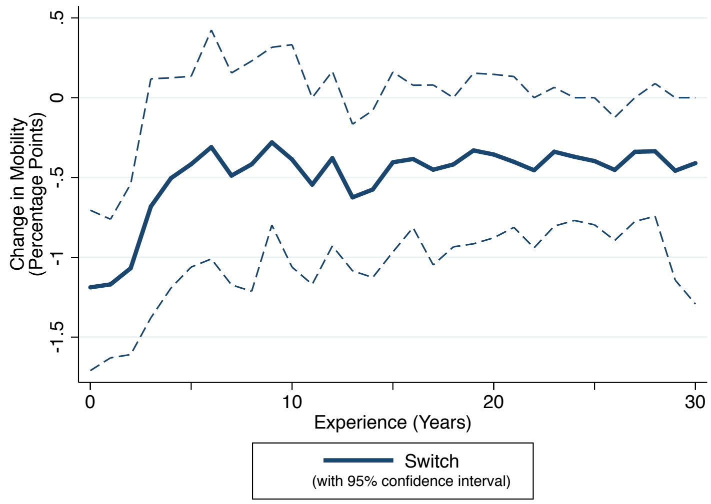


Figure 6.19: "Pull Effect" of $5,000 Increase in Salary at All Other Schools



I also use the subsample of high school teachers to estimate equations for attrition and mobility without controlling for unobserved heterogeneity. Tables C.13 and C.14 of the appendix present the results of this estimation. Figures C.4 through C.9 of the appendix show the marginal effects of school characteristics on the mobility probabilities. Comparing these results with the results from the model with unobserved heterogeneity (Figures 6.14 through 6.19 described above) there are a few interesting differences. Most notably, as shown in Figure C.6, the effects of an increase in salary at the current school on the probability that a teacher switches schools are negative and significant across all experience levels. When jointly estimated with the other equations, these marginal effects of increased salary on the probability of switching become positive (Figure 6.16). This change in sign between the effects predicted by two specifications also occurs when comparing the effects of changes in salary at other schools (Figures 6.19 and C.9), although this effect is insignificant for most levels of experience when jointly estimated.

6.3 Comparison of Models with and without Non-pecuniary Characteristics

The majority of previous studies use student demographics, particularly the percent of students eligible for free or reduced lunch and the percent of black students, as the main representatives of the non-pecuniary characteristics of teaching at a school. These student characteristics could be correlated with other non-pecuniary attributes that are important to teachers, yet unobservable to the researcher. For example, consider the possibility of there existing a negative correlation between these non-pecuniary characteristics and both student demographics and the probability a teacher leaves the current school. Excluding these non-pecuniary characteristics could result in overestimating the effect of certain student demographics on teacher mobility probabilities.

In order to have a clearer understanding of the influence of these non-pecuniary benefits, I estimate the district-level model from section 4.2 without the non-pecuniary characteristics described by the working condition surveys for a random sample of 25,000 teachers. The excluded variables are: school safety, respect of teachers, if teachers are shielded from disruptions, professional development opportunities, class load, amount of interfering duties, and if teachers are involved in decision-making. I then compare the simulated marginal effects of changes in the percent of free lunch students and percent of black students with the marginal effects simulated from estimates that include the non-pecuniary characteristics. I use a likelihood ratio test to determine whether there is a significant difference between the restricted model (without the non-pecuniary characteristics) and the unrestricted model (with the non-pecuniary benefits). The likelihood test statistic was significant at the 0.001% level, consequently rejecting the null hypothesis that the maxima of the restricted and unrestricted log-likelihood functions are the same.

The results of these simulated marginal effects over the range of experience are displayed in Figures 6.20 to 6.25. These figures allow a visual comparison of the two models, with and without the non-pecuniary benefits. The 95% confidence intervals of these effects are determined through bootstrapping using 100 draws from the covariance matrix of each model.

Figures 6.20 through 6.22 show the marginal effects of the models for a 25 percentage point increase in the percent of student eligible for free or reduced lunch on the probability a teacher switches to a different school within the same district, switches to a different school in a different district, and attrits for the public school system, respectively. Regarding these marginal effects on switching within the same district (Figure 6.20), excluding the non-pecuniary characteristics produces larger changes in the mobility probability for teachers with 13 to 22 years of experience. The overlapping confidence intervals of the estimates suggest that the difference in effects are not significantly different.

Figure 6.21 displays the marginal effects on the probability of switching schools outside of the district. For teachers with less than ten years of experience, including the non-pecuniary characteristics increasing the marginal effect of this student demographic group on mobility outside the district. The magnitude of this difference is largest for first year teachers at approximately 0.7 percentage points. The differences in effects decrease as experience increases and are insignificant for teachers beyond seven years of experience.

The marginal effects on attrition for the two models are shown in Figure 6.22. The marginal effects from the model with the non-pecuniary characteristics are larger for teachers with three or less years of experience. This difference changes sign as experience increases, with overlapping confidence intervals across most levels of experience.

Figure 6.20: Model Comparison: Marginal Effects of Increasing Pct. Lunch
Switching Within District

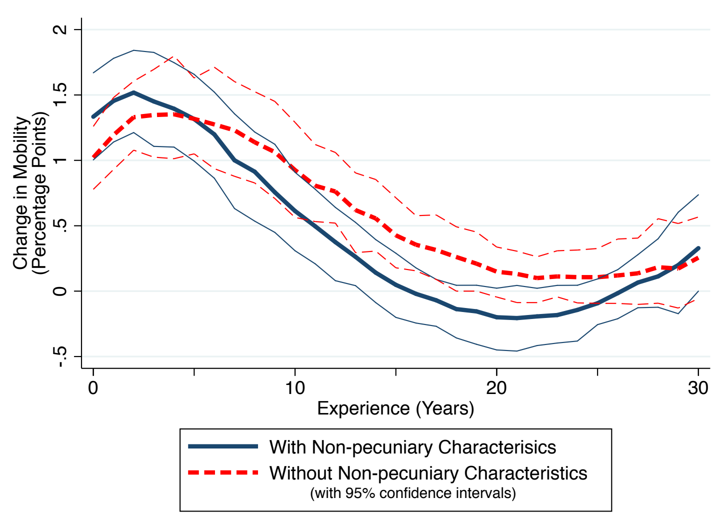


Figure 6.21: Model Comparison: Marginal Effects of Increasing Pct. Lunch Switching Outside District

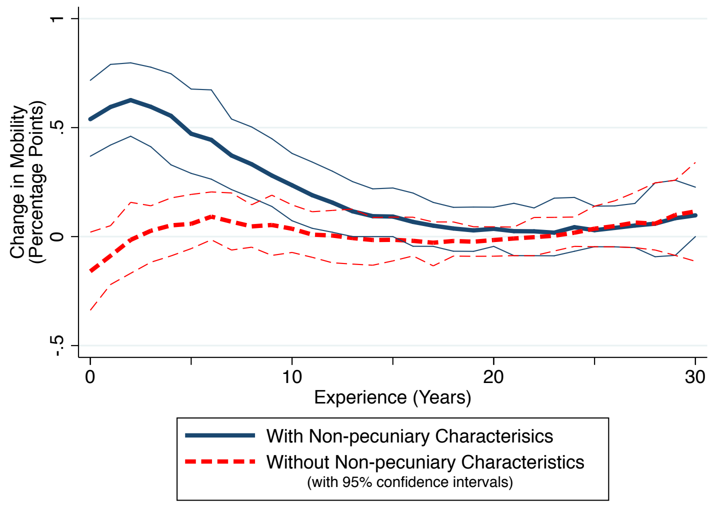
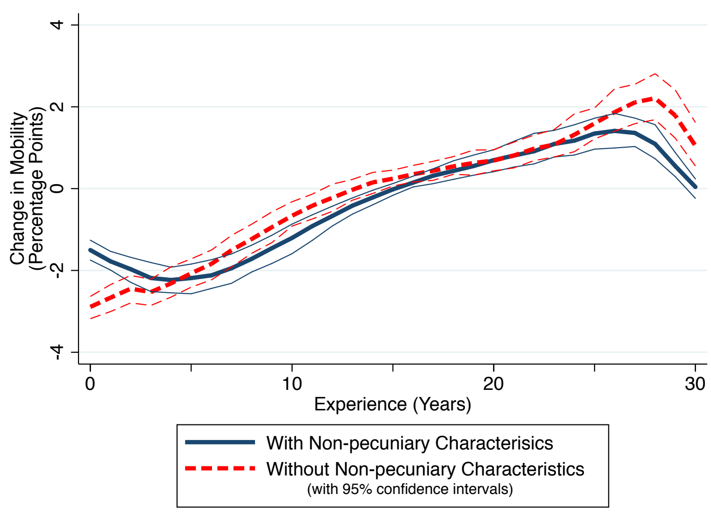


Figure 6.22: Model Comparison: Marginal Effects of Increasing Pct. Lunch Attrition



Figures 6.23 through 6.25 show the marginal effects of the two specifications for a 25 percentage point increase in the percent of black students. Figure 6.23 displays these effects for the probability of switching to a different school within the same district. The magnitude of this difference is largest for teachers with less than three years of experience, with a maximum of approximately 0.8 percentage points. This difference declines across experience but remains greater than 0.5 percentage points for teachers with less than twenty years of experience. Figure 6.24 displays the marginal effects for the probability of switching to a different school in a different district. The differences between the marginal effects of the two models are small.

Figure 6.25 displays the marginal effects on the probability of attrition for the two models. The magnitude of the difference shows that the model without non-pecuniary characteristics estimates the effect of the percent of black students on attrition as consistently one percentage point larger than the model with non-pecuniary characteristics across all levels of experience. This difference between the models is larger for teachers with ten or fewer years of experience, with the largest difference being approximately 1.5 percentage points.

The results of these comparisons between the two models show that including the non-pecuniary characteristics does influence the estimated marginal effects. This difference is perhaps most apparent for the effect of the percent of black students on the probability of teacher attrition. These results suggest that the exclusion of variables that better characterize non-pecuniary aspects of a school may result in confounded estimates of the effect of certain student demographics.

Figure 6.23: Model Comparison: Marginal Effects of Increasing Pct. Black Switching Within District

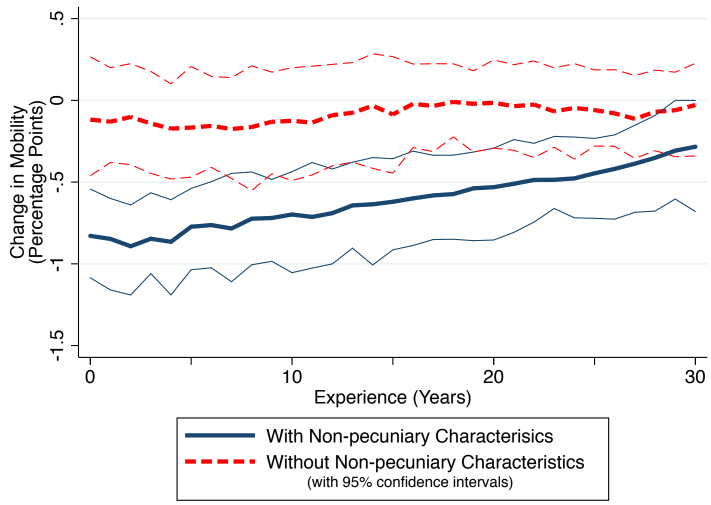
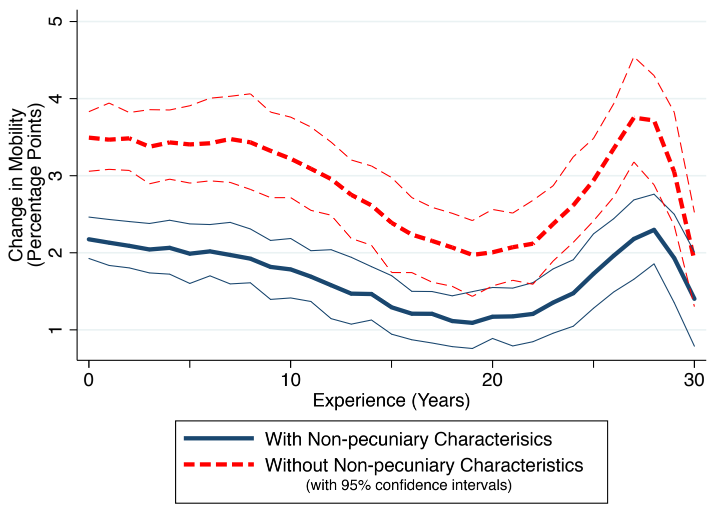


Figure 6.24: Model Comparison: Marginal Effects of Increasing Pct. Black Switching Outside District

Figure 6.25: Model Comparison: Marginal Effects of Increasing Pct. Black Attrition



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 probabilities, along with several endogenous teacher credential probabilities, using longitudinal data on North Carolina public schools. I jointly estimate these equations using a discrete factor random effects method that reduces potential bias by controlling for individual permanent and time-varying unobserved heterogeneity.

Results show that, on average, teacher mobility outcomes are more sensitive to changes in student demographic makeup, relative to changes in salary. These results, although small in magnitude, 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 difficulty in 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. I use a policy simulation characterizing the effects of providing teachers with “preferred” school environments to observe the effects on attrition. The results show that this policy may help to keep some teachers in the public schools longer, but after approximately ten years, the percent of these teachers still remaining is the same as without the policy.

This research also investigates the "pull" aspect of mobility, using two different empirical specifications in which characteristics of potential employment options draw a teacher from her current school. The first of these specifications uses the entire sample of teachers with a randomly selected set of school alternatives. Results show the effects of changes in school characteristics on mobility probabilities are larger for inexperienced teachers. The second of these specifications uses a subsample of high school teachers from the central Piedmont region. These results are generally smaller in magnitude than the results of the previous models, and statistically insignificant for several levels of teaching experience.

7.1 Limitations and Future Research

The composition of teacher quality within a school results from the complex behavior and restrictions of both labor supply and labor demand forces. The administrative data available provide only the outcome, specifically the match between teacher and school, of this complicated process. Unfortunately, the nature of these administrative data results in the absence of personal information about teachers. These specific data may be important in examining a profession where the substantial effect of family transitions on career decisions are supported anecdotally as well as in the literature. Therefore, these administrative data, analyzed alone, may invariably provide challenges in fully explaining teacher mobility with the school system. Fully describing the teacher quality composition requires more detailed data, or more complicated empirical techniques.

This research assumes there are no demand side restrictions in the hiring process. The broad protection of teacher tenure laws suggests that most transitions of teachers are voluntary moves. Also, during the sample period of these data, studies show the state of North Carolina was a net importer of teachers. For these reasons, it is reasonable to assume that most separations of teachers from their school are not a result of demand side decisions. Even though most separations may be initiated by the supply side, certainly the demand side restrictions are involved when teachers are hired at a particular school.

Demand side restrictions create several broad general equilibrium type issues. These issues involve the constraints individuals face concerning employment opportunities, particularly the availability of positions. While assuming these problems do not exist is more palatable in labor research using commonly used large national surveys, these assumptions have greater potential for creating bias in my research, which examines the match between employee and employer in a particular labor market.

One potential bias comes through the assumption that the set of school alternatives ($\mathcal{S}$) for each individual is exogenous. My model assumes that each school enters each teacher's alternative set with the same probability. Realistically, not every school is willing to hire every type of teacher. Schools make hiring decisions based on both observable and unobservable (to the researcher) characteristics of the teacher. If, in practical terms, a teacher cannot obtain a job at a school with more preferred characteristics and instead is constrained to accept a job at a school with less preferred characteristics, it will appear as though the teacher did not prefer the characteristics as strongly as she actually did. In estimation, this constraint will manifest itself in coefficients of those characteristics that are biased toward zero. This assumption could mute the effect of preferred school characteristics on mobility probabilities.

An additional cause of bias could come from the fact that teachers can only move to a school that has an open position. Because teachers cannot leave unless a position opens, limited open positions could make it appear as though they prefer the characteristics of their current school more than they actually do. Furthermore, if most positions open due to a teacher leaving, those same school characteristics will be associated with both a departing and arriving teacher. Although, including teaching experience interacted with school characteristics should help reduce the contribution that retiring teachers make to this issue. Similar to the previous bias mentioned, this bias could potentially result in underestimated effects of school characteristics, with the coefficient on preferred characteristics being smaller than the true coefficient.

Both of these biases could help to explain the relatively small, and sometimes counter-intuitive, effects of changes in school characteristics presented in the previous chapter. For example, these biases could explain the unexpected results of a salary increase on mobility. Particularly, in Table 6.5 and Figure 6.3 we see an increase in salary is associated with an increase in attrition rates for teachers of certain experience levels. Also, Figures 6.16 and 6.19 show that an increase in salary is associated with an increase in the probability that a teacher will leave the current school. Given simple economic theory on the effects of wage on labor force behavior, it is difficult to find a consistent explanation for these observed results. Is this result due to teachers disliking higher salaries, or are the complexities and constraints of sorting within the school system biasing the estimates? It seems more plausible that the latter could be the primary source, through biased coefficients, of these confounding results.

These biases may be reduced through improvements in data and estimation methods. With the existing data, some pattern of hiring at schools could be inferred. For example, comparisons of teachers hired at particular schools could be made using methods similar to propensity score matching. Information on the unobserved constraints posed by the demand side could be gained by comparing teachers that never choose a particular school with teachers with similar observable characteristics that do choose a particular school.

Potentially, the largest gain in mitigation of these biases comes through acquiring additional data on the demand side of the market. The current data, showing only the outcome of the match between school and teacher, does not provide the details of the hiring process of schools. As mentioned above, one of the greatest sources of bias involved with the existing estimation is the assumption that each school enters the teacher's set of alternatives with equal probability. Practically, this is representing the notion that every teacher is able to move to any school of her choosing. Supplementing the existing data with additional data that provides further information on the hiring practices of schools could help to limit the bias. For example, obtaining the resumes of individuals interviewed in specific schools or districts would provide observable characteristics of those individuals considered for a position. Although these resumes may not include unobservable measures of quality, such as qualitative evaluation of the interview or sample classroom setting, they could provide observable characteristics such as teaching experience, NBPTS certification, or attainment of an advanced degree. These additional data could then be used in construction of the set of alternatives for each individual. Specifically, the probability of a school entering the alternative set of an individual could be a function of the observable characteristics of the teacher and school. Ben-Akiva and Lerman

(1985) and Train (2003) refer to the unequal probability of selecting alternatives as importance sampling. In general, importance sampling is used to increase efficiency in estimation, because some alternatives appear less frequently in the data, and subsequently have a lower probability of being selected. For example, Train, McFadden, and Ben-Akiva (1987) use importance sampling to reduce the probability of infrequently available telephone calling plans in entering the set of alternatives when estimating the demand for telephone service.

In order to better capture demand side constraints, the construction of the set of alternatives could reflect the availability of each alternative to an individual, rather than just the low frequency of an observed outcome in the data. Several studies in the literature incorporate methods of constraining the set of alternatives. The following are examples from the literature that use various methods to generate probabilistic sets of alternatives.

Swait and Ben-Akiva (1987) evaluate a discrete choice model with constrained choice sets using Brazilian work mode choice data. In their framework, they estimate the probability that an individual is constrained to a single alternative, or is free to choose from a set of alternatives. They find that this model performed better than a model that did not place restrictions on the set of alternatives.

In his study on affirmative action in university admissions, Arcidiacono (2005) limits the set of alternatives for an individual when selecting a college. This set of alternatives represents the colleges to which an individual is accepted. The probability of acceptance into a university is estimated as a function of both university and applicant characteristics, using limited data on the set of schools to which individuals applied and were accepted.

Palma, Picard, and Waddell (2007) develop a model to account for constraints on the availability of alternatives in situations where the supply of alternatives with specific characteristics may not be able to meet demand. In these situations, individuals may not be able to obtain the alternative with preferred characteristics, resulting in biased estimates. Palma et al. apply their model with capacity constraints to the housing market in Paris, France.

Aaberge, Colombino, and Wennemo (2009) use simulations to evaluate the consequences of sampling construction assumptions regarding the set of alternatives in labor supply discrete choice models. They conclude that while the fit of the model is generally robust regarding these assumptions, the out-of-sample predictions may be adversely affected. Because of this, they recommend caution when using these types of models for policy simulations. Similarly, Niu and Tienda (2008) show, using Texas data on college admissions, that model results from constraining choice sets is very sensitive to the methods used to select these choice sets.

Several of the studies mentioned above employ methods which may be applicable to the future direction of my research. These methods could help to reduce the bias from the general equilibrium forces that affect teacher sorting, and current estimation. The ultimate goal of this research path is to better characterize the quality of teachers in a school to analyze the effect of this observable teacher quality on student achievement. This agenda could include analyses at the school level by examining the effect of the percentage of teachers with certain credentials on average school achievement. Another possibility is analysis at the classroom level, with classroom achievement for each teacher being jointly estimated along with the teacher credential and mobility outcomes.

A Variable Descriptions

Table A.1: 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 school	Teaches at an elementary school.
Middle school	Teaches at a middle school.
High school	Teaches at a high school.
College: Private	Undergraduate institution is a private college.
College: Research university	Undergraduate institution is a research university.
College: Urban	Undergraduate institution is located in urban area.
College: Rural	Undergraduate institution is located in rural area.
College: Historically black	Undergraduate institution is a historically black college.
College: Most competitive	Barron's Selectivity Index: most competitive institution.
College: Highly competitive	Barron's Selectivity Index: highly competitive institution.
College: Very competitive	Barron's Selectivity Index: very competitive institution.
College: In NC	Undergraduate institution is located in North Carolina.
College: Border state	Undergraduate institution located in SC, TN, VA, or GA.
College: Other state	Undergraduate institution not in NC, SC, TN, VA, or GA.
College: Graduate program	Undergraduate institution has graduate courses in education.
Salary (1000's)	Teacher's base salary from state salary records.
NBPTS certified	Indicator variable for if a teacher is NBPTS certified.
Advanced 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.

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Table A.1 continuing from previous page

Variable	Description
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.
Pct. teachers with NBPTS	Percent of teachers at school with NBPTS certification.
Pct. teachers with adv. degree	Percent of teachers at school with an advanced degree.
Pct. teachers 0 to 2 years experience	Percent of teachers at school with zero to two years of teaching experience.
Pct. teachers 3 to 10 years experience	Percent of teachers at school with three to ten years of teaching experience.
Local revenue pct	Percent of total revenue that is provided by local sources (local revenue).
Local revenue per student (1000's)	Local revenue per student.
Expenditures per student (1000's)	Total expenditures per student.
Avg. salary supplement (1000's)	Average teacher salary supplement within the district.
Pct. of teachers w/supplement	Percent of teachers receiving salary supplement.
School is safe	Teacher working condition survey: School is safe.
Teachers are respected	Teacher working condition survey: Teachers are trusted and respected.
Teachers shielded from disruptions	Teacher working condition survey: Leadership shields teachers from disruptions.
Professional development	Teacher working condition survey: Teachers have resources for professional development.
Reasonable class load	Teacher working condition survey: Teachers have reasonable student/class loads.
Low interfering duties	Teacher working condition survey: Teachers are protected from interfering duties.
High standards for teachers	Teacher working condition survey: Teachers are held to high standards.
Teachers involved w/decisions	Teacher working condition survey: Teachers are involved in school decisions.
Number of school openings	Number of school openings within the district.
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-agriculture employment (1000's)	County nonagricultural employment level.
Median HH income	County median household income.

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Table A.1 continuing from previous page

Variable	Description
County unemployment rate	County unemployment rate.
Population per mile^2 (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.
NBPTS salary differential (1000's)	State monthly salary differential for NBPTS certification.
Master's salary differential (1000's)	State monthly salary schedule differential for a master's degree.
Graduate 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.

B Summary Statistics

Table B.1: Summary Statistics: Teacher Characteristics

	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 university	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 competitive	0.01	0.09	0.00	0.07
College: Highly competitive	0.03	0.17	0.02	0.15
College: Very competitive	0.10	0.30	0.09	0.28
College: In NC	0.63	0.48	0.71	0.45
College: Graduate program	0.53	0.50	0.65	0.48
Elementary school	0.36	0.49	0.35	0.50
Middle school	0.33	0.48	0.34	0.49
High school	0.31	0.47	0.31	0.48
Salary (1000's)	29.00	9.26	34.24	9.12
NBPTS certified	0.01	0.09	0.04	0.20
Advanced degree	0.25	0.44	0.28	0.46
Experience	8.19	9.35	12.65	9.68

Table B.2: Summary Statistics: School and Community Characteristics

Variable	All Years Mean	All Years Std. Dev.
Students per teacher	14.45	5.60
Total students (100's)	6.33	3.47
Pct. Black	32.14	25.62
Pct. Lunch	36.28	24.01
Urban	0.25	0.44
Rural	0.27	0.44
School is safe	2.42	1.15
Teachers are respected	2.42	1.14
Teachers shielded from disruptions	2.42	1.15
Professional development	2.44	1.14
Reasonable class load	2.38	1.14
Low interfering duties	2.40	1.14
High standards for teachers	2.41	1.13
Teachers involved w/decisions	2.31	1.19
Local revenue pct	0.29	0.09
Local revenue per student (1000's)	2.14	1.08
Expenditures per student (1000's)	7.24	1.50
Number of school openings	1.05	1.98
Avg. salary supplement (1000's)	2.19	3.21
Pct. of teachers 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 differential (1000's)	2.05	1.56
Master's salary differential (1000's)	3.01	2.22
Graduate tuition (1000's)	1.18	1.82
Non-agriculture employment (1000's)	122.23	153.56
County unemployment rate	4.98	2.07
Population per mile^2 (100's)	4.01	3.84

Table B.3: 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 B.4: 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	

C Model Results

C.1 District Level Model Results

Table C.1: District Level Estimation Results: Teacher Credential Outcomes
(jointly estimated with attrition and mobility equations)

	Advanced Degree			**NBPTS**		
Variable	Coefficient		S.E.	Coefficient		S.E.
Teacher Characteristics						
Male	-0.487		(0.398)	-1.220	**	(0.543)
Black	0.317		(0.670)	-1.348	***	(0.470)
Other race	-0.063		(0.342)	-0.271		(0.215)
NBPTS certified	0.450		(0.564)	-		-
Lagged NBPTS decision $(t-1)$	-1.051		(0.753)	-		-
Advanced degree	-		-	0.656		(0.762)
Degree decision $(t-1)$	-		-	0.104		(0.282)
Lagged mobility decision $(t-1)$	0.053		(0.050)	-0.483	***	(0.066)
Experience	-0.054		(0.109)	0.122		(0.186)
Experience^2	-0.891		(0.621)	-1.500	**	(0.693)
Experience^3	1.974	*	(1.063)	2.592	***	(0.927)
Black × Experience	-0.109		(0.136)	0.163		(0.112)
Black × Experience^2	1.158	**	(0.576)	-1.005	**	(0.478)
Black × Experience^3	-2.732	***	(0.943)	1.866	**	(0.864)
Male × Experience	0.049		(0.076)	0.142	**	(0.071)
Male × Experience^2	-0.315		(0.423)	-1.023	**	(0.439)
Male × Experience^3	0.527		(0.885)	2.057	**	(0.882)
NBPTS × Experience	0.151		(0.135)	-		-
NBPTS × Experience^2	-1.391	*	(0.777)	-		-
NBPTS × Experience^3	3.889	***	(1.137)	-		-
Adv. degree × Experience	-		-	0.062		(0.039)
Adv. degree × Experience^2	-		-	-0.163		(0.269)
Adv. degree × Experience^3	-		-	0.316		(0.618)
Salary (1000's)	0.259	***	(0.020)	0.061	*	(0.034)
Salary × Experience	-0.008	*	(0.005)	-0.011	*	(0.007)
Salary × Experience^2	0.038		(0.027)	0.071	**	(0.028)
Salary × Experience^3	-0.072	*	(0.040)	-0.137	***	(0.033)
College: Private	-0.106		(0.075)	-0.120	**	(0.051)
College: Research university	0.036		(0.437)	0.197		(0.334)
College: Urban	0.016		(0.180)	0.059		(0.049)
College: Rural	0.046		(0.119)	-0.002		(0.062)
College: Graduate program	0.380	***	(0.048)	0.285	***	(0.031)
College: Historically black	-0.133		(0.620)	-0.296		(0.181)
College: Most competitive	0.242		(0.930)	0.613		(0.556)
College: Highly competitive	0.239		(0.757)	0.309		(0.841)
College: Very competitive	0.016		(0.309)	0.105		(0.286)
School Characteristics						

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Table C.1 continuing from previous page

Variable	Advanced Degree Coefficient		S.E.	NBPTS Coefficient		S.E.
Pct. Black	-0.143		(0.538)	0.307		(0.817)
Male × Pct black	0.081		(0.529)	-0.384		(0.819)
Black × Pct Black	0.346		(0.601)	-0.253		(0.800)
Pct. Black × Experience	0.039		(0.109)	0.025		(0.137)
Pct. Black × Experience^2	-0.949		(0.658)	-0.399		(0.569)
Pct. Black × Experience^3	3.258	**	(1.398)	1.370		(0.925)
Pct. Lunch	0.251		(0.527)	-0.235		(0.847)
Male × Pct lunch	0.199		(0.578)	-0.031		(0.781)
Black Pct lunch	-0.242		(0.615)	0.036		(0.775)
Pct. Lunch × Experience	0.005		(0.123)	0.054		(0.148)
Pct. Lunch × Experience^2	0.133		(0.762)	-0.464		(0.632)
Pct. Lunch × Experience^3	-0.574		(1.574)	0.640		(0.947)
Students per teacher	0.024		(0.036)	-0.009		(0.056)
Total students (100's)	0.005		(0.008)	0.011	*	(0.006)
School is safe	0.058	***	(0.022)	0.019		(0.020)
Teachers are respected	-0.007		(0.022)	0.015		(0.020)
Teachers shielded from disruptions	-0.023		(0.043)	0.038		(0.056)
Professional development	-0.022		(0.016)	-0.006		(0.017)
Reasonable class load	-0.033		(0.020)	0.038	**	(0.019)
Low interfering duties	0.020		(0.017)	-0.003		(0.016)
High standards for teachers	-0.036		(0.023)	-0.074	***	(0.020)
Teachers involved w/decisions	0.042	**	(0.021)	-0.014		(0.018)
Teachers shielded × Experience	0.006		(0.008)	-0.002		(0.009)
Teachers shielded × Experience^2	-0.033		(0.031)	-0.008		(0.032)
Pct. teachers with adv. degree	6.285	***	(0.528)	-0.910		(0.755)
Pct. teachers with NBPTS	-0.987	***	(0.339)	12.752	***	(0.922)
Pct. teachers 0 to 2 years experience	1.277	**	(0.583)	1.261		(0.864)
Pct. teachers 3 to 10 years experience	1.241	***	(0.471)	0.030		(0.878)
Pct. low English × Experience	-0.008		(0.188)	0.007		(0.157)
Pct. low English × Experience^2	0.187		(0.758)	0.059		(0.751)
Pct. low math × Experience	0.154		(0.200)	0.003		(0.163)
Pct. low math × Experience^2	-0.717		(0.745)	-0.125		(0.746)
Middle school	0.004		(0.068)	0.046		(0.055)
High school	-0.109		(0.124)	0.151		(0.098)
District & Community Characteristics						
Urban	-0.089		(0.055)	0.070		(0.054)
Rural	0.064		(0.054)	0.026		(0.044)
Local revenue pct	-1.518	*	(0.917)	-0.040		(0.722)
Local revenue per student (1000's)	0.044		(0.084)	0.004		(0.069)
Expenditures per student (1000's)	-0.067		(0.051)	-0.014		(0.040)
Number of school openings	-0.011		(0.009)	0.002		(0.016)
Avg. salary supplement (1000's)	-0.012	**	(0.006)	0.017	***	(0.006)
Pct. of teachers w/supplement	-0.195		(0.422)	0.077		(0.563)
Non-agriculture employment (1000's)	-0.035	***	(0.009)	0.029	*	(0.016)
Median HH income	-0.007		(0.007)	0.000		(0.007)
County unemployment rate	-0.020		(0.022)	-0.026		(0.029)
Population per mile^2 (100's)	0.016		(0.020)	-0.034		(0.025)

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Table C.1 continuing from previous page

Variable	Advanced Degree Coefficient		S.E.	NBPTS Coefficient		S.E.
UG completions (1000's)	-0.053		(0.084)	0.124		(0.169)
Grad completions (100's)	0.089		(0.119)	-0.140		(0.261)
Colleges in county	0.032	**	(0.016)	-0.004		(0.015)
Schools in county	-0.071		(0.053)	0.009		(0.120)
Students in county (1000's)	0.201	***	(0.070)	-0.103		(0.190)
SC border	-0.066		(0.075)	0.105		(0.085)
GA border	0.045		(0.429)	-0.111		(0.686)
TN border	-0.068		(0.546)	-0.033		(0.588)
VA border	0.120		(0.238)	-0.004		(0.071)
NBPTS salary differential (1000's)	0.020	***	(0.006)	0.115	***	(0.010)
Master's salary differential (1000's)	0.049	***	(0.011)	0.030		(0.020)
Graduate tuition (1000's)	-0.001		(0.011)	0.012		(0.011)
Time trend	-1.813	***	(0.116)	0.519	**	(0.246)
$\text{Time}^2/100$	21.650	***	(1.004)	-4.041	**	(2.003)
$\text{Time}^3/1000$	-7.457	***	(0.520)	0.501		(1.074)
Constant	41.481	***	(0.708)	47.187	***	(0.943)

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

Table C.2: District Level Estimation Results: Teacher Mobility Outcomes
(jointly estimated with credential equations)

	Mobility (conditional upon not attritting)					
	Switch Within District		Switch Outside District		Attrit	
Variable	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Teacher Characteristics						
Male	-0.077	(0.121)	-0.007	(0.145)	-0.089	(0.1217)
Black	0.058	(0.385)	0.463	(0.494)	0.460 ***	(0.0983)
Other race	0.082 *	(0.045)	-0.240 **	(0.116)	0.243 ***	(0.0443)
NBPTS certified	0.382	(0.529)	-0.162	(0.763)	77.336 ***	(3.2346)
Advanced degree	0.162	(0.123)	0.275 **	(0.137)	0.764 ***	(0.1804)
Lagged NBPTS decision $(t-1)$	0.306 **	(0.133)	0.291	(0.488)	-0.262 **	(0.1224)
Degree decision $(t-1)$	-0.016	(0.279)	-0.078	(0.125)	0.235	(0.4982)
Lagged mobility decision $(t-1)$	0.150 ***	(0.024)	0.381 ***	(0.033)	-0.098 **	(0.0386)
Experience	-0.045	(0.089)	-0.104	(0.119)	-0.337 ***	(0.0676)
Experience^2	-0.216	(0.444)	-0.021	(0.455)	1.060 ***	(0.3888)
Experience^3	0.647	(0.835)	0.918	(0.635)	0.348	(0.9176)
Black × Experience	-0.002	(0.038)	0.028	(0.042)	-0.078 **	(0.0364)
Black × Experience^2	0.002	(0.296)	-0.259	(0.344)	0.742 **	(0.342)
Black × Experience^3	0.031	(0.612)	0.407	(0.746)	-1.949 **	(0.8134)
Male × Experience	-0.002	(0.036)	0.056	(0.037)	-0.123 ***	(0.0371)
Male × Experience^2	0.014	(0.301)	-0.292	(0.328)	0.988 ***	(0.3613)
Male × Experience^3	0.046	(0.647)	0.502	(0.727)	-2.051 **	(0.8813)
Adv. degree × Experience	-0.014	(0.035)	-0.018	(0.048)	-0.081 *	(0.0463)
Adv. degree × Experience^2	0.053	(0.264)	0.125	(0.390)	0.920 **	(0.3821)
Adv. degree × Experience^3	0.031	(0.535)	-0.166	(0.821)	-2.620 ***	(0.8677)
NBPTS × Experience	-0.095	(0.100)	0.045	(0.146)	-0.163	(0.1653)
NBPTS × Experience^2	0.608	(0.471)	-0.241	(0.752)	2.410 ***	(0.5878)
NBPTS × Experience^3	-1.057	(0.919)	0.518	(1.480)	-7.225 ***	(0.9753)
Salary (1000's)	-0.014	(0.014)	-0.020	(0.017)	-0.044 ***	(0.013)
Salary × Experience	0.001	(0.003)	0.000	(0.004)	0.015 ***	(0.0024)
Salary × Experience^2	0.003	(0.016)	0.006	(0.018)	-0.127 ***	(0.0139)
Salary × Experience^3	-0.018	(0.027)	-0.027	(0.023)	0.278 ***	(0.0282)
College: Private	-0.046 ***	(0.016)	-0.039 *	(0.023)	0.016	(0.0155)

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Table C.2 continuing from previous page

	Mobility (conditional upon not attritting)								
	Switch Within District			**Switch Outside District**			**Attrit**		
Variable	Coefficient		S.E.	Coefficient		S.E.	Coefficient		S.E.
College: Research university	-0.004		(0.030)	-0.024		(0.057)	0.049		(0.0328)
College: Urban	0.013		(0.023)	0.018		(0.028)	-0.004		(0.0174)
College: Rural	0.057	***	(0.022)	0.062	**	(0.030)	-0.090	***	(0.0194)
College: Graduate program	-0.078	***	(0.026)	-0.017		(0.033)	-0.583	***	(0.016)
College: Historically black	-0.008		(0.039)	-0.105	***	(0.040)	-0.076	***	(0.028)
College: Most competitive	-0.084		(0.314)	-0.106		(0.682)	0.583		(0.4161)
College: Highly competitive	-0.079		(0.050)	0.157	**	(0.073)	0.306	***	(0.0666)
College: Very competitive	-0.002		(0.026)	0.112	***	(0.043)	0.084	***	(0.0294)
School Characteristics									
Pct. Black	0.048		(0.521)	0.796	**	(0.381)	1.361	***	(0.2928)
Male × Pct black	-0.376		(0.409)	-0.274		(0.416)	-0.263		(0.3054)
Black × Pct Black	-0.185		(0.628)	-1.299	**	(0.587)	-0.104		(0.3452)
Pct. Black × Experience	0.093		(0.081)	0.049		(0.074)	-0.124	**	(0.0528)
Pct. Black × Experience^2	-0.571		(0.420)	-0.142		(0.360)	0.851	**	(0.3801)
Pct. Black × Experience^3	1.096		(0.845)	0.007		(0.679)	-2.086	**	(0.8838)
Pct. Lunch	0.391		(0.564)	0.205		(0.391)	-0.954	***	(0.3185)
Male × Pct lunch	0.561		(0.548)	0.039		(0.572)	1.018	**	(0.4077)
Black Pct lunch	-0.248		(0.647)	0.070		(0.595)	-0.465		(0.3582)
Pct. Lunch × Experience	0.021		(0.086)	0.039		(0.082)	0.043		(0.0549)
Pct. Lunch × Experience^2	-0.170		(0.436)	-0.396		(0.392)	0.552		(0.3811)
Pct. Lunch × Experience^3	0.434		(0.868)	1.036		(0.694)	-1.697	*	(0.8787)
Students per teacher	0.033	**	(0.014)	0.045	**	(0.019)	-0.028		(0.0194)
Total students (100's)	0.010	***	(0.003)	-0.004		(0.004)	-0.013	***	(0.0025)
School is safe	-0.013		(0.009)	-0.009		(0.013)	0.038	***	(0.0079)
Teachers are respected	-0.082	***	(0.009)	-0.078	***	(0.012)	-0.057	***	(0.0087)
Teachers shielded from disruptions	0.009		(0.019)	0.000		(0.021)	-0.047	***	(0.0176)
Professional development	-0.025	***	(0.007)	-0.021	**	(0.009)	0.014	*	(0.0071)
Reasonable class load	0.066	***	(0.008)	0.000		(0.011)	0.024	***	(0.0076)
Low interfering duties	-0.023	***	(0.008)	0.000		(0.010)	-0.003		(0.0075)
High standards for teachers	0.068	***	(0.009)	0.040	***	(0.012)	0.009		(0.0086)
Teachers involved w/decisions	0.000		(0.008)	0.000		(0.010)	-0.001		(0.0077)

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Table C.2 continuing from previous page

	Mobility (conditional upon not attritting)								
	Switch Within District			**Switch Outside District**			**Attrit**		
Variable	Coefficient		S.E.	Coefficient		S.E.	Coefficient		S.E.
Teachers shielded × Experience	-0.004		(0.004)	-0.004		(0.005)	0.006	*	(0.0033)
Teachers shielded × Experience^2	0.008		(0.012)	0.006		(0.018)	-0.021	*	(0.0111)
Pct. teachers with adv. degree	-0.503		(0.324)	-0.291		(0.568)	-0.385	*	(0.221)
Pct. teachers with NBPTS	-0.340		(0.766)	-0.261		(0.702)	-0.298		(0.5364)
Pct. teachers 0 to 2 years experience	0.693	*	(0.380)	1.337	***	(0.453)	0.876	***	(0.2229)
Pct. teachers 3 to 10 years experience	0.442		(0.293)	0.335		(0.674)	0.146		(0.1957)
Pct. low English × Experience	-0.152		(0.155)	-0.028		(0.069)	-0.160		(0.1506)
Pct. low English × Experience^2	0.285		(0.682)	-0.042		(0.311)	0.474		(0.669)
Pct. low math × Experience	0.241		(0.155)	0.021		(0.069)	0.206		(0.1497)
Pct. low math × Experience^2	-0.520		(0.682)	0.003		(0.307)	-0.693		(0.664)
Middle school	0.149	***	(0.021)	0.246	***	(0.030)	0.073	***	(0.0178)
High school	-0.395	***	(0.035)	0.313	***	(0.056)	0.100	***	(0.0248)
District & Community Characteristics									
Urban	0.033		(0.021)	-0.075	**	(0.030)	0.014		(0.0179)
Rural	0.025		(0.024)	-0.051	**	(0.025)	-0.042	**	(0.0197)
Local revenue pct	3.673	***	(0.922)	-1.642	**	(0.764)	-0.774		(0.8425)
Local revenue per student (1000's)	-0.349	***	(0.084)	0.078		(0.071)	0.122	*	(0.0738)
Expenditures per student (1000's)	0.208	***	(0.021)	-0.056	*	(0.031)	0.003		(0.0218)
Number of school openings	0.007	***	(0.001)	0.000		(0.001)	0.016	***	(0.0007)
Avg. salary supplement (1000's)	-0.009	***	(0.002)	-0.014	***	(0.003)	-0.003		(0.002)
Pct. of teachers w/supplement	0.317		(0.330)	0.173		(0.464)	0.152		(0.3233)
Non-agriculture employment (1000's)	-0.064	***	(0.003)	-0.010	*	(0.005)	0.000		(0.0033)
Median HH income	0.002		(0.003)	0.010	**	(0.004)	0.002		(0.0027)
County unemployment rate	-0.010		(0.008)	-0.014	*	(0.009)	-0.027	***	(0.0067)
Population per mile^2 (100's)	0.010		(0.007)	0.016		(0.010)	0.036	***	(0.0068)
UG completions (1000's)	0.010		(0.023)	-0.196	***	(0.027)	-0.049	**	(0.023)
Grad completions (100's)	0.012		(0.035)	0.449	***	(0.040)	0.126	***	(0.0357)
Colleges in county	0.040	***	(0.006)	-0.025	***	(0.009)	-0.029	***	(0.0055)
Schools in county	0.066	***	(0.018)	-0.167	***	(0.026)	-0.015		(0.0173)
Students in county (1000's)	0.143	***	(0.024)	0.148	***	(0.037)	0.023		(0.0252)
SC border	0.109	***	(0.025)	-0.065		(0.047)	0.017		(0.0193)

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Table C.2 continuing from previous page

	Mobility (conditional upon not attritting)								
	Switch Within District			**Switch Outside District**			**Attrit**		
Variable	Coefficient		S.E.	Coefficient		S.E.	Coefficient		S.E.
GA border	0.108		(0.426)	-0.094		(0.696)	0.124		(0.4291)
TN border	0.196	**	(0.085)	-0.413	**	(0.177)	0.076		(0.0734)
VA border	-0.019		(0.034)	-0.049		(0.040)	0.002		(0.0262)
Time trend	0.291	***	(0.056)	0.164	***	(0.058)	0.486	***	(0.0369)
$\text{Time}^2/100$	-4.181	***	(0.866)	-1.798	**	(0.844)	-5.867	***	(0.5513)
$\text{Time}^3/1000$	1.670	***	(0.399)	0.735	*	(0.386)	2.284	***	(0.2559)
Constant	6.807	***	(0.785)	1.520	**	(0.761)	15.955	***	(1.3056)

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

Table C.3: District Level Estimation Results: Unobserved Heterogeneity

		Credential Equations		Mobility Equations		
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)

Table C.4: District Level Estimation Results: Initially Observed Values

							School Quality								
	Adv. Degree			NBPTS			Medium			High			Experience		
Variable	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Male	0.119	***	0.029	-1.118		(0.954)	-0.061	***	(0.015)	-0.051	***	(0.014)	0.008	***	(0.002)
Black	0.110	*	0.058	-0.965		(0.673)	0.723	***	(0.027)	1.250	***	(0.026)	0.013	***	(0.003)
Other race	0.633	***	0.194	-1.451	*	(0.810)	0.480	***	(0.044)	0.930	***	(0.041)	-0.017	***	(0.005)
Colg: Border state	2.447	***	0.118	0.356		(0.869)	-0.131	***	(0.024)	-0.140	***	(0.024)	0.001		(0.003)
Colg: Other state	7.690	***	0.367	1.107	***	(0.159)	-0.005		(0.015)	-0.008		(0.015)	-0.003	**	(0.002)
Colg: Grad program	1.805	***	0.056	1.229	***	(0.255)	-0.150	***	(0.016)	-0.238	***	(0.016)	0.042	***	(0.002)
Colg: Private	-0.008		0.041	-0.204		(0.186)	-0.006		(0.014)	-0.067	***	(0.013)	-0.002		(0.002)
Colg: Research univ.	0.219	***	0.058	-0.065		(0.739)	0.128	***	(0.026)	0.039		(0.026)	-0.019	***	(0.003)
Colg: Urban	-0.029		0.031	0.122		(0.435)	-0.112	***	(0.016)	-0.259	***	(0.015)	-0.011	***	(0.002)
Colg: Rural	0.020		0.031	0.012		(0.473)	-0.433	***	(0.016)	-0.690	***	(0.016)	0.020	***	(0.002)
Colg: Hist. black	0.148	*	0.082	-0.784		(0.833)	0.107	***	(0.032)	0.293	***	(0.030)	0.039	***	(0.004)
Colg: Most comp.	1.273	*	0.701	0.849		(0.621)	-0.012		(0.136)	0.239	*	(0.125)	-0.043	***	(0.009)
Colg: Highly comp.	0.764	***	0.087	0.636		(0.928)	-0.005		(0.039)	0.013		(0.039)	-0.006		(0.005)
Colg: Very comp.	0.190	***	0.046	0.331		(0.727)	-0.038	*	(0.023)	-0.093	***	(0.022)	-0.034	***	(0.003)
Graduation UE	-0.101	***	0.025	0.036		(0.120)	-0.002		(0.012)	0.003		(0.011)	-0.025	***	(0.001)
NBPTS salary	0.019	***	0.002	0.045	***	(0.008)	-0.002	***	(0.001)	-0.005	***	(0.001)	0.041	***	(0.000)
Master's salary	0.001		0.008	-0.084	***	(0.025)	0.002		(0.004)	0.001		(0.004)	-0.005	***	(0.000)
License policy 2	0.349		0.391	7.792	***	(1.060)	0.069		(0.349)	-0.052		(0.349)	0.010		(0.010)
License policy 3	-0.006		0.352	7.655	***	(0.723)	0.082		(0.335)	-0.014		(0.335)	-0.128	***	(0.008)
License policy 4	-0.309		0.372	8.415	***	(0.821)	0.036		(0.343)	-0.031		(0.342)	-0.227	***	(0.008)
License policy 5	-0.814	**	0.394	8.833	***	(0.671)	0.030		(0.345)	-0.025		(0.343)	-0.527	***	(0.008)
License policy 6	-1.742	***	0.373	9.390	***	(0.631)	0.033		(0.342)	0.000		(0.340)	-1.021	***	(0.008)
License policy 7	-3.357	***	0.385	4.935	***	(0.855)	0.095		(0.331)	0.212		(0.330)	-3.111	***	(0.008)
License policy 8	-4.137	***	0.387	4.323	***	(0.859)	0.090		(0.336)	0.260		(0.335)	-3.295	***	(0.008)
Time trend	0.060		0.040	0.313	*	(0.179)	0.084	*	(0.044)	-0.049		(0.046)	-0.039	***	(0.003)
$Time^2/100$	0.405		0.673	6.638	***	(0.990)	-1.390	*	(0.797)	0.797		(0.820)	1.100	***	(0.043)
$Time^3/1000$	0.077		0.331	-4.737	***	(0.723)	0.621		(0.383)	-0.380		(0.393)	-0.480	***	(0.021)
Constant	-7.415	***	0.686	-20.65	***	(0.839)	0.258		(0.329)	0.766	**	(0.330)	1.197	***	(0.010)

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

C.1.1 Supplemental Figures

Figure C.1: Effects of Pct. Lunch, Pct. Black, and Salary on Attrition
(One Std. Dev. Increase)

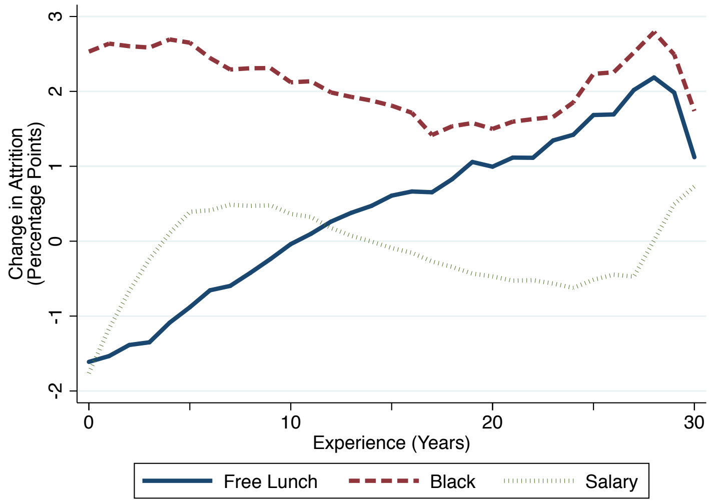

Figure C.2: Effects of Pct. Lunch, Pct. Black, and Salary on Within District Mobility
(One Std. Dev. Increase)

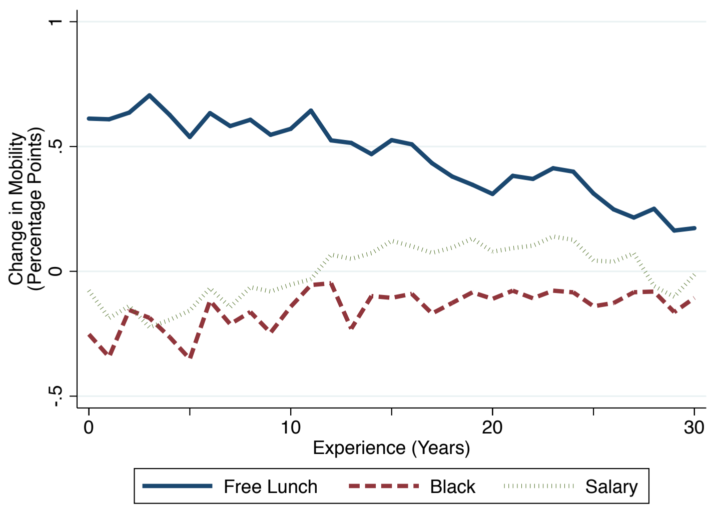

Figure C.3: Effects of Pct. Lunch, Pct. Black, and Salary on Out of District Mobility (One Std. Dev. Increase)

Table C.5: District Level Estimation Results: Teacher Credential Outcomes (without unobserved heterogeneity)

	Advanced Degree			**NBPTS**		
Variable	Coefficient		S.E.	Coefficient		S.E.
Teacher Characteristics						
Male	-0.514	***	(0.139)	-1.126	***	(0.227)
Black	0.155		(0.194)	-1.258	***	(0.370)
Other race	-0.073		(0.085)	-0.234	**	(0.097)
NBPTS certified	1.000	***	(0.094)	-		(0.000)
Lagged NBPTS decision $(t-1)$	-0.928	***	(0.107)	-		(0.000)
Advanced degree	-		(0.000)	0.379	*	(0.201)
Degree decision $(t-1)$	-		(0.000)	0.523	***	(0.072)
Lagged mobility decision $(t-1)$	0.064	*	(0.039)	-0.488	***	(0.051)
Experience	-0.002		(0.104)	0.069		(0.127)
Experience^2	-1.222	**	(0.529)	-1.104	**	(0.559)
Experience^3	2.456	***	(0.848)	1.819	*	(0.965)
Black × Experience	-0.054		(0.046)	0.157	**	(0.079)
Black × Experience^2	0.740	**	(0.353)	-0.980	**	(0.450)
Black × Experience^3	-1.970	**	(0.815)	1.819	**	(0.856)
Male × Experience	0.070	*	(0.039)	0.128	***	(0.047)
Male × Experience^2	-0.451		(0.341)	-0.934	***	(0.319)
Male × Experience^3	0.825		(0.818)	1.897	***	(0.637)
NBPTS × Experience	0.211	***	(0.032)	-		(0.000)
NBPTS × Experience^2	-1.714	***	(0.377)	-		(0.000)
NBPTS × Experience^3	4.479	***	(1.004)	-		(0.000)
Adv. degree × Experience	-		(0.000)	0.146	***	(0.025)
Adv. degree × Experience^2	-		(0.000)	-0.765	***	(0.201)
Adv. degree × Experience^3	-		(0.000)	1.510	***	(0.463)
Salary (1000's)	0.171	***	(0.014)	0.051	**	(0.024)
Salary × Experience	-0.008	***	(0.003)	-0.011	**	(0.005)
Salary × Experience^2	0.055	***	(0.018)	0.069	***	(0.023)
Salary × Experience^3	-0.113	***	(0.032)	-0.133	***	(0.030)
College: Private	-0.110	***	(0.027)	-0.121	***	(0.027)
College: Research university	0.060		(0.051)	0.180	***	(0.043)
College: Urban	-0.013		(0.033)	0.052	*	(0.030)
College: Rural	0.022		(0.035)	-0.002		(0.032)
College: Graduate program	0.109	***	(0.026)	0.262	***	(0.026)
College: Historically black	-0.073		(0.048)	-0.264	***	(0.069)
College: Most competitive	0.314	*	(0.168)	0.589	**	(0.236)
College: Highly competitive	0.198	***	(0.074)	0.326	***	(0.069)
College: Very competitive	0.080	*	(0.048)	0.100	**	(0.043)
School Characteristics						
Pct. Black	-0.699	**	(0.332)	0.150		(0.512)
Male × Pct black	-0.024		(0.178)	-0.424		(0.320)
Black × Pct Black	0.481	**	(0.190)	-0.281		(0.337)
Pct. Black × Experience	0.159	**	(0.078)	0.052		(0.097)
Pct. Black × Experience^2	-1.624	***	(0.555)	-0.559		(0.588)
Pct. Black × Experience^3	4.348	***	(1.273)	1.635		(1.197)
Pct. Lunch	0.627	*	(0.321)	-0.010		(0.523)

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Table C.5 continuing from previous page

Variable	Advanced Degree Coefficient		S.E.	NBPTS Coefficient		S.E.
Male × Pct lunch	0.173		(0.206)	-0.076		(0.406)
Black Pct lunch	-0.179		(0.191)	-0.004		(0.346)
Pct. Lunch × Experience	-0.077		(0.079)	0.020		(0.107)
Pct. Lunch × Experience^2	0.492		(0.604)	-0.282		(0.659)
Pct. Lunch × Experience^3	-1.011		(1.422)	0.320		(1.352)
Students per teacher	0.022		(0.022)	-0.011		(0.034)
Total students (100's)	-0.001		(0.004)	0.010	**	(0.004)
School is safe	0.052	***	(0.015)	0.018		(0.014)
Teachers are respected	-0.002		(0.017)	0.018		(0.018)
Teachers shielded from disruptions	0.002		(0.036)	0.039		(0.040)
Professional development	-0.010		(0.014)	-0.004		(0.013)
Reasonable class load	-0.018		(0.014)	0.039	***	(0.013)
Low interfering duties	0.025	*	(0.014)	-0.003		(0.014)
High standards for teachers	-0.040	**	(0.016)	-0.073	***	(0.015)
Teachers involved w/decisions	0.024	*	(0.014)	-0.015		(0.016)
Teachers shielded × Experience	-0.001		(0.007)	-0.003		(0.006)
Teachers shielded × Experience^2	-0.009		(0.026)	-0.003		(0.020)
Pct. teachers with adv. degree	5.400	***	(0.163)	-0.925	**	(0.362)
Pct. teachers with NBPTS	-1.113		(0.944)	11.757	***	(0.180)
Pct. teachers 0 to 2 years experience	1.025	***	(0.226)	1.198	***	(0.317)
Pct. teachers 3 to 10 years experience	1.123	***	(0.136)	0.001		(0.265)
Pct. low English × Experience	0.084		(0.108)	0.009		(0.085)
Pct. low English × Experience^2	-0.288		(0.560)	0.013		(0.374)
Pct. low math × Experience	0.011		(0.107)	0.005		(0.084)
Pct. low math × Experience^2	-0.009		(0.555)	-0.103		(0.365)
Middle school	0.027		(0.030)	0.053	*	(0.032)
High school	-0.058		(0.043)	0.162	***	(0.042)
District & Community Characteristics						
Urban	-0.054		(0.035)	0.065	*	(0.039)
Rural	0.040		(0.033)	0.021		(0.034)
Local revenue pct	-1.355		(0.938)	-0.094		(0.969)
Local revenue per student (1000's)	0.067		(0.082)	0.005		(0.084)
Expenditures per student (1000's)	-0.074	***	(0.026)	-0.024		(0.025)
Number of school openings	-0.007		(0.007)	0.004		(0.008)
Avg. salary supplement (1000's)	-0.013	**	(0.005)	0.016	***	(0.005)
Pct. of teachers w/supplement	-0.234		(0.320)	0.069		(0.212)
Non-agriculture employment (1000's)	-0.021	***	(0.006)	0.031	***	(0.006)
Median HH income	-0.004		(0.003)	0.001		(0.003)
County unemployment rate	0.004		(0.009)	-0.021	**	(0.008)
Population per mile^2 (100's)	0.020		(0.013)	-0.037	***	(0.012)
UG completions (1000's)	-0.102	***	(0.036)	0.110	***	(0.034)
Grad completions (100's)	0.156	***	(0.051)	-0.115	**	(0.048)
Colleges in county	0.015		(0.011)	-0.005		(0.010)
Schools in county	-0.073	***	(0.027)	-0.005		(0.027)
Students in county (1000's)	0.152	***	(0.041)	-0.088	**	(0.042)
SC border	-0.090	**	(0.036)	0.102	***	(0.039)
GA border	-0.062		(0.277)	-0.075		(0.160)

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Table C.5 continuing from previous page

Variable	Advanced Degree Coefficient		S.E.	NBPTS Coefficient		S.E.
TN border	-0.010		(0.079)	-0.014		(0.079)
VA border	0.102	**	(0.049)	0.018		(0.051)
NBPTS salary differential (1000's)	0.018	***	(0.002)	0.113	***	(0.005)
Master's salary differential (1000's)	0.048	***	(0.004)	0.031	***	(0.005)
Graduate tuition (1000's)	-0.001		(0.008)	0.013		(0.008)
Time trend	-1.410	***	(0.086)	0.658	***	(0.170)
$Time^2/100$	16.504	***	(1.140)	-5.666	**	(2.242)
$Time^3/1000$	-5.677	***	(0.483)	1.136		(0.944)
Constant	-6.889	***	(0.514)	-11.715	***	(0.786)

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

Table C.6: District Level Estimation Results: Teacher Mobility Outcomes
(without unobserved heterogeneity)

	Mobility (conditional upon not attritting)								
	Switch Within District			Switch Outside District			Attrit		
Variable	Coefficient		S.E.	Coefficient		S.E.	Coefficient		S.E.
Teacher Characteristics									
Male	-0.086	*	(0.045)	-0.022		(0.050)	-0.110	***	(0.0214)
Black	0.054		(0.071)	0.435	***	(0.073)	0.275	***	(0.0276)
Other race	0.085	**	(0.039)	-0.240	***	(0.056)	0.158	***	(0.0205)
NBPTS certified	0.411	*	(0.243)	-0.202		(0.322)	-1.148	***	(0.2304)
Advanced degree	0.124	***	(0.045)	0.141	***	(0.048)	0.018		(0.0202)
Lagged NBPTS decision $(t-1)$	0.299	***	(0.053)	0.263	***	(0.073)	-0.423	***	(0.0386)
Degree decision $(t-1)$	0.035		(0.056)	-0.052		(0.069)	0.012		(0.0308)
Lagged mobility decision $(t-1)$	0.167	***	(0.022)	0.423	***	(0.025)	-0.002		(0.0133)
Experience	-0.058	*	(0.031)	-0.150	***	(0.032)	0.117	***	(0.0138)
Experience^2	-0.092		(0.257)	0.439	*	(0.261)	-1.719	***	(0.128)
Experience^3	0.366		(0.574)	-0.075		(0.597)	4.158	***	(0.296)
Black × Experience	-0.002		(0.022)	0.032		(0.023)	-0.037	***	(0.006)
Black × Experience^2	-0.001		(0.175)	-0.291		(0.199)	0.223	***	(0.0418)
Black × Experience^3	0.033		(0.366)	0.474		(0.434)	-0.410	***	(0.0788)
Male × Experience	-0.002		(0.012)	0.059	***	(0.014)	-0.055	***	(0.0053)
Male × Experience^2	0.021		(0.095)	-0.311	**	(0.121)	0.398	***	(0.0382)
Male × Experience^3	0.029		(0.205)	0.536	**	(0.268)	-0.737	***	(0.0739)
Adv. degree × Experience	-0.005		(0.013)	0.007		(0.015)	0.098	***	(0.0054)
Adv. degree × Experience^2	-0.002		(0.094)	-0.011		(0.115)	-0.593	***	(0.0371)
Adv. degree × Experience^3	0.127		(0.192)	0.076		(0.242)	0.857	***	(0.0711)
NBPTS × Experience	-0.093		(0.062)	0.044		(0.080)	0.054		(0.0603)
NBPTS × Experience^2	0.603		(0.432)	-0.254		(0.549)	-0.050		(0.427)
NBPTS × Experience^3	-1.069		(0.912)	0.572		(1.133)	-0.623		(0.8864)
Salary (1000's)	-0.014	***	(0.004)	-0.022	***	(0.004)	0.013	***	(0.0011)
Salary × Experience	0.001		(0.001)	0.001		(0.001)	-0.008	***	(0.0003)
Salary × Experience^2	0.001		(0.009)	-0.002		(0.008)	0.061	***	(0.0029)
Salary × Experience^3	-0.012		(0.020)	-0.010		(0.017)	-0.109	***	(0.0066)
College: Private	-0.048	***	(0.013)	-0.047	***	(0.017)	0.004		(0.007)

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Table C.6 continuing from previous page

Variable	Mobility (conditional upon not attritting) Switch Within District			Switch Outside District			Attrit		
	Coefficient		S.E.	Coefficient		S.E.	Coefficient		S.E.
College: Research university	-0.003		(0.024)	-0.032		(0.030)	0.008		(0.0127)
College: Urban	0.011		(0.015)	0.015		(0.019)	-0.019	**	(0.008)
College: Rural	0.058	***	(0.016)	0.067	***	(0.020)	-0.052	***	(0.0088)
College: Graduate program	-0.090	***	(0.012)	-0.008		(0.016)	-0.317	***	(0.0065)
College: Historically black	-0.008		(0.026)	-0.103	***	(0.033)	-0.039	***	(0.0143)
College: Most competitive	-0.070		(0.086)	-0.080		(0.090)	0.339	***	(0.0365)
College: Highly competitive	-0.075	*	(0.041)	0.168	***	(0.044)	0.177	***	(0.0199)
College: Very competitive	0.002		(0.023)	0.121	***	(0.028)	0.067	***	(0.012)
School Characteristics									
Pct. Black	0.042		(0.102)	0.739	***	(0.144)	0.537	***	(0.0441)
Male × Pct black	-0.384	***	(0.080)	-0.281	***	(0.102)	-0.124	***	(0.0409)
Black × Pct Black	-0.171	*	(0.094)	-1.269	***	(0.347)	-0.051		(0.0456)
Pct. Black × Experience	0.095	***	(0.037)	0.057	*	(0.032)	0.026	*	(0.014)
Pct. Black × Experience^2	-0.579	*	(0.298)	-0.175		(0.266)	-0.241	**	(0.1027)
Pct. Black × Experience^3	1.101	*	(0.641)	0.049		(0.593)	0.278		(0.2)
Pct. Lunch	0.393	***	(0.107)	0.256		(0.167)	-0.404	***	(0.0514)
Male × Pct lunch	0.582	***	(0.095)	0.044		(0.133)	0.587	***	(0.0502)
Black Pct lunch	-0.252	***	(0.097)	0.069		(0.382)	-0.251	***	(0.0477)
Pct. Lunch × Experience	0.017		(0.037)	0.026		(0.035)	-0.010		(0.0178)
Pct. Lunch × Experience^2	-0.149		(0.301)	-0.340		(0.293)	0.409	***	(0.133)
Pct. Lunch × Experience^3	0.405		(0.649)	0.972		(0.654)	-0.912	***	(0.2603)
Students per teacher	0.033	***	(0.010)	0.046	***	(0.012)	-0.009		(0.0068)
Total students (100's)	0.010	***	(0.002)	-0.003		(0.003)	-0.007	***	(0.0011)
School is safe	-0.012		(0.007)	-0.009		(0.009)	0.025	***	(0.0039)
Teachers are respected	-0.083	***	(0.009)	-0.076	***	(0.011)	-0.033	***	(0.0047)
Teachers shielded from disruptions	0.010		(0.013)	0.004		(0.015)	-0.019	***	(0.0064)
Professional development	-0.025	***	(0.007)	-0.020	**	(0.008)	0.008	**	(0.0036)
Reasonable class load	0.066	***	(0.007)	-0.001		(0.008)	0.014	***	(0.0035)
Low interfering duties	-0.023	***	(0.007)	-0.001		(0.009)	-0.001		(0.0038)
High standards for teachers	0.067	***	(0.008)	0.039	***	(0.010)	0.006		(0.0043)
Teachers involved w/decisions	0.000		(0.008)	-0.001		(0.009)	-0.001		(0.004)

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Table C.6 continuing from previous page

	Mobility (conditional upon not attritting)								
	Switch Within District			**Switch Outside District**			**Attrit**		
Variable	Coefficient		S.E.	Coefficient		S.E.	Coefficient		S.E.
Teachers shielded × Experience	-0.005	**	(0.002)	-0.004	*	(0.003)	0.002	**	(0.0009)
Teachers shielded × Experience^2	0.008		(0.007)	0.007		(0.009)	-0.007	**	(0.0029)
Pct. teachers with adv. degree	-0.505	***	(0.067)	-0.280	***	(0.087)	-0.161	***	(0.0354)
Pct. teachers with NBPTS	-0.361	***	(0.126)	-0.256		(0.246)	-0.024		(0.0642)
Pct. teachers 0 to 2 years experience	0.703	***	(0.067)	1.333	***	(0.089)	0.519	***	(0.0367)
Pct. teachers 3 to 10 years experience	0.442	***	(0.066)	0.333	***	(0.086)	0.147	***	(0.0359)
Pct. low English × Experience	-0.150	***	(0.049)	-0.018		(0.058)	-0.128	***	(0.0227)
Pct. low English × Experience^2	0.276		(0.210)	-0.069		(0.254)	0.451	***	(0.0823)
Pct. low math × Experience	0.241	***	(0.049)	0.015		(0.058)	0.165	***	(0.0227)
Pct. low math × Experience^2	-0.518	**	(0.209)	0.020		(0.253)	-0.575	***	(0.0819)
Middle school	0.148	***	(0.014)	0.237	***	(0.019)	0.025	***	(0.008)
High school	-0.395	***	(0.023)	0.306	***	(0.026)	0.048	***	(0.0113)
District & Community Characteristics									
Urban	0.034	**	(0.016)	-0.074	***	(0.022)	-0.009		(0.0092)
Rural	0.024		(0.018)	-0.049	**	(0.020)	-0.027	***	(0.0093)
Local revenue pct	3.675	***	(0.354)	-1.619	**	(0.667)	-0.396		(0.509)
Local revenue per student (1000's)	-0.347	***	(0.033)	0.077		(0.061)	0.054		(0.0443)
Expenditures per student (1000's)	0.209	***	(0.010)	-0.054	***	(0.016)	0.003		(0.0101)
Number of school openings	0.008	***	(0.001)	0.000		(0.001)	0.010	***	(0.0003)
Avg. salary supplement (1000's)	-0.009	***	(0.002)	-0.014	***	(0.003)	-0.002	**	(0.001)
Pct. of teachers w/supplement	0.318	***	(0.084)	0.177	*	(0.095)	0.116	***	(0.0368)
Non-agriculture employment (1000's)	-0.064	***	(0.003)	-0.010	***	(0.004)	-0.003	*	(0.0015)
Median HH income	0.002	*	(0.001)	0.010	***	(0.002)	0.001		(0.001)
County unemployment rate	-0.010	**	(0.005)	-0.012	**	(0.006)	-0.011	***	(0.0023)
Population per mile^2 (100's)	0.011	*	(0.006)	0.015	*	(0.008)	0.027	***	(0.0032)
UG completions (1000's)	0.010		(0.015)	-0.190	***	(0.020)	-0.028	***	(0.0083)
Grad completions (100's)	0.012		(0.023)	0.439	***	(0.028)	0.075	***	(0.0126)
Colleges in county	0.040	***	(0.005)	-0.025	***	(0.007)	-0.017	***	(0.0026)
Schools in county	0.066	***	(0.012)	-0.166	***	(0.017)	-0.008		(0.0067)
Students in county (1000's)	0.144	***	(0.018)	0.146	***	(0.025)	0.016		(0.0102)
SC border	0.108	***	(0.017)	-0.068	***	(0.022)	-0.003		(0.0098)

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Table C.6 continuing from previous page

	Mobility (conditional upon not attritting)								
	Switch Within District			**Switch Outside District**			**Attrit**		
Variable	Coefficient		S.E.	Coefficient		S.E.	Coefficient		S.E.
GA border	0.113		(0.081)	-0.088		(0.109)	0.046		(0.0386)
TN border	0.198	***	(0.044)	-0.418	***	(0.065)	0.025		(0.0232)
VA border	-0.020		(0.027)	-0.048	*	(0.029)	0.001		(0.0134)
Time trend	0.272	***	(0.030)	0.119	**	(0.050)	0.158	***	(0.0156)
$Time^2/100$	-3.977	***	(0.464)	-1.309	*	(0.777)	-1.952	***	(0.2522)
$Time^3/1000$	1.599	***	(0.214)	0.558		(0.355)	0.745	***	(0.1194)
Constant	-5.731	***	(0.226)	-2.691	***	(0.221)	-2.118	***	(0.121)

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

C.2 School Level Model Results

Table C.7: School Level Estimation Results: Teacher Mobility Outcomes

	School Choice		
Variable	Coefficient		S.E.
Pct. Black	-0.064		(0.048)
Pct. Black × Male	0.735	***	(0.055)
Pct. Black × Black	2.411	***	(0.047)
Pct. Black × Experience	-0.096	***	(0.015)
Pct. Black × Experience^2	0.610	***	(0.114)
Pct. Black × Experience^3	-1.036	***	(0.242)
Pct. Black × NBPTS	0.283		(0.202)
Pct. Black × Adv. degree	0.137	***	(0.052)
Pct. Black × Competitive college	0.415	***	(0.062)
Pct. Lunch	-0.350	***	(0.050)
Pct. Lunch × Male	-1.369	***	(0.060)
Pct. Lunch × Experience	-0.037	**	(0.016)
Pct. Lunch × Experience^2	0.091		(0.125)
Pct. Lunch × Experience^3	0.051		(0.266)
Pct. Lunch × NBPTS	-0.360	*	(0.217)
Pct. Lunch × Adv. degree	-0.133	**	(0.062)
Pct. Lunch × Competitive college	-0.762	***	(0.065)
School is safe	0.054	***	(0.004)
Teachers are respected	0.043	***	(0.005)
Teachers shielded from disruptions	0.007		(0.005)
Pct. Students with low English score	0.302	*	(0.160)
Pct. low English × NBPTS	-1.069		(0.885)
Pct. low English × Adv. degree	0.231		(0.266)
Pct. Students with low math score	-0.357	**	(0.160)
Pct. low math × NBPTS	0.200		(0.884)
Pct. low math × Adv. degree	-0.164		(0.267)
Urban	-0.063	***	(0.010)
Rural	-0.030	***	(0.010)
Local revenue per student (1000's)	0.226	***	(0.007)
Expenditures per student (1000's)	-0.226	***	(0.007)
Indicator for current school	3.452	***	(0.007)
Distance from current school	-0.019	***	(0.000)
Distance × Male	0.002	***	(0.000)
Distance × Experience	-0.001	***	(0.000)
Avg. salary at School	0.078	***	(0.004)
Avg. salary × NBPTS	-0.023		(0.021)
Avg. salary × Adv. degree	0.012	**	(0.006)
Total students (100's)	0.048	***	(0.001)
Pct. teachers with adv. degree	-0.421	***	(0.046)
Adv. degree × Pct. adv. degree	2.182	***	(0.090)
Pct. teachers with NBPTS	-0.756	***	(0.073)
NBPTS × Pct. NBPTS	6.677	***	(0.382)
Pct. teachers 0 to 2 years experience	0.516	***	(0.046)
Pct. teachers 3 to 10 years experience	1.395	***	(0.043)

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

C.3 School Level Model Results using Subsample of Teachers

Table C.8: Model Fit: Predicted Outcomes versus Observed Outcomes

	Actual	Predicted		Actual	Predicted
Credential Outcomes					
Adv. Degree	14.0	10.6			
NBPTS	15.3	15.6			
Mobility Outcomes					
Attrit	18.5	21.9			
School Alternative					
1	1.43	1.42	36	0.52	0.53
2	1.18	1.19	37	0.45	0.48
3	1.63	1.65	38	0.35	0.35
4	1.29	1.29	39	0.60	0.61
5	0.69	0.70	40	0.48	0.48
6	0.94	0.95	41	0.18	0.16
7	1.19	1.17	42	0.36	0.32
8	1.57	1.54	43	0.37	0.37
9	1.43	1.66	44	2.60	2.60
10	1.21	1.23	45	0.76	0.75
11	1.99	1.96	46	0.94	0.98
12	0.20	0.23	47	0.98	0.96
13	1.09	1.08	48	2.10	2.14
14	1.07	1.06	49	0.66	0.61
15	1.00	0.97	50	1.79	1.73
16	2.03	2.06	51	2.47	2.49
17	2.12	2.12	52	1.83	1.78
18	1.41	1.31	53	1.40	1.42
19	2.27	2.27	54	1.71	1.66
20	2.19	2.19	55	1.74	1.76
21	1.58	1.65	56	1.54	1.59
22	1.12	1.09	57	2.85	2.81
23	2.22	2.22	58	2.58	2.57
24	1.91	1.89	59	2.64	2.65
25	1.99	1.94	60	2.88	2.94
26	1.84	1.87	61	1.84	1.59
27	1.50	1.45	62	0.91	0.99
28	2.05	2.03	63	2.02	2.04
29	2.59	2.56	64	2.52	2.54
30	0.36	0.33	65	2.59	2.62
31	0.54	0.55	66	2.60	2.66
32	0.37	0.41	67	0.74	0.81
33	0.48	0.48	68	1.99	1.95
34	0.46	0.49	69	1.55	1.53
35	0.36	0.32	70	1.20	1.21

Table C.9: School Level Subsample Estimation Results: Teacher Credential Outcomes (jointly estimated with mobility and attrition equations)

	Advanced Degree			**NBPTS**		
Variable	Coefficient		S.E.	Coefficient		S.E.
Constant	-47.736	***	(8.412)	-16.433	***	(1.960)
Time trend	-7.149	***	(1.287)	2.402	***	(0.835)
$\text{Time}^2/100$	91.676	***	(17.879)	-27.508	**	(11.325)
$\text{Time}^3/1000$	-34.591	***	(7.382)	9.520	**	(4.797)
Male	-1.676		(1.070)	-0.201		(0.589)
Black	1.935	***	(0.627)	-0.724		(0.479)
Other race	-0.567		(0.940)	-0.123		(0.492)
NBPTS certified	-3.167	***	(1.081)	-		-
Lagged NBPTS decision $(t-1)$	-1.142		(1.189)	-		-
Advanced degree	-		-	0.972	**	(0.403)
Degree decision $(t-1)$	-		-	-0.495		(0.371)
Lagged mobility decision $(t-1)$	-1.479	*	(0.837)	-0.793	*	(0.475)
Experience	-1.294	***	(0.418)	0.033		(0.163)
Experience^2	10.099	**	(4.720)	-0.938		(1.035)
Experience^3	-36.226	**	(15.686)	1.402		(2.038)
Male × Experience	0.323		(0.400)	0.044		(0.129)
Male × Experience^2	-2.435		(4.440)	-0.879		(0.844)
Male × Experience^3	-1.621		(14.304)	2.235		(1.643)
Salary (1000's)	0.765	***	(0.100)	-0.003		(0.017)
Missing experience	-1.410		(1.042)	-1.280	*	(0.737)
College: Private	-0.760	**	(0.350)	-0.224	*	(0.123)
College: Urban	0.402		(0.422)	0.142		(0.143)
College: Rural	0.178		(0.535)	0.116		(0.167)
College: Graduate program	0.204		(0.274)	0.378	***	(0.118)
College: Historically black	0.298		(0.567)	-0.764	**	(0.357)
College: Competitive	0.746	**	(0.360)	-0.045		(0.133)
Black × Pct Black	-0.199		(1.390)	0.652		(1.053)
Male × Pct black	0.648		(1.121)	-0.669		(0.781)
Black Pct lunch	-4.247		(3.108)	-1.123		(1.275)
Total students (100's)	-0.027		(0.047)	0.008		(0.018)
Pct. Black	0.403		(2.148)	3.367		(2.095)
Pct. Lunch	-3.430		(4.504)	2.999		(2.944)
School is safe	-0.359	*	(0.196)	0.048		(0.081)
Teachers are respected	-0.051		(0.193)	0.044		(0.085)
Teachers shielded from disruptions	0.195		(0.195)	-0.105		(0.076)
Urban	-0.477		(0.362)	-0.066		(0.150)
Rural	0.654		(0.512)	-0.026		(0.253)
Local revenue per student (1000's)	-0.467	*	(0.243)	-0.035		(0.121)
Expenditures per student (1000's)	-0.840	***	(0.249)	-0.139		(0.110)
Median HH income	-0.007		(0.035)	0.019		(0.016)
County unemployment rate	-0.466	***	(0.153)	-0.076		(0.068)
Population per mile^2 (100's)	0.232	**	(0.092)	-0.050		(0.035)
NBPTS salary differential (1000's)	0.051	**	(0.020)	0.157	***	(0.033)
Master's salary differential (1000's)	0.250	***	(0.030)	0.017		(0.013)
Graduate tuition (1000's)	-0.244	**	(0.097)	0.052		(0.044)

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Table C.9 continuing from previous page

	Advanced Degree			NBPTS		
Variable	Coefficient		S.E.	Coefficient		S.E.
Pct. Lunch × Experience	1.290		(1.573)	-0.744		(0.725)
Pct. Lunch × Experience^2	-13.871		(16.502)	5.394		(5.012)
Pct. Lunch × Experience^3	63.781		(48.363)	-10.495		(10.108)
Pct. Black × Experience	0.006		(0.916)	-0.761		(0.516)
Pct. Black × Experience^2	1.975		(9.842)	4.905		(3.520)
Pct. Black × Experience^3	-42.096		(27.658)	-9.448		(7.031)
Pct. low English × Experience	-9.279	***	(2.208)	0.433		(0.690)
Pct. low English × Experience^2	37.726	***	(10.901)	-1.940		(2.089)
Pct. low math × Experience	4.395	***	(1.531)	-0.533		(0.631)
Pct. low math × Experience^2	-16.644	**	(6.967)	2.096		(1.915)
Pct. teachers with adv. degree	7.152	***	(1.546)	-0.796		(0.862)
Pct. teachers with NBPTS	3.261		(2.349)	14.949	***	(1.150)
Pct. Students with low math score	-12.974	**	(6.180)	4.802		(4.321)
Pct. Students with low English score	37.326	***	(8.569)	-1.373		(4.918)

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

Table C.10: School Level Subsample Estimation Results: Teacher Attrition Outcome (jointly estimated with credential and mobility equations)

	Attrit		
Variable	Coefficient		S.E.
Teacher Characteristics			
Male	-0.164	*	(0.091)
Black	0.399	***	(0.116)
Other race	-0.052		(0.130)
Advanced degree	0.319	***	(0.045)
NBPTS certified	-0.900	***	(0.218)
Degree decision $(t-1)$	0.121		(0.149)
Lagged NBPTS decision $(t-1)$	-0.523	**	(0.211)
Lagged mobility decision $(t-1)$	0.020		(0.126)
Experience	-0.028		(0.028)
Experience^2	-0.602	***	(0.200)
Experience^3	2.403	***	(0.403)
Male × Experience	-0.032		(0.025)
Male × Experience^2	0.300		(0.191)
Male × Experience^3	-0.580		(0.390)
Salary (1000's)	-0.015	***	(0.003)
College: Private	0.028		(0.039)
College: Urban	-0.031		(0.046)
College: Rural	-0.103	*	(0.057)
College: Graduate program	-0.237	***	(0.037)
College: Historically black	-0.090		(0.082)
College: Competitive	0.048		(0.047)
School & Community Characteristics			
Pct. Black	0.761	***	(0.281)
Male × Pct black	-0.040		(0.179)
Black × Pct Black	-0.569	**	(0.246)
Pct. Black × Experience	-0.063		(0.064)
Pct. Black × Experience^2	0.704		(0.442)
Pct. Black × Experience^3	-1.620	*	(0.865)
Pct. Lunch	-0.910	**	(0.400)
Black Pct lunch	0.068		(0.418)
Pct. Lunch × Experience	0.058		(0.078)
Pct. Lunch × Experience^2	0.128		(0.504)
Pct. Lunch × Experience^3	-0.403		(1.003)
Total students (100's)	0.001		(0.006)
School is safe	-0.006		(0.027)
Teachers are respected	-0.052	*	(0.027)
Teachers shielded from disruptions	-0.016		(0.026)
Pct. teachers with adv. degree	0.094		(0.267)
Pct. teachers with NBPTS	-0.196		(0.481)
Pct. Students with low English score	2.393	***	(0.882)
Pct. low English × Experience	-0.314	**	(0.149)
Pct. low English × Experience^2	0.241		(0.481)
Pct. Students with low math score	-0.027		(0.714)
Pct. low math × Experience	0.209		(0.130)

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Table C.10 continuing from previous page

	Attrit		
Variable	Coefficient		S.E.
Pct. low math × Experience^2	-0.507		(0.417)
Urban	0.109	**	(0.051)
Rural	-0.146	*	(0.080)
Local revenue per student (1000's)	-0.011		(0.039)
Expenditures per student (1000's)	0.124	***	(0.034)
Median HH income	-0.014	***	(0.005)
County unemployment rate	0.084	***	(0.021)
Population per mile^2 (100's)	0.005		(0.010)
Time trend	0.793	***	(0.124)
Time^2/100	-9.523	***	(1.807)
Time^3/1000	3.414	***	(0.825)
Constant	-3.156	***	(0.424)

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

Table C.11: School Level Subsample Estimation Results: Teacher Mobility Outcomes (jointly estimated with credential and attrition equations)

	School Choice		
Variable	Coefficient		S.E.
Pct. Black	0.544		(1.082)
Pct. Black × Male	0.392		(0.472)
Pct. Black × Black	4.387	***	(0.496)
Pct. Black × Experience	-0.301	*	(0.164)
Pct. Black × Experience^2	2.199	*	(1.295)
Pct. Black × Experience^3	-3.696		(2.794)
Pct. Black × NBPTS	0.485		(2.213)
Pct. Black × Adv. degree	0.813		(0.558)
Pct. Black × Competitive college	0.493		(0.555)
Pct. Lunch	0.411		(1.169)
Pct. Lunch × Male	0.628		(0.905)
Pct. Lunch × Experience	-0.305		(0.354)
Pct. Lunch × Experience^2	1.626		(2.913)
Pct. Lunch × Experience^3	-3.500		(6.338)
Pct. Lunch × NBPTS	-3.828		(3.685)
Pct. Lunch × Adv. degree	0.257		(1.034)
Pct. Lunch × Competitive college	-2.422	**	(1.048)
School is safe	0.121		(0.086)
Teachers are respected	0.015		(0.074)
Teachers shielded from disruptions	0.093		(0.082)
Pct. Students with low English score	3.222	**	(1.351)
Pct. low English × NBPTS	9.150		(10.034)
Pct. low English × Adv. degree	-5.190	***	(1.930)
Pct. Students with low math score	-3.265	***	(1.037)
Pct. low math × NBPTS	-2.297		(6.341)
Pct. low math × Adv. degree	1.644		(1.402)
Urban	0.025		(0.191)
Rural	-0.150		(0.186)
Local revenue per student (1000's)	0.060		(0.111)
Expenditures per student (1000's)	-0.091		(0.098)
Indicator for current school	8.425	***	(0.206)
Distance from current school	-0.061	***	(0.005)
Distance × Male	0.016	***	(0.004)
Distance × Experience	-0.003	***	(0.000)
Avg. salary at School	-0.163		(0.274)
Avg. salary × NBPTS	0.355		(0.286)
Avg. salary × Adv. degree	-0.001		(0.084)
Total students (100's)	0.050	*	(0.026)
Pct. teachers with adv. degree	-0.450		(0.790)
Adv. degree × Pct. adv. degree	0.850		(0.939)
Pct. teachers with NBPTS	0.018		(1.215)
NBPTS × Pct. NBPTS	5.763		(6.317)
Pct. teachers 0 to 2 years experience	0.148		(0.786)
Pct. teachers 3 to 10 years experience	-0.232		(0.771)

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

Table C.12: School Level Subsample Estimation Results: Unobserved Heterogeneity

	Permanent Mass Points							Time-varying Mass Points		
Mass Point	2	3	4	5	6	7	8	2	3	4
Weight	0.030	0.129	0.046	0.540	0.128	0.003	0.091	0.018	0.020	0.018
Adv. Degree	35.637	41.200	17.239	-40.137	-281.154	494.341	-0.240	1.148	-37.963	47.423
	(7.215)	(7.020)	(5.212)	(30.564)	(11.030)	(109.002)	(1.466)	(1.155)	(2.011)	(7.259)
NBPTS	0.704	0.319	-0.456	-0.869	-2.626	-0.250	-0.817	2.034	0.457	0.386
	(0.358)	(0.275)	(0.343)	(0.2706)	(2.805)	(31.634)	(0.342)	(0.482)	(0.794)	(0.571)
Attrit	-4.440	-0.069	0.181	-0.091	2.081	71.266	-0.127	0.078	-30.594	0.730
	(0.538)	(0.140)	(0.155)	(0.122)	(0.214)	(897.539)	(0.129)	(0.666)	(779.300)	(0.212)
School										
2	-5.015	-1.658	-5.461	-0.049	-0.880	5.665	-2.170	1.584	4.547	0.907
	(1.338)	(1.092)	(1.303)	(1.142)	(2.528)	(12.704)	(2.278)	(1.418)	(1.856)	(1.811)
3	-5.487	-3.827	-3.648	-1.285	-1.373	-4.077	-1.033	0.630	5.028	10.457
	(1.458)	(0.961)	(1.675)	(1.030)	(2.410)	(1.000)	(2.428)	(1.674)	(1.886)	(1.465)
4	1.986	-5.429	-1.889	2.766	0.095	-3.828	0.681	-2.890	1.609	3.938
	(1.211)	(0.857)	(1.884)	(1.078)	(2.582)	(1.000)	(2.493)	(1.635)	(1.941)	(2.264)
5	2.388	-5.209	-1.719	0.380	2.704	-2.829	1.244	-6.079	-0.955	6.799
	(1.272)	(1.250)	(2.019)	(1.343)	(2.337)	(1.000)	(2.567)	(1.956)	(2.069)	(1.719)
6	-1.692	-0.879	-0.667	-1.968	-0.407	4.400	-0.907	1.514	1.173	8.345
	(2.261)	(1.040)	(1.450)	(1.073)	(2.492)	(1.202)	(2.677)	(1.391)	(1.998)	(1.776)
7	-3.236	-4.495	-1.260	0.087	-1.744	1.901	-0.706	-0.642	6.389	5.501
	(1.768)	(0.937)	(1.442)	(1.240)	(2.362)	(1.242)	(2.456)	(1.669)	(1.858)	(2.250)
8	-5.169	-0.601	-2.111	2.926	-1.659	11.234	0.004	-7.804	-48.025	5.520
	(1.647)	(1.238)	(1.805)	(1.058)	(2.587)	(170.970)	(3.013)	(1.612)	(1.000)	(1.750)
9	-30.461	-0.920	-0.375	1.142	1.284	74.336	-0.558	1.949	-4.242	-0.357
	(1.000)	(1.138)	(1.534)	(1.170)	(2.270)	(162.987)	(2.697)	(1.276)	(1.902)	(1.901)
10	-0.304	-1.671	-2.306	-1.737	-1.839	-7.138	-0.124	3.097	-3.413	10.414
	(1.559)	(1.014)	(1.503)	(1.055)	(2.500)	(1.000)	(2.459)	(1.227)	(2.131)	(1.536)
11	-2.005	-2.807	-1.422	-1.186	-1.754	-0.057	-0.685	4.413	5.648	3.984
	(1.536)	(1.040)	(1.334)	(1.017)	(2.435)	(218.769)	(2.378)	(1.136)	(1.699)	(1.675)
12	-3.643	-0.225	-1.761	-1.276	2.125	-3.900	-1.358	-0.648	3.404	-19.627
	(1.672)	(1.237)	(1.915)	(1.478)	(2.336)	(1.000)	(4.553)	(2.096)	(1.869)	(1.002)
13	-0.547	-0.061	1.676	2.480	-4.725	-3.166	-0.156	0.429	-6.453	1.270

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Table C.12 continuing from previous page

	Permanent Mass Points							**Time-varying Mass Points**		
Mass Point	2	3	4	5	6	7	8	2	3	4
Weight	0.030	0.129	0.046	0.540	0.128	0.003	0.091	0.018	0.020	0.018
School										
	(2.468)	(1.121)	(1.480)	(1.125)	(2.384)	(1.001)	(2.853)	(1.322)	(2.022)	(2.119)
14	-6.717	-4.128	-3.532	0.235	-2.043	-2.025	-0.176	3.692	-2.847	3.905
	(2.947)	(1.288)	(1.533)	(1.141)	(2.830)	(1.000)	(2.514)	(1.205)	(1.972)	(1.974)
15	0.184	-6.211	-2.785	0.709	0.863	-8.805	-0.631	-0.851	-3.777	5.804
	(1.575)	(1.150)	(1.563)	(1.238)	(2.305)	(1.000)	(2.577)	(2.211)	(2.281)	(2.160)
16	2.674	0.659	3.042	1.260	1.334	3.122	1.063	-6.167	-4.108	0.367
	(1.360)	(0.998)	(1.294)	(1.250)	(2.291)	(1.000)	(2.648)	(1.465)	(1.879)	(1.744)
17	-0.390	-0.590	-1.874	2.477	-1.541	8.586	1.941	-2.268	-4.638	0.596
	(1.358)	(1.034)	(1.509)	(1.089)	(2.416)	(1.746)	(2.386)	(1.366)	(1.808)	(1.829)
18	-5.933	-2.864	-3.916	1.577	-4.182	-0.455	-1.744	-5.812	3.756	-1.299
	(1.429)	(1.413)	(2.281)	(1.278)	(2.434)	(1.000)	(2.489)	(1.603)	(1.751)	(1.842)
19	-4.761	-3.261	-4.351	-0.503	-0.867	-5.085	0.104	-3.309	6.422	9.886
	(1.532)	(1.201)	(1.496)	(1.217)	(2.467)	(1.000)	(2.415)	(1.705)	(1.701)	(1.568)
20	-2.383	-4.292	-5.991	-0.245	-2.043	-13.163	0.035	1.026	5.921	6.270
	(1.469)	(1.155)	(1.394)	(1.130)	(2.398)	(1.000)	(2.389)	(1.239)	(1.688)	(2.621)
21	-3.073	-1.411	-0.145	1.641	3.084	-0.032	2.501	-7.950	-4.338	-0.155
	(1.924)	(1.402)	(1.313)	(1.243)	(2.240)	(1.000)	(2.400)	(1.490)	(1.914)	(1.871)
22	-1.985	-5.860	-2.317	-0.478	-2.407	-5.012	-2.165	-7.171	-1.460	11.297
	(1.826)	(1.306)	(1.525)	(1.310)	(2.907)	(1.000)	(2.557)	(5.238)	(2.085)	(1.600)
23	2.372	-0.938	1.773	2.844	-4.446	65.412	2.118	-7.907	-3.385	7.122
	(1.291)	(1.218)	(1.321)	(1.087)	(2.369)	(103.391)	(2.351)	(1.647)	(1.870)	(1.581)
24	1.276	-2.136	-1.171	-0.354	-3.703	4.407	0.177	-3.156	5.291	7.146
	(1.417)	(1.345)	(1.451)	(1.065)	(2.394)	(929.890)	(2.366)	(1.388)	(1.702)	(2.223)
25	1.960	-1.611	1.227	0.963	-5.958	-5.677	0.420	1.961	-3.529	2.532
	(1.291)	(1.261)	(1.337)	(1.151)	(2.293)	(1.000)	(2.480)	(1.172)	(1.830)	(1.680)
26	1.154	-3.758	-2.405	-1.162	-5.623	-4.678	-2.078	4.269	-1.570	9.508
	(1.377)	(1.278)	(1.530)	(1.145)	(2.552)	(1.000)	(2.446)	(1.125)	(1.794)	(1.642)
27	-1.171	-4.531	-1.394	-1.667	-0.701	-9.818	-2.057	-2.085	5.431	7.681
	(1.614)	(1.190)	(1.574)	(1.085)	(2.369)	(1.000)	(2.560)	(1.563)	(1.725)	(1.947)
28	-3.295	-0.976	-1.582	-0.767	-1.767	-5.478	-0.894	2.273	-0.165	4.635

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Table C.12 continuing from previous page

	Permanent Mass Points							Time-varying Mass Points		
Mass Point	2	3	4	5	6	7	8	2	3	4
Weight	0.030	0.129	0.046	0.540	0.128	0.003	0.091	0.018	0.020	0.018
School										
	(1.440)	(1.122)	(2.220)	(1.164)	(2.489)	(1.000)	(2.533)	(1.308)	(1.995)	(1.798)
29	2.109	-3.610	-4.319	-0.873	-3.896	-4.244	-1.810	-3.385	5.938	4.536
	(1.246)	(1.316)	(1.406)	(1.103)	(2.501)	(1.000)	(2.481)	(1.450)	(1.697)	(1.686)
30	-3.893	-5.232	-2.836	-0.859	-6.479	-1.469	-0.075	-4.028	1.466	10.161
	(1.794)	(1.090)	(1.827)	(1.286)	(2.488)	(1.000)	(2.503)	(2.842)	(2.241)	(1.626)
31	-0.867	-2.463	-6.626	-3.503	-3.184	-14.591	-3.334	3.798	0.522	0.677
	(1.537)	(1.230)	(1.696)	(1.275)	(2.568)	(1.000)	(2.607)	(1.275)	(1.957)	(2.726)
32	-6.830	-3.487	-5.253	1.657	1.731	0.590	1.577	1.775	-4.049	0.144
	(3.194)	(1.308)	(2.467)	(1.149)	(2.264)	(1.000)	(2.443)	(1.283)	(2.300)	(2.199)
33	1.667	-6.933	1.795	2.305	-1.203	-3.497	-0.345	-8.561	-1.466	-2.626
	(1.386)	(1.339)	(1.359)	(1.206)	(2.661)	(1.000)	(2.764)	(1.855)	(2.049)	(4.414)
34	-2.432	-1.314	-1.539	-0.987	0.739	-4.439	-0.404	-3.034	-4.283	4.228
	(1.681)	(1.231)	(2.518)	(1.331)	(2.310)	(1.000)	(2.695)	(1.908)	(2.464)	(2.290)
35	-64.340	-3.725	-3.203	-2.745	-2.322	6.333	-0.239	3.976	5.256	4.118
	(1.000)	(1.207)	(1.627)	(1.102)	(2.513)	(162.908)	(2.444)	(1.262)	(1.824)	(1.952)
36	-1.611	-4.349	0.967	2.813	-5.291	1.452	0.094	-0.012	-7.892	-1.525
	(3.123)	(1.321)	(1.472)	(1.098)	(2.359)	(1.000)	(2.621)	(1.261)	(2.219)	(2.292)
37	-4.517	0.054	-1.918	-1.047	-1.425	-4.165	1.776	-1.450	-46.083	5.304
	(1.555)	(0.900)	(1.906)	(1.314)	(2.616)	(1.000)	(2.425)	(1.614)	(1.000)	(2.147)
38	-2.257	-2.458	-2.434	-1.805	-0.783	-1.168	-1.584	2.611	3.757	3.852
	(2.791)	(1.178)	(1.634)	(1.108)	(2.482)	(368.422)	(2.617)	(1.409)	(1.864)	(2.056)
39	-2.703	-2.672	-0.213	0.924	-1.896	-3.488	-3.057	-5.670	-4.812	5.036
	(3.232)	(1.409)	(1.604)	(1.179)	(2.653)	(1.000)	(2.512)	(1.732)	(2.096)	(2.087)
40	-2.397	0.888	1.003	1.133	-3.965	-0.930	-1.484	-2.260	-4.179	-2.857
	(4.807)	(0.873)	(1.450)	(1.354)	(2.443)	(1.000)	(5.015)	(2.141)	(2.129)	(5.575)
41	-0.544	-7.501	-2.621	-1.883	-0.273	-3.596	-26.758	-0.219	-2.793	11.179
	(1.494)	(1.345)	(1.611)	(1.253)	(2.399)	(1.000)	(1.000)	(4.646)	(2.508)	(1.569)
42	-72.248	-5.288	-2.064	0.449	-0.756	-3.145	-32.957	-4.346	-22.101	9.640
	(1.000)	(1.246)	(1.923)	(1.367)	(2.454)	(1.000)	(1.000)	(1.923)	(11.797)	(1.739)
43	-1.327	-0.338	-1.654	1.145	0.011	-7.959	-0.599	-45.053	-0.009	6.781

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Table C.12 continuing from previous page

	Permanent Mass Points							**Time-varying Mass Points**		
Mass Point	2	3	4	5	6	7	8	2	3	4
Weight	0.030	0.129	0.046	0.540	0.128	0.003	0.091	0.018	0.020	0.018
School										
	(2.837)	(1.002)	(2.178)	(1.238)	(2.713)	(1.000)	(2.867)	(1.000)	(2.573)	(2.081)
44	-4.073	-4.095	-3.913	-0.793	1.945	6.192	0.605	-4.571	6.667	5.430
	(1.493)	(1.396)	(1.593)	(1.293)	(2.430)	(223.056)	(2.445)	(1.448)	(1.734)	(2.284)
45	3.312	0.607	3.577	0.327	-0.366	6.408	0.093	-9.202	-5.789	0.426
	(1.359)	(1.304)	(1.316)	(2.270)	(3.727)	(1.012)	(6.058)	(2.301)	(2.273)	(2.904)
46	-3.186	-2.882	-2.574	0.342	-1.189	5.029	1.244	3.207	-2.628	5.133
	(1.705)	(1.466)	(1.575)	(1.422)	(2.836)	(3.185)	(2.692)	(1.453)	(1.981)	(2.715)
47	-1.195	-1.222	-1.714	-0.863	-2.901	1.124	-0.081	-5.919	5.116	5.224
	(2.288)	(1.433)	(2.031)	(1.402)	(2.392)	(1.006)	(2.879)	(2.025)	(1.879)	(2.411)
48	0.234	0.704	-2.165	-0.308	3.258	3.475	2.467	-2.192	-3.689	-2.424
	(1.786)	(1.146)	(1.722)	(1.328)	(2.273)	(1.000)	(2.432)	(1.742)	(1.920)	(1.813)
49	0.924	-0.789	0.115	1.198	-2.802	-1.165	-1.864	2.032	1.290	-24.063
	(1.712)	(1.472)	(1.661)	(1.458)	(2.461)	(1.000)	(2.467)	(1.356)	(2.223)	(1.000)
50	-4.738	1.205	-3.526	2.115	-2.129	6.292	1.358	-4.650	-1.744	4.109
	(1.515)	(1.004)	(1.395)	(1.349)	(2.384)	(263.433)	(2.593)	(1.706)	(1.897)	(2.144)
51	-1.127	0.792	-2.151	0.808	2.919	-10.939	2.685	-1.168	0.396	4.127
	(1.646)	(1.015)	(1.806)	(1.235)	(2.292)	(1.000)	(2.372)	(1.430)	(2.004)	(1.882)
52	-1.971	-4.368	-2.978	-1.318	-0.335	2.255	-1.366	4.507	6.820	9.357
	(1.550)	(1.007)	(1.339)	(1.077)	(2.444)	(2.995)	(2.392)	(1.139)	(1.706)	(1.835)
53	-2.893	-0.441	1.249	-0.453	1.569	-6.365	0.063	-1.146	-39.743	5.656
	(1.521)	(1.011)	(1.403)	(1.165)	(2.285)	(1.000)	(2.707)	(1.592)	(1.000)	(1.853)
54	-0.548	-1.006	0.479	0.560	-3.663	0.991	-0.605	-5.102	4.629	5.398
	(2.334)	(1.279)	(1.439)	(1.286)	(2.366)	(1.005)	(2.727)	(1.665)	(1.823)	(2.085)
55	2.416	-0.858	0.741	0.735	-1.774	3.695	-0.979	1.181	-3.511	1.281
	(1.199)	(1.021)	(1.365)	(1.170)	(2.450)	(1.048)	(2.801)	(1.292)	(1.870)	(1.687)
56	1.555	-1.947	-3.834	-1.568	1.431	-11.492	-2.297	0.321	6.534	4.656
	(1.321)	(1.103)	(1.309)	(1.092)	(2.318)	(1.000)	(2.538)	(1.992)	(1.708)	(2.484)
57	-1.114	-0.325	-2.308	3.018	-2.928	-4.739	2.751	-8.809	2.024	-0.521
	(1.682)	(1.115)	(1.797)	(1.156)	(2.312)	(1.000)	(2.345)	(1.343)	(1.948)	(1.753)
58	-3.164	-2.223	-0.417	2.520	-1.474	-10.850	-0.793	-1.096	-1.323	4.206

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Table C.12 continuing from previous page

	Permanent Mass Points							**Time-varying Mass Points**		
Mass Point	2	3	4	5	6	7	8	2	3	4
Weight	0.030	0.129	0.046	0.540	0.128	0.003	0.091	0.018	0.020	0.018
School										
	(1.502)	(1.313)	(1.454)	(1.196)	(2.334)	(1.000)	(2.454)	(1.267)	(1.945)	(1.949)
59	-0.697	-1.776	-1.533	2.313	0.680	-11.749	2.200	-6.972	3.696	0.632
	(1.595)	(1.463)	(1.551)	(1.342)	(2.554)	(1.000)	(2.438)	(1.456)	(1.810)	(1.788)
60	-1.079	-3.306	0.413	1.215	3.281	-2.700	1.324	-0.529	-1.999	3.533
	(1.546)	(1.176)	(1.193)	(1.169)	(2.222)	(1.000)	(2.491)	(1.116)	(1.790)	(2.019)
61	-2.765	0.128	-5.314	3.906	4.252	12.718	-22.474	-10.992	-4.271	-3.128
	(2.049)	(1.110)	(1.537)	(1.154)	(2.245)	(13.550)	(1.000)	(1.420)	(1.874)	(1.694)
62	0.244	-4.778	-2.980	0.258	2.964	2.814	1.013	-8.606	-2.679	5.714
	(1.442)	(1.825)	(1.810)	(1.543)	(2.285)	(35.789)	(2.585)	(2.120)	(2.037)	(1.927)
63	-4.438	-0.378	-6.670	-0.527	3.603	6.560	0.360	-0.308	4.561	2.828
	(1.389)	(1.118)	(1.249)	(1.101)	(2.233)	(5.854)	(2.513)	(1.298)	(1.808)	(1.791)
64	1.655	-0.921	-0.177	2.150	1.862	-61.523	1.111	-8.949	-1.407	0.329
	(1.212)	(1.242)	(1.378)	(1.197)	(2.447)	(198.166)	(2.556)	(1.483)	(1.943)	(1.732)
65	-0.625	-2.445	-1.436	-0.106	-1.079	-0.875	1.718	0.305	0.403	3.131
	(1.396)	(1.293)	(1.458)	(1.151)	(2.444)	(1.000)	(2.375)	(1.126)	(2.088)	(1.921)
66	-0.463	-2.758	0.132	2.037	-0.820	-2.183	2.482	-7.009	-0.704	6.980
	(1.733)	(1.385)	(1.420)	(1.319)	(2.466)	(1.000)	(2.459)	(1.446)	(1.910)	(1.618)
67	-3.915	-4.237	-4.067	0.883	2.519	-3.022	-2.425	-9.944	-2.750	8.795
	(2.015)	(1.236)	(1.704)	(1.268)	(2.317)	(1.000)	(2.482)	(5.408)	(2.121)	(1.603)
68	-3.790	-4.147	-4.537	1.318	-0.102	7.493	-0.333	-9.099	6.114	5.783
	(1.678)	(1.279)	(1.648)	(1.209)	(2.465)	(54.667)	(2.495)	(1.623)	(1.744)	(2.519)
69	-0.084	-2.137	-0.920	2.448	-3.475	2.120	0.452	-8.868	0.268	6.461
	(1.856)	(1.698)	(2.317)	(1.124)	(2.642)	(1.000)	(2.868)	(2.007)	(2.132)	(2.064)
70	-208.278	-2.795	-1.389	-1.818	-2.120	-6.585	-1.280	5.503	-0.865	8.289
	(1.000)	(1.441)	(1.968)	(1.306)	(3.039)	(1.000)	(2.656)	(1.287)	(2.024)	(7.661)

Note: First mass point for permanent and time-varying are normalized to zero.

C.4 School Level Model Results using Subsample of Teachers (without controlling for unobserved heterogeneity)

Table C.13: School Level Subsample Estimation Results: Teacher Attrition Outcome (without unobserved heterogeneity)

	School Choice		
Variable	Coefficient		S.E.
Teacher Characteristics			
Male	-0.165	**	(0.077)
Black	0.272	***	(0.099)
Other race	-0.011		(0.113)
Advanced degree	0.272	***	(0.034)
NBPTS certified	-1.062	***	(0.189)
Degree decision $(t-1)$	0.001		(0.139)
Lagged NBPTS decision $(t-1)$	-0.735	***	(0.196)
Lagged mobility decision $(t-1)$	0.071		(0.115)
Experience	-0.087	***	(0.023)
Experience^2	-0.026		(0.157)
Experience^3	0.937	***	(0.303)
Male × Experience	-0.032		(0.021)
Male × Experience^2	0.293	*	(0.152)
Male × Experience^3	-0.561	*	(0.296)
Salary (1000's)	-0.013	***	(0.002)
College: Private	0.017		(0.032)
College: Urban	-0.059		(0.039)
College: Rural	-0.116	**	(0.047)
College: Graduate program	-0.227	***	(0.030)
College: Historically black	-0.069		(0.071)
College: Competitive	0.060		(0.039)
School & Community Characteristics			
Pct. Black	0.482	*	(0.249)
Male × Pct black	-0.032		(0.154)
Black × Pct Black	-0.247		(0.213)
Pct. Black × Experience	0.023		(0.060)
Pct. Black × Experience^2	0.062		(0.408)
Pct. Black × Experience^3	-0.530		(0.768)
Pct. Lunch	-0.717	**	(0.363)
Black Pct lunch	0.037		(0.369)
Pct. Lunch × Experience	0.007		(0.091)
Pct. Lunch × Experience^2	0.637		(0.650)
Pct. Lunch × Experience^3	-1.714		(1.278)
Total students (100's)	-0.004		(0.005)
School is safe	-0.013		(0.022)
Teachers are respected	-0.059	**	(0.023)
Teachers shielded from disruptions	0.000		(0.022)
Pct. teachers with adv. degree	0.000		(0.229)
Pct. teachers with NBPTS	-0.201		(0.422)
Pct. Students with low English score	1.933	**	(0.834)

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Table C.13 continuing from previous page

	School Choice		
Variable	Coefficient		S.E.
Pct. low English × Experience	-0.473	***	(0.133)
Pct. low English × Experience^2	1.187	***	(0.414)
Pct. Students with low math score	-0.229		(0.658)
Pct. low math × Experience	0.204	*	(0.117)
Pct. low math × Experience^2	-0.468		(0.368)
Urban	0.100	**	(0.043)
Rural	-0.136	*	(0.070)
Local revenue per student (1000's)	-0.001		(0.037)
Expenditures per student (1000's)	0.105	***	(0.031)
Median HH income	-0.012	***	(0.004)
County unemployment rate	0.075	***	(0.021)
Population per mile^2 (100's)	0.006		(0.008)
Time trend	0.505	***	(0.169)
Time^2/100	-6.603	**	(2.565)
Time^3/1000	2.465	**	(1.169)
Constant	-1.864	***	(0.467)

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

Table C.14: School Level Subsample Estimation Results: Teacher Mobility Outcomes (without unobserved heterogeneity)

	School Choice		
Variable	Coefficient		S.E.
Pct. Black	-0.350		(0.494)
Pct. Black × Male	0.619		(0.382)
Pct. Black × Black	3.196	***	(0.378)
Pct. Black × Experience	-0.296	**	(0.140)
Pct. Black × Experience^2	2.218	*	(1.146)
Pct. Black × Experience^3	-4.069		(2.502)
Pct. Black × NBPTS	0.764		(1.801)
Pct. Black × Adv. degree	0.566		(0.467)
Pct. Black × Competitive college	0.480		(0.463)
Pct. Lunch	-0.005		(0.851)
Pct. Lunch × Male	-0.208		(0.711)
Pct. Lunch × Experience	-0.035		(0.252)
Pct. Lunch × Experience^2	-0.002		(2.065)
Pct. Lunch × Experience^3	-0.239		(4.486)
Pct. Lunch × NBPTS	-3.185		(2.649)
Pct. Lunch × Adv. degree	0.069		(0.839)
Pct. Lunch × Competitive college	-1.563	*	(0.877)
School is safe	0.070	*	(0.041)
Teachers are respected	0.014		(0.044)
Teachers shielded from disruptions	0.008		(0.041)
Pct. Students with low English score	1.606		(1.190)
Pct. low English × NBPTS	7.181		(5.268)
Pct. low English × Adv. degree	-2.452		(2.101)
Pct. Students with low math score	-2.714	***	(0.850)
Pct. low math × NBPTS	-2.283		(5.400)
Pct. low math × Adv. degree	0.265		(1.382)
Urban	-0.145	**	(0.072)
Rural	-0.191		(0.127)
Local revenue per student (1000's)	0.094		(0.068)
Expenditures per student (1000's)	-0.047		(0.061)
Indicator for current school	6.009	***	(0.063)
Distance from current school	-0.046	***	(0.003)
Distance × Male	0.012	***	(0.003)
Distance × Experience	-0.002	***	(0.000)
Avg. salary at School	0.081	*	(0.046)
Avg. salary × NBPTS	0.424	*	(0.236)
Avg. salary × Adv. degree	0.031		(0.063)
Total students (100's)	0.038	***	(0.010)
Pct. teachers with adv. degree	-0.535		(0.490)
Adv. degree × Pct. adv. degree	0.961		(0.797)
Pct. teachers with NBPTS	0.185		(0.845)
NBPTS × Pct. NBPTS	-0.626		(5.206)
Pct. teachers 0 to 2 years experience	0.834		(0.563)
Pct. teachers 3 to 10 years experience	1.110	**	(0.536)

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

Figure C.4: "Push Effect" of 25 Percentage Point Increase in Pct. Lunch at Current School (without unobserved heterogeneity)

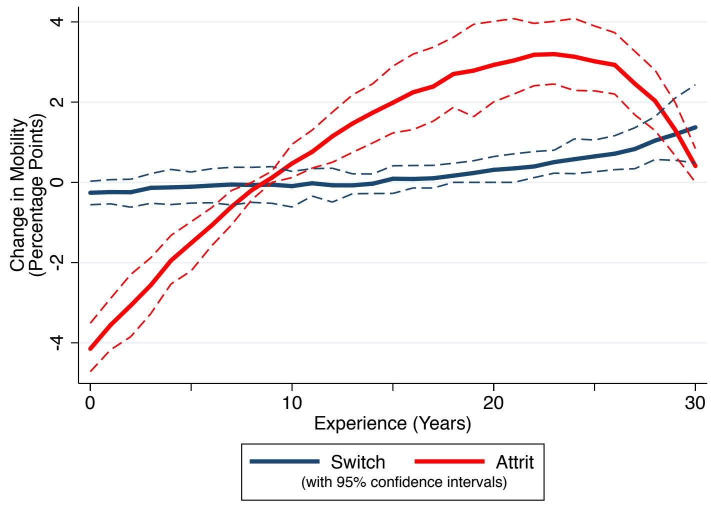


Figure C.5: "Push Effect" of 25 Percentage Point Increase in Pct. Black at Current School (without unobserved heterogeneity)

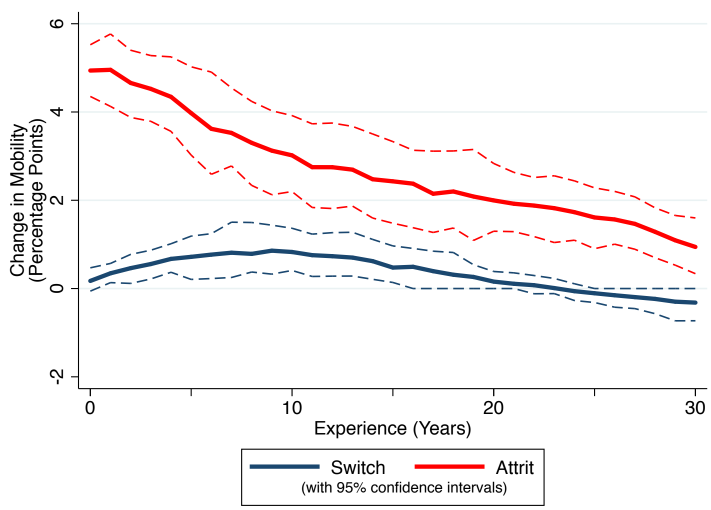


Figure C.6: "Push Effect" of $5,000 Increase in Salary at Current School
(without unobserved heterogeneity)

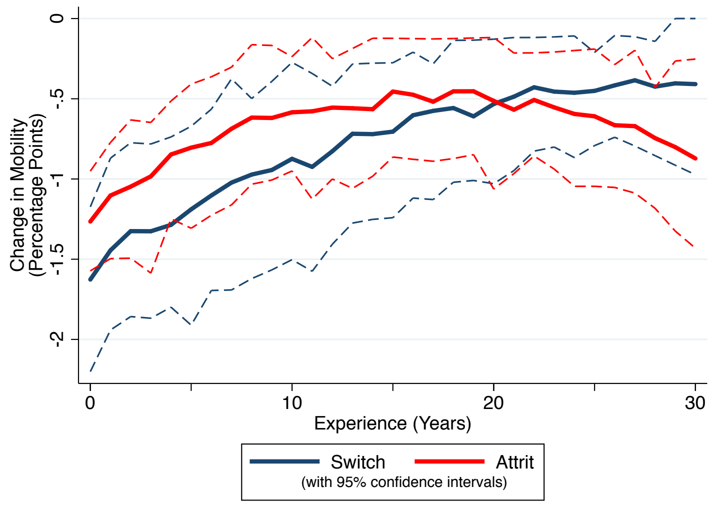


Figure C.7: "Pull Effect" of 25 Percentage Point Increase in Pct. Lunch at All Other Schools
(without unobserved heterogeneity)

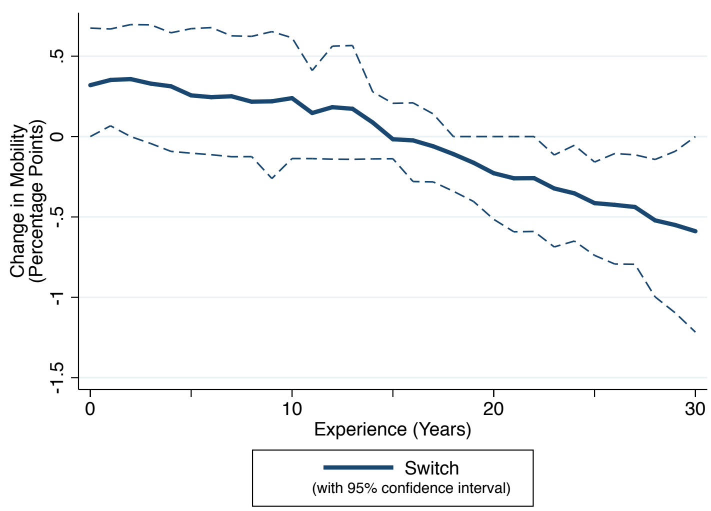


Figure C.8: “Pull Effect” of 25 Percentage Point Increase in Pct. Black at All Other Schools (without unobserved heterogeneity)

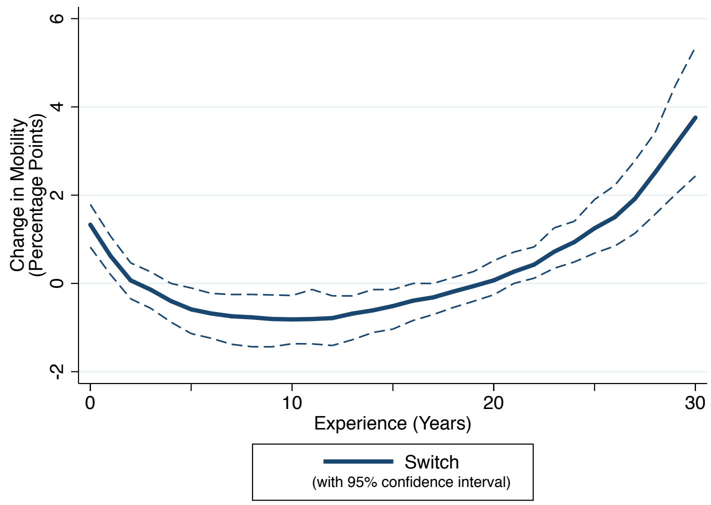
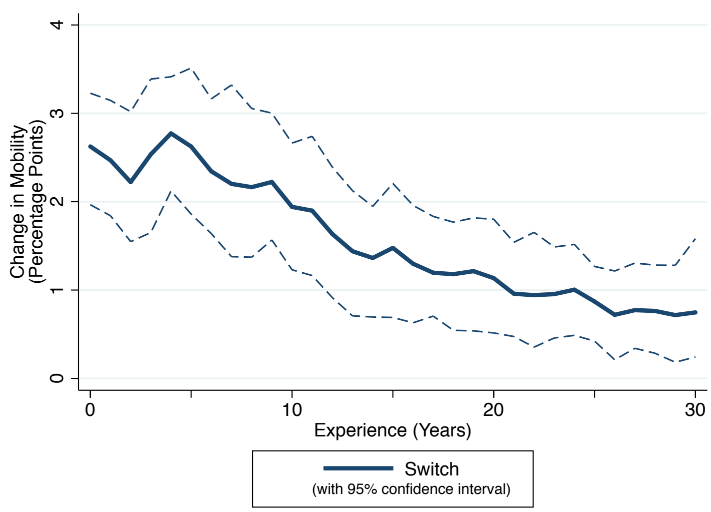


Figure C.9: “Pull Effect” of $5,000 Increase in Salary at All Other Schools (without unobserved heterogeneity)



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