Teacher Career Paths, Teacher Quality, and Persistence in the Classroom: Are Public Schools Keeping Their Best?

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Abstract

In this paper we examine the mobility of early-career teachers of varying quality, measured using value-added estimates of teacher performance. Unlike previous studies that have examined these issues, we focus on the variation in these effects across the effectiveness distribution. We find that, on average, more effective teachers tend to stay in their initial schools and in the teaching profession. But there also appears to be heterogeneity in mobility behavior across the performance distribution and evidence that teacher mobility is affected by student demographics and achievement levels. © 2010 by the Association for Public Policy Analysis and Management.

INTRODUCTION

The evidence that teacher quality is the key *schooling* factor influencing student outcomes (Aaronson, Barrow, & Sander, 2007; Goldhaber, Brewer, & Anderson, 1999; Rivkin, Hanushek, & Kain, 2005; Rockoff, 2004) raises significant concerns over teacher attrition and sorting in public schools. In particular, research generally shows that the most academically prepared teachers—measured by ACT scores, college selectivity, and degrees in technical subjects—are more likely to leave both high poverty and minority schools and the teaching profession (Podgursky, Monroe, & Watson, 2004; Lankford, Loeb & Wyckoff, 2002).

When these patterns of sorting and attrition are coupled with evidence of a correlation between measures of teachers' academic proficiency and student achievement (e.g., Ehrenberg & Brewer, 1994, 1995; Ferguson, 1991; Ferguson & Ladd, 1996; Goldhaber, 2007; Strauss & Sawyer, 1986; Summers & Wolfe, 1975), it is tempting to conclude that public schools are losing many of their most effective teachers. This conclusion would be premature given that easily observed and quantifiable teacher attributes, such as credentials and test scores, are only weakly correlated with student achievement (Aaronson, Barrow, & Sander, 2007; Clotfelter, Ladd, & Vigdor, 2007; Goldhaber & Brewer, 2001; Gordon, Kane, & Staiger, 2006; Hanushek, 1986, 1997).

A few recent studies that measure teacher quality based on test score gains made by a teacher's students find that, on average, more effective teachers tend to stay in the classroom. Average trends, however, can mask important variation in behavior across teachers with different levels of effectiveness. Thus, it is worth examining differences in mobility behavior and asking: "Are public schools keeping their 'best' teachers, and what conditions predict who stays and who goes?"

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We investigate these questions by studying elementary teachers who began teaching in North Carolina in 1996 to 2002. This panel allows us to explore the early career paths of teachers, including transfers from one teaching position to another, both within and between school districts, as well as exits out of the North Carolina public school workforce. And, because teachers can be matched to the students in their classrooms, we explore how career transitions are related to a more direct measure of worker quality: value-added estimates of teachers' effectiveness.

Several different authors examining various state and district contexts focus on teacher mobility and its relationship with effectiveness (we use the terms "effectiveness," "quality," and "productivity" interchangeably), measured in value-added student achievement terms. Although most of these studies find, contrary to expectations, that more effective teachers are *less* likely to leave both their schools and the profession, studies from Florida suggest that mobility patterns may vary along the effectiveness distribution.

Krieg (2006)—the only paper currently published in a peer-reviewed journal—examines teachers in Washington State and finds the propensity to leave the profession declines with teacher effectiveness. And studies by Hanushek et al. (2005), who examine teachers in a large urban district in Texas, and Boyd et al. (2007), who examine teachers in New York City, reach a similar conclusion. Research using Florida data, however, suggests a somewhat more complex picture. West and Chingos (2009) find a positive correlation between teacher effectiveness and the propensity to stay in their initial school placements, but, illustrating the importance of examining mobility across the effectiveness distribution, both the highest and lowest performing teachers in the Florida school system have exit rates that exceed those for teachers in the middle of the distribution. Feng and Sass (2008) also examine mobility across the effectiveness distribution. Like West and Chingos, they find that the relationship between teacher effectiveness and exits varies along the distribution (with the most and least effective teachers having a higher propensity to exit their schools than teachers in the middle of the distribution). But this research also illustrates the importance of considering the type of move. For instance, these authors find a negative relationship between teacher effectiveness and within-district moves among teachers in the highest quartile of effectiveness. By contrast, they did not find any significant relationship between teacher effectiveness and cross-district moves.

Collectively, these studies offer a mixed picture of teacher mobility and attrition in public schools. Some suggest that public schools are, on average, "keeping their best" teachers, and others find that more effective teachers are moving to improve their teaching environments or leaving the field entirely. But this research does not provide all of the relevant detail we need to understand the relationship between teacher effectiveness and mobility. For example, only West and Chingos (2009) and Feng and Sass (2008) directly examine the propensity to leave schools at different points along the distribution of teacher effectiveness—an important concern if we want to know whether school systems are retaining their very best teachers or encouraging their least effective teachers to find an alternative occupation (see Gordon, Kane, & Staiger, 2006; Hanushek, 2009). And while all the prior research considers factors such as student population and school size, only the working paper from Feng and Sass (2008) directly models important local labor market factors such as the marketability of teachers and conditions in the local teacher and external labor markets. We argue in the next section that only an assessment of all of these issues makes it possible to fully understand the ramifications of teacher mobility for schools serving different types of students and the school system as a whole.

Our findings suggest that there is significant nuance in teachers' patterns of mobility. Overall, the likelihood of staying in a school or in the system increases with teachers' effectiveness. But, interestingly, the factors predicting teacher mobility appear to vary across the effectiveness distribution in ways that raise concerns about the quality and distribution of the teacher workforce.[1]

EXPLORING DIFFERENT TYPES OF TEACHER MOBILITY

We examine three types of teacher job moves: moving to another school in the same district (within-district moves), moving to a school in another district (cross-district moves), and moving out of the North Carolina public school system altogether. From the vantage point of schools, all three exits look the same—the teacher leaves the school. But there are at least two arguments for more carefully considering the type of move that teachers make. First, each type of move may be differentially motivated. Second, different types of moves have different consequences for the educational system.

A teacher's within-district move may result in a significant change in working conditions due to a change in the context of their teaching, such as school demographics that change from one school to the next.[2] These moves, however, often do not result in an improved salary because districts usually pay teachers according to district-wide salary schedules.[3] Cross-district moves, by contrast, may result in both changes in working conditions and salary. These moves are also more likely to entail transaction costs associated with learning a new curriculum, district culture, or, in many cases, relocation.[4] In fact, recent research on teachers from Florida finds that offsetting these transaction costs does increase the chance that teachers will change districts (Feng, 2009). Teachers willing to bear the costs of moving to a new district are likely to be seeking significant changes in salary or working conditions, which cannot be achieved by a within-district move. It is also possible that teachers, especially those for whom a move entails a significant geographic change in employment location, are doing so for non-job, family-related reasons (Frank, 1978). Given that moves within districts and across districts have different implications for the teacher, it is likely that the factors leading to the move might be different as well.

A similar case can be made when considering moves out of teaching. For instance, although school working conditions, such as the academic preparedness of a school's students, might be an important factor in the decision to switch schools, they may be completely irrelevant for the teacher who has concluded that teaching does not suit her.[5]

[1] Previous research by Hoxby and Leigh (2004) and Corcoran, Evans, and Schwab (2004) explore whether teachers are "pushed" by the narrowing of pay within teaching or "pulled" from the teaching profession by increased opportunities outside of teaching. Unfortunately, the analysis in this paper cannot determine if the attrition from the field we observe is a result of teachers being pushed out or pulled out of the field.

[2] A significant amount of research shows that teachers are sensitive to working conditions (Feng, 2009; Ingersoll & Smith, 2003), which to some extent can be proxied by the attributes of their students (Goldhaber, Destler, & Player, 2010; Guarino, Santibanez, & Daley, 2006; Hanushek, Kain, & Rivkin, 2004; Lankford, Loeb, & Wyckoff, 2002).

[3] In general, collectively bargained teacher contracts place all teachers in a district on a common salary schedule. In North Carolina, the teacher contract is bargained at the state level and applies to all teachers in the state. Even though the contract allows some districts to supplement the salary schedule to compensate for different costs of living across the state, North Carolina principals, as is typical across the country, do not have the flexibility to offer individual teachers wage bonuses.

[4] In North Carolina, school districts are relatively large county-wide districts, which increases the chance that a cross-district move will require that the teacher physically move residences.

[5] We cannot directly observe whether those leaving the North Carolina public school system are leaving the teaching profession entirely, but we suspect this to be the case for the majority of these teachers. The national Schools and Staffing Survey found that approximately 12 percent of teachers leaving schools for other schools actually cross state borders to continue teaching. However, because one of North Carolina's most dense districts lies along the state border, we do control for a border location in all of our analyses. More detail on how we control for location is given in the data and methods sections.

Different move types are also likely to have very different impacts on the educational system. Exits from the system represent a loss to the teacher workforce (that may or may not impact its overall average quality), whereas teacher moves within and across districts portend a possible redistribution of teacher quality within the system. Finally, different types of moves imply different costs associated with recruitment, hiring and selection, and acculturation of new staff (Milanowski & Odden, 2007).[6]

A SIMPLE MODEL OF TEACHER CAREER TRANSITIONS

A simple model of utility maximization suggests that a teacher is more likely to remain in a particular teaching job if the expected lifetime benefits of doing so exceed those of moving to another job or profession. For simplicity, imagine a case where individual *i* chooses among various jobs, *j*, in order to maximize the present value of expected utility:[7]

$$\max_j pv[u^i(T_j)], \quad \text{given } j \in \{j\}_i \tag{1}$$

Let T_j be the characteristics of job *j*. T_j is a function of both compensation, C_j, and other non-pecuniary job factors, N_j (these include, for instance, the demographics of students in school *j*).

$$T_j = f(C_j, N_j) \tag{2}$$

The compensation available for alternative jobs depends on the marketability of the individual's qualities, including their training, experience, and skills (X_i).

$$C_j = f(X_i) \tag{3}$$

The marketability of certain skills will differ depending on the job being sought. A teacher's marketability may depend on some traditional teacher quality indicators such as certification, graduate degrees, and teaching experience (Ballou & Podgursky, 1997), even though value-added models of student achievement suggest that some of these indicators poorly predict a teacher's effectiveness in the classroom (Aaronson, Barrow, & Sander, 2007; Clotfelter, Ladd, & Vigdor, 2007; Goldhaber, 2007; Goldhaber & Brewer, 1997; Gordon, Kane, & Staiger, 2006; Rivkin, Hanushek, & Kain, 2005). Typically, however, the labor market as a whole tends to reward measures of academic proficiency, such as the selectivity of the individual's undergraduate institution (Ballou, 1996).

Individual *i* will opt to keep her current teaching job ($\hat{j}$) if the present value of expected utility associated with this job exceeds that of the best alternative job less any costs of transferring jobs [$u^i(r_j)$]:

$$pv[u^i(T_{\hat{j}}, X_i)] > \max_{j \neq \hat{j}} [pv[u^i(T_j, X_i)] - u^i(r_j)]] \tag{4}$$

[6] The costly elements of hiring new staff include administrative costs of separating exiting staff and hiring new staff, personnel and activities to engage in advertising and recruitment, staff time (at the district and school level) to screen prospective teachers, and, importantly, resources at the district and school level to train new staff in the local curriculum, instructional practice, and district approaches. Some authors (Milanowski & Odden, 2007) argue that losses in productivity should also be included in the overall cost of teacher replacement. Depending on the specific district circumstances (e.g., the level of centralization and local salaries) and elements of turnover, studies estimate that turnover costs range from as low as $3,400 to the tens of thousands (Milanowski & Odden, 2007).

[7] This simple model ignores the demand side of the market. For a more comprehensive analysis of how teacher and school district preferences interact to produce a distribution of teachers across schools, see Boyd et al. (2005) or Ballou (1996).

Given this framework, the likelihood of leaving a teaching job could vary along three dimensions: (1) the relative compensation that teachers can command in an alternative job (C), which is a function of the individual's characteristics that determine marketability (X_i); (2) the relative value of non-pecuniary rewards of teaching and non-teaching jobs (N_j); and (3) the transaction costs associated with a job switch [$u^i(r_j)$].

The model, not surprisingly, predicts that individuals would be more likely to leave their current position as compensation in alternative jobs rises. This conclusion is consistent with empirical evidence showing that the relative financial rewards and job opportunities in and outside of teaching influence teacher attrition rates and the length of time that teachers stay in the profession.[8] In addition, this model predicts that individuals would be more likely to leave as the non-pecuniary factors associated with alternative jobs become relatively more favorable and when transaction costs are lower.

The model offers some predictions for the relationship between teacher effectiveness and mobility, but the specific predictions depend on the nature of the human capital that drives effectiveness—whether it is job-specific, industry-specific, or more general[9]—and the extent to which this human capital is easily recognized by prospective employers.[10] For example, if human capital is primarily *job-specific*, because it depends on the fit with colleagues or unique instructional methodologies used in a school, then the model would predict unambiguously that the propensity to stay in a given school should increase with effectiveness. The assumption here is that teachers would reap non-pecuniary rewards (that is, have a higher value of N in the model above) from being more effective (and may, in some cases, also be able to command higher compensation), but they would *not* be more marketable in other schools or outside of teaching.[11]

The predictions are less clear if there are industry-specific or general components to human capital. In the case of *industry-specific* human capital, teacher effectiveness will be positively associated with non-pecuniary rewards (N) in their current and alternate schools. In addition, their skills (X) would make them more marketable in the teacher labor market. Here the model predicts that effectiveness decreases the likelihood that teachers will exit teaching, but it is unclear whether the satisfaction with the current school will be enough to offset satisfaction or compensation from teaching in an alternate school.

In the third case, in which a teacher's effectiveness is reflective of general human capital, the model offers even less guidance. In this case, a good teacher would be expected to be effective in alternative occupations, implying that she would also have greater out-of-teaching marketability. Here the model offers no clear predictions about the transfer or exit of teachers given their effectiveness: A teacher's decision to transfer or exit will depend on which end of the scale (the rewards of teaching in the current school versus compensation from alternative jobs) carries more weight.

DATA AND ANALYTIC APPROACH

The data for this study are collected by the state of North Carolina for administrative purposes and include detailed information on schools, teachers, and students.

[8] See Baugh and Stone (1982), Brewer (1996), Dolton and van der Klaauw (1999), Greenberg and McCall (1974), Murnane (1981), Murnane and Olsen (1989), and Stinebrickner, Scafidi, and Sjoquist (2007).
[9] See Becker (1962) for a discussion of specific versus general human capital.
[10] Note that effectiveness, as we measure it, only affects marketability if our measure of it is related to individual characteristics that can be observed by potential employers.
[11] While districts typically pay all teachers by a standardized schedule, which makes all within-district compensation the same for a given experience and education level, teachers can still receive supplemental compensation for taking on additional responsibilities, such as overseeing extracurricular activities. Such supplemental compensation may serve as a means of rewarding effective teachers.

These data include, for instance, school-level information on the percentages of free and reduced lunch (FRL) recipients; the percentage of African American students in schools; each school's average math performance; teacher-level information on race and ethnicity, gender, and measures of academic and professional credentials such as a teacher's degree attainment, the average SAT score at a teacher's undergraduate institution, pre-service licensure exam score, and a variable indicating whether the teacher has earned National Board of Professional Teaching Standards (NBPTS) certification; and student-level information on race and ethnicity, gender, FRL status, and performance on the end-of-grade state assessments in math.[12] We combine the North Carolina schooling data with information retrieved from the Bureau of Labor Statistics on local labor market conditions and geographic information on the concentration of schools from the federal Common Core of Data. These data sources allow us to account for labor market and geographic contexts that might affect teacher mobility.

Importantly, the data also include links between teachers and students, which we utilize to estimate measures of teachers' effectiveness. We restrict the data to teachers and students in the elementary grade level (grades 4 through 6) because we are more confident that at this level the teacher–student links provide good matches of students to their *classroom* teachers.[13]

We also restrict our sample to teachers who entered the North Carolina public school system between the 1995–1996 (hereafter 1996) and 2001–2002 school years so that we can observe the start date for every teacher in our sample.[14] Our focus on early- to mid-career teachers includes the period when attrition out of the occupation is highest. As is apparent in national trends (Ingersoll & Smith, 2003), the most rapid loss of teachers in our sample also occurs in the early years, with 25 percent of teachers exiting the North Carolina system within the first four years of teaching. Focusing on the early- to mid-career cohorts also eliminates the complication of modeling the retirement of teachers.

The longitudinal nature of these data allows us to identify the movement of teachers across schools and the movement out of the North Carolina system. However, one important limitation of the North Carolina data is that we do not know what happens to teachers who exit the system. It is likely, however, that in most cases these exits represent teachers who leave the teaching profession for another career.[15] But it is also possible that teachers are leaving the labor market entirely, or leaving the North Carolina public system for teaching jobs in private schools or in another state. North Carolina shares borders with four other states, and one of its largest districts (Charlotte-Mecklenburg) is near the state border. In order to account for the possibility that mobility (especially exit from the system) may be different for teachers in districts on the state border, we include indicators for districts along the state border in all models described below.

Given that men and women often show systematic differences in labor market behavior (Keith & McWilliams, 1997), we estimate transitions for men and women

[12] These assessments are vertically aligned and designed to measure student growth.

[13] The North Carolina data link students to teachers by identifying the teacher who is proctoring the students' exam; it is possible that some proctors are not students' classroom teachers. To better ensure that we have accurate links between students' assessments and the teacher primarily responsible for the instruction of these students, we limited our sample to elementary teachers who are listed as having taught a "self-contained class," meaning the teacher was the sole instructor of core academics for the students in her class.

[14] Our data set includes observations from 1995 through 2003. The first year is dropped because we want to observe who has entered the system (those not present in 1995 but present in 1996). The last year is dropped because we need to record the mobility decision in the last year of our analytic sample (2002), which requires that we observe the teacher's school assignment in 2003 relative to 2002.

[15] As mentioned above, evidence from the National Center for Education Statistics' Teacher Follow-Up Survey suggests that most moves out of a state system are due to teachers leaving the profession (only 12 percent of teachers who left their state's public school system after the 2000–2001 school year were still teaching in either a private school or a public school in another state).

separately. For simplicity, we only report estimates from women, who make up almost 85 percent of the elementary teachers in North Carolina.[16] In total, the 1996 to 2002 sample of women included 30,564 person-year observations from 9,027 different teachers: 3,192 cases of teachers transferring to a new school within the district (by 2,588 different individuals); 2,649 cases of teachers transferring to a teaching position in a new district (by 2,185 different individuals); and 2,442 cases of teachers exiting the system. In total, 34 percent of female teachers in our sample never move schools, 38 percent transfer but never exit, and 28 percent exit. The number of different teaching positions ranged from 1 to 5.

Table 1 reports sample statistics from the year 2002 for the four possible outcomes: (1) those who remain in their original schools as teachers, (2) those who make a within-district move, (3) those who make a cross-district move, and (4) those who leave the North Carolina public school system. Teachers who exit the system tend to be less effective than those who move districts or who stay in their current job. A relatively large share of all teachers are located in districts that border South Carolina and just over a quarter of all teachers who exited the system left from districts on this border; this demonstrates the importance of controlling for border districts in the regressions described below.

Teachers who exited the North Carolina system in 2002 did not come from markedly more selective undergraduate colleges, nor were they more likely to have an advanced degree. They were, however, more likely to leave schools with a higher percentage of students receiving free or reduced priced lunch, a higher percentage of African American students, and students scoring lower on math achievement tests.

Measuring Teacher Effectiveness

We measure a teacher's performance based on value-added model (VAM) estimates of effectiveness, which are standardized within grade and year.[17] There is no universally accepted method for calculating a teacher's value-added contribution, and research shows that methodology and context can influence the measure (Ballou, Sanders, & Wright, 2004; McCaffrey et al., 2004; Rothstein, 2010; Rubin, Stuart, & Zanutto, 2004; Tekwe et al., 2004). The primary specification we utilize is:

$$y_{ijt} = \alpha + \theta_i + \Phi_j + \varepsilon_{ijt} \tag{5}$$

In this model, student i's achievement in class j and year t is a function of student, θ_i, and teacher, Φ_j, fixed effects. From this equation, the coefficient values of the teacher-specific effects (Φ_j) are used as measures of effectiveness.[18]

In this specification, teacher effectiveness is pooled over all years in which the teacher has data. Pooling teachers' effectiveness measures across years offers some statistical and conceptual advantages. First, by including all data available on teachers, this estimate offers better reliability than estimates based on a single year of data (Koedel & Betts, in press). Second, this specification captures the long-term effectiveness of a teacher. For instance, we learn whether a generally effective or

[16] The results based on data from men differ slightly from those for women. While the overall relationship between teacher effectiveness and mobility is similar, we find that college selectivity was less of a factor for within- and cross-district moves for men than it was for women. In addition, in the male sample we see fewer statistically significance differences between effectiveness quintiles, possibly a consequence of the substantially smaller size of the male teacher sample. The number of observations for men is only 4,348.

[17] This measure of teacher quality is controversial, as these scores are measured with error (Gordon, Kane, & Staiger, 2006; McCaffrey et al., 2009) and are potentially compromised by complications from matching and lagged effects (Rothstein, 2009).

[18] We normalize (mean zero, standard deviation of one) these estimates across all teachers employed by North Carolina public schools from 1996 to 2002 for whom we could calculate a value-added score.

Table 1. Descriptive statistics for teacher effectiveness, labor market, and school context factors.

	No Move	Transfer Within Districts	Transfer Across Districts	Exit the System
Teacher characteristics				
Teacher effectiveness measure	0.06	−0.06	−0.18	−0.18
	(1.10)	(1.05)	(0.96)	(1.00)
Percent African American teachers	14.43	18.31	18.71	18.75
Percent other nonwhite ethnicity teachers	1.59	1.85	1.25	1.10
Labor market factors				
Average district salary supplement/$100	25.86	29.62	24.18	28.45
	(14.53)	(15.27)	(13.91)	(15.25)
Average county wage/$100	152.34	158.41	149.32	157.50
	(28.94)	(30.69)	(29.29)	(30.67)
Number of schools within 5-mile radius	12.15	15.77	10.78	14.70
	(11.77)	(14.03)	(10.92)	(12.67)
Percent county unemployment	4.79	4.71	4.93	4.82
	(1.049)	(0.92)	(1.10)	(1.01)
Average SAT at teacher's undergraduate college/100 points	8.89	8.95	8.82	9.00
	(1.06)	(1.10)	(1.06)	(1.12)
Teacher's pre-service exam score	10.22	9.94	4.53	8.19
	(0.65)	(0.66)	(0.61)	(0.68)
Percent with master's or higher degree	12.88	17.69	9.15	11.76
Percent holding NBPTS certification	1.99	2.78	0.85	0.76
Percent bordering SC	19.98	29.77	18.03	26.16
Percent bordering TN	1.50	1.71	1.29	0.37
Percent bordering VA	5.27	3.88	4.72	6.12
Percent bordering GA	0.45	0.47	0.00	0.37
School context factors				
School-wide percent of students on FRL	47.62	48.35	50.08	51.11
	(22.50)	(22.80)	(22.59)	(22.78)
School-wide percent of African American students	34.15	38.39	37.47	41.22
	(24.33)	(25.51)	(25.59)	(24.32)
Enrollment/10 students	63.18	65.12	62.76	63.84
	(24.68)	(30.65)	(27.96)	(25.30)
Standardized school-wide math score	0.007	0.032	0.038	0.029
	(0.18)	(0.26)	(0.19)	(0.187)
Z-score FRL (within districts)	0.17	0.17	0.19	0.28
	(0.91)	(0.90)	(0.92)	(0.93)
Z-score African American (within districts)	0.01	0.16	0.13	0.22
	(0.96)	(0.97)	(0.97)	(0.96)
2002 *N*	4,921	650	481	544
Total *N* in analytic sample	19,763	2,665	2,263	2,071

Note: Standard deviations are in parentheses.

ineffective teacher is moving instead of whether a teacher having a good or bad year is moving.

The distinction between short- and long-term measures of effectiveness is important. A teacher's effectiveness may substantially deviate in the short run from her long-term level. We might predict, for instance, that teachers exert less effort when they plan to quit teaching, leading to a short-run drop in effectiveness (an "Ashenfelter dip"), or that effectiveness is impacted by the fit between the teacher and class or school.[19] Effectiveness measures based on teacher effectiveness pooled across years will tend to mask these variations.[20]

It is important to note that the specification described by Equation (5) has some key limitations. First, our VAM does not include school fixed effects and therefore does not account for unobserved (time invariant) school-level factors; these influences end up being included in the teacher effect measures. Second, some researchers (e.g., Rothstein, 2009) suggest that models including student fixed effects produce biased teacher effect estimates. Third, because this specification pools teachers' effectiveness across their career, the appropriateness of this VAM depends on the stability of the measure over a teacher's career. To explore whether these concerns impact our results, we estimate the models of teacher mobility, described below, utilizing teacher effects derived from a variety of alternative VAM specifications, which are described in the Tests of Robustness section.

Modeling Teacher Mobility

We employ competing risk models to estimate the risk that individual teachers leave their current teaching position given their own characteristics and the characteristics of the school in which they teach.[21] Hazard models are conceptually appealing for studies of teacher movement and attrition. They measure the risk of changing schools or leaving teaching given the length of time the teacher has been with a school or in the school system, which we count in one-year increments. Accounting for time is important because we know that new teachers are substantially more vulnerable to moves and exits than those with more experience. These models also provide some flexibility with our data by allowing us to analyze the movement of teachers without necessarily viewing the entire career of all teachers. That is, these models can describe career movement with censored data. Finally, the models allow the effects of the explanatory variables to differ depending on the type of move the teacher makes.

All of our analyses are based on a discrete time hazard model (Equation 6), which defines an individual's odds of leaving the position as a function of the baseline hazard [$\lambda_0(t)$] and a series of covariates (X_{in}) that would include measures of the teacher's quality, teacher's background characteristics, labor market conditions, and school characteristics.[22]

$$h_i(t) = \lambda_0(t)e^{\sum_{n=1}^{k}\beta_n X_{in}} \tag{6}$$

All models account for a teacher being located in a district along a state border, local labor market conditions, school characteristics, and basic teacher demographics and are estimated by a conditional maximum likelihood logit. Each model represents time as discrete because the school year provides the field with an annual hiring cycle during which most new hires, transfers, or exits occur.[23] Because a

[19] We explore these issues explicitly in the Tests of Robustness section of the results.

[20] Of course, for teachers who have short careers (at least in our data set), a short-run change in effectiveness will have an outsized impact on a teacher's career measure.

[21] We also estimated models that included a measure of the average number of FRL students in the classroom but do not present these models in this paper.

[22] For computation, Equation (6) is often rewritten as the log hazard:

$$\ln h_i(t) = \mathrm{a}(t) + \sum_{n=1}^{k}\beta_n X_{in}, \quad \text{where } \alpha(t) = \ln \lambda_0(t).$$

[23] Because some teachers do transfer, exit, or begin their careers mid-year, we also estimated all of the models using log-log models for continuous time. Results from these models qualitatively parallel the results provided in this paper's discussion. However, because we test our mobility models controlling for school fixed effects—something that cannot be done with the log-log models—we present the results of the logit models.

teacher's stay could result in one of three primary outcomes (transferring to a new school within the district, transferring to a new school outside the district, or leaving the North Carolina system[24]), Equation (7) accounts for the j "competing risks":

$$\text{logit } h_{ij}(t) = \alpha_j(t) + \sum_{n=1}^{k} \beta_{nj} X_{inj} \quad \text{where } j = 1, 2, 3 \tag{7}$$

We estimate these competing risk models with separate logit regressions[25] and report robust standard errors to account for clustering at the school level.[26] Because teachers can at times stay and at other times move or exit, individual teachers can be identified as stayers, movers, or exiters at different points in their career.

RESULTS

It is important to note that teacher mobility is not necessarily problematic. When a teacher finds a more productive fit in a different school, both the individual and the system benefit. Likewise, the attrition of the weakest teachers from the teaching profession improves the overall quality of the system's teachers. However, mobility and attrition are problematic if highly productive teachers leave the field or opt out of disadvantaged schools in large numbers or if ineffective teachers float around the system, moving from school to school. Some of the most important questions about teacher mobility and attrition require that we examine how the factors associated with teacher mobility vary across the teacher effectiveness distribution.

We focus on three distinct types of moves: within-district moves, cross-district moves, and exits from the North Carolina public education system. Understanding the complex nature of these results, we structure the results discussion by describing each move type in subsections below. Within each subsection, we briefly discuss the relationship between teacher effectiveness and teacher moves and then address three issues: (1) how labor market factors relate to teachers' moves, (2) how school contexts relate to teachers' moves, and (3) whether and how these effects vary across the effectiveness distribution.[27]

Teacher Effectiveness and Within-District Moves

We begin our analysis of teacher transfers by focusing on a teacher's odds of moving between schools within a school district. The estimated coefficients from four specifications of the competing hazard model for within-district moves are presented in Table 2. The first specification (panel I, column A) includes a continuous measure of teacher effectiveness (estimated by Equation 4) as well as individual teacher characteristics (including years of service), variables intended to account for labor market factors that influence a teacher's other job options and marketability, and a set of variables that describe school context. This specification most closely parallels those typically estimated in the existing empirical literature. The second model **(**panel I, column B**)** substitutes school fixed effects for observable

[24] Moving to administration is a fourth possible outcome. However, only 112 teachers in this sample actually made the move to administration. With so few making this move, the models of moves to administration do not converge. To focus the paper on the moves of greatest importance for our sample, we only report models that estimate the hazard of moving to administration.

[25] We estimate these models separately for each move type instead of using a multinomial logit, which estimates all move types simultaneously. Allison (1995) reports that doing so results in a slight loss of precision in the estimates but in exchange allows us to more easily present and describe results for different move types and potentially specify models for the different move types differently. We, however, estimate parallel models using multinomial logit specifications and find these results to be qualitatively similar.

[26] We also estimate models with school fixed effects and find very little difference in the results.

[27] Quintile ranks were determined from the complete sample of teachers in the state and not just the early-career sample used in these analyses.

Table 2. Panel I: Log odds estimates from models of teachers' within-district moves.

Parameter	Model A	Model B	Model C
Teacher effectiveness	−0.1196**	−0.131**	
	(0.0221)	(0.0242)	
Lowest quintile			0.1657**
			(0.0616)
Quintile 2			0.057
			(0.0632)
Quintile 3 (reference category)			
Quintile 4			−0.088
			(0.0649)
Highest quintile			−0.1584**
			(0.0702)
Teacher demographic background			
African American	−0.064	−0.074	−0.059
	(0.069)	(0.0757)	(0.0691)
Other nonwhite	0.080	0.069	0.084
	(0.1594)	(0.1852)	(0.1597)
Labor market factors			
Average district salary supplement /$100	0.0056**	−0.005	0.0056**
	(0.0029)	(0.0051)	(0.0029)
Average county wage/$100	−0.0038**	0.005	−0.0037**
	(0.0015)	(0.0058)	(0.0015)
Number of schools within 5-mi. radius	0.0079**		0.008**
	(0.0026)		(0.0026)
Percent unemployment in county	−0.0272*	0.005	−0.0272*
	(0.0147)	(0.0206)	(0.0148)
Average SAT at undergraduate college/100	0.004	0.053	0.005
	(0.0233)	(0.0252)	(0.0233)
Pre-service exam score	−0.0374	−0.055	−0.0355
	(0.0318)	(0.0346)	(0.0321)
Master's or higher degree	0.1394**	0.2231**	0.1413**
	(0.0571)	(0.0635)	(0.0572)
NBPTS certified	0.4697**	0.8058**	0.4505**
	(0.2109)	(0.209)	(0.2109)
School context factors			
Percent FRL	0.002	0.0092**	0.002
	(0.0028)	(0.0042)	(0.0028)
Percent African American	0.001	0.0353**	0.001
	0.0022	(0.011)	(0.0022)
Enrollment/10 students	0.0056**	0.0283**	0.0056**
	(0.0015)	(0.0053)	(0.0015)
School-wide math score	−0.405**	−0.3127	−0.4097**
	(0.1569)	(0.3786)	(0.1562)
Z-score FRL	0.024	−0.0491	0.0233
	(0.0562)	(0.0938)	(0.0561)
Z-score African American	0.0827*	−0.1757	0.0826*
	(0.0465)	(0.1408)	(0.0466)
Includes school fixed effects	No	Yes	No
Model log likelihood	−8,007.540	−7,956.480	−8,009.880

Notes: All models control for years of teaching experience. All models except those with school fixed effects control for the district's location on the state's border.

Standard errors are in parentheses.

* Indicates significance level of $p \leq 0.05$. ** Indicates significance level of $p \leq 0.01$.

Table 2. Panel II: Log odds estimates from models of teachers' within-district moves: Effects of labor market and school context factors by effectiveness quintile.

Parameter	Lowest quintile	2nd quintile	3rd quintile	4th quintile	5th quintile
Teacher effectiveness	−0.2334**	0.270	−0.058	−0.036	−0.0906*
	(0.0852)	(0.4767)	(0.5737)	(0.3336)	(0.0483)
Labor market factors					
Average district salary supplement/$100	0.005	0.001	0.006	0.003	0.0124*
	(0.0053)	(0.0053)	(0.0052)	(0.0057)	(0.0067)
Average county wage/$100	−0.003	−0.0049*	−0.002	−0.004	−0.003
	(0.0026)	(0.0027)	(0.0026)	(0.0029)	(0.0029)
Number of schools within 5-mi. radius	0.0135**	0.0103**	0.0104**	0.0024	0.0011
	(0.0052)	(0.0048)	(0.0051)	(0.0059)	(0.0058)
Percent unemployment in county	−0.0078	−0.0772**	0.0073	−0.0414	−0.0259
	(0.0252)	(0.0282)	(0.0279)	(0.0272)	(0.0306)
Average SAT at undergraduate college/100	0.0017	0.0334	0.0017	0.008	−0.0137
	(0.0354)	(0.0387)	(0.0384)	(0.0406)	(0.0382)
Pre-service exam score	0.0031	0.0415	−0.0835	−0.1566**	−0.0657
	(0.0614)	(0.0693)	(0.079)	(0.0777)	(0.073)
Master's or higher degree	−0.0437	0.2413*	0.3045**	0.2685**	−0.144
	(0.1234)	(0.1332)	(0.1265)	(0.1311)	(0.1526)
NBPTS certified	0.0766	0.6666	0.5063	0.1859	0.575
	(0.5076)	(0.4967)	(0.4147)	(0.4491)	(0.3891)
School context factors					
Percent FRL	−0.002	0.0097*	−0.001	0.0096**	−0.004
	(0.0047)	(0.0051)	(0.0049)	(0.0049)	(0.0054)
Percent African American	0.005	−0.001	−0.004	−0.002	0.004
	(0.0037)	(0.0043)	(0.0041)	(0.0042)	(0.0044)
Enrollment/10 students	0.0033	0.0079**	0.0043*	0.0048**	0.0107**
	(0.0023)	(0.0022)	(0.0025)	(0.0024)	(0.0027)
School-wide math score	−0.321	−0.4318	−0.1799	−0.2941	−0.7133**
	(0.2746)	(0.2818)	(0.2879)	(0.2886)	(0.2624)
Z-score FRL	0.1457	−0.0078	0.2213**	−0.3309**	0.0169
	(0.0984)	(0.1081)	(0.1088)	(0.1161)	(0.1169)
Z-score African American	−0.040	0.135	0.026	0.3111**	0.043
	(0.0832)	(0.0856)	(0.092)	(0.09)	(0.1008)
Model log likelihood	−7,960.67				

Notes: All models control for years of teaching experience. All models except those with school fixed effects control for the district's location on the state's border.

Standard errors are in parentheses.

* Indicates significance level of $p \leq 0.05$. ** Indicates significance level of $p \leq 0.01$.

school variables to account for unobservable school characteristics, such as working conditions, that could influence mobility (Ingersoll & Smith, 2003). In the third specification (panel I, column C), we replace the continuous measure of teacher effectiveness with a vector of indicators identifying the quintile of the effectiveness distribution in which each teacher falls. This specification allows for a nonlinear relationship between teacher effectiveness and teacher moves. Finally, our fourth specification, presented in panel II of Table 2, interacts these quintile rankings with labor market and school context variables.

On average we find that the odds of leaving a school for another school in the same district decline as teacher effectiveness increases—this finding is squarely in line with several of the studies described earlier. Specifically (based on estimates provided in column A of Table 2), the odds of transferring between schools within a district decline by 11 percent when estimated teacher effectiveness increases by a standard deviation.[28] Adding the labor market and school context variables to the model adds explanatory power to the model (not shown) and each set of variables is jointly significant,[29] but their addition has almost no impact on the teacher effectiveness coefficients.

Because credentials might give teachers more bargaining power and job options, we expect them to be correlated with within-district moves.[30] Likewise, because a high concentration of schools within a close proximity signals a large number of job options with minimal transfer costs, we expect within-district transfers to increase with the concentration of schools. In general, our findings are consistent with these hypotheses. For example, the odds of a within-district move increase when a teacher is certified by the National Board for Professional Teaching Standards (60 percent) or holds an advanced degree (14 percent). Both results are consistent with previous research (Goldhaber & Hansen, 2010; Hanushek, Kain, & Rivkin, 2004). In addition, a high concentration of schools locally has a small but statistically significant and positive effect on the odds of a within-district move.[31]

If the system's best teachers are inclined to leave schools serving the most challenging students, teachers will be inequitably distributed across schools—a critical issue in teacher mobility research. A significant body of evidence suggests that this is the case (Goldhaber, Destler, & Player, 2010; Guarino, Santibanez, & Daley, 2006; Hanushek, Kain, & Rivkin, 2004; Lankford, Loeb, & Wyckoff, 2002). We find that North Carolina's elementary teachers tend to leave schools that are larger and lower performing. The odds of transferring to another school in the district increases by just under 1 percent with each additional 10 students enrolled and increases by about 33 percent with a one standard deviation decline in the school's average math score.

The percentage of FRL students and the percentage of African American students alone do not significantly predict within-district moves. However, it appears that many teachers view their schools' contexts as they relate to other schools around them. When we compare the relative disadvantage of schools within districts using the within-district standardized percent of FRL (*Z*-score FRL) and percent of African American students (*Z*-score African American), we find that teachers located in schools with relatively high concentrations of African American students are more likely to transfer (the odds increase 9 percent with each additional standard deviation) to new schools in the district.[32] This result falls in line with previous analyses on teachers' mobility and the racial composition of schools (Hanushek, Kain, & Rivkin, 2004; Jackson, 2009).

[28] Note that the coefficients reported in the tables reflect the log odds of transferring. In the text we have converted these log odds into the percent change in odds based on the following equation: % change in odds = $100(e^{\beta} - 1)$, where b is the estimated log odds coefficient.
[29] The chi-squared log likelihood test for the labor market variables was 718.1 for 8 degrees of freedom. The test for the school context variables yielded a chi-square of 152.6 for 6 degrees of freedom. Therefore, we cannot reject the addition of these variables.
[30] The empirical evidence on whether various teacher credentials are in fact signals, however, is weak. The teacher quality literature, for example, has not found a consistent association between teachers' degrees and effectiveness in the classroom (Goldhaber & Brewer, 1997).
[31] An additional school within 5 miles increases the odds of transferring within the district by 0.8 percent.
[32] Although it seems reasonable to expect that these school-level effects will be overshadowed by the teacher's own classroom conditions as principals reward better teachers with more advantaged classrooms (Player, 2010; Rothstein, 2010), we do not find this to be the case. Instead, in a separate analysis that uses a subset of observations with classroom-level student demographic information, we find that controlling for the concentration of FRL students in a teacher's individual classroom slightly improves the fit of the model but does not eliminate the school-level effects.

We might expect teacher mobility to be affected by unobserved conditions in schools. To account for this we include school fixed effects in the model (shown in column B).[33] As it turns out, the coefficient on teacher effectiveness is virtually unchanged in this specification.[34]

How do findings differ along the teacher effectiveness distribution? This is an important question, as the models that assume that the relationship between teacher effectiveness and mobility is linear (as in columns A and B) are quite restrictive. We explore this issue using a model specification that includes variables for the teacher's quintile in the effectiveness distribution (the third quintile is the reference category) in column C of Table 2.[35]

The model with indicators for the quintile of teacher effectiveness shows that the odds of exiting are similar for teachers in the second through fourth quintiles of effectiveness. Only teachers at the extremes show statistically significant differences in the odds of transfer. The least effective teachers (those in the lowest quintile) are more likely to transfer to new schools in the district than teachers in the middle of the effectiveness distribution; the most effective teachers (those in the highest quintile) are less likely to make within-district transfers relative to teachers in the middle of the effectiveness distribution.

Do the labor market and school contextual factors have differential impacts on effective and ineffective teachers? This issue is explored in panel II of Table 2, a specification that includes interaction terms between quintile of effectiveness and the various labor market and school context variables. There are some interesting differences across effectiveness quintiles in the factors that affect within-district mobility of teachers but few consistent patterns. For instance, having an advanced degree corresponds with greater within-district transfer of teachers in the second, third, and fourth quintiles but not teachers in the lowest or highest quintile. Teachers in the third quintile appear to be more likely to leave a school with relatively high concentrations of FRL students, but teachers in the fourth quintile appear to be less likely to leave these schools. Also, we clearly see that only the most effective teachers are more likely to transfer to other schools in the district when teaching in lower performing schools.

In sum, the odds of moving to a new school in the district decreases with teacher effectiveness, teachers' credentials (NBPTS and advanced degrees), the relative concentration of low-income students, and school performance. However, the relationship between each of these covariates and within-district moves varies across the effectiveness distribution.

Teacher Effectiveness and Moves Between School Districts

This section focuses on transfers across district lines. As explained above, the potential costs of moving and learning a new district's culture and curriculum may make

[33] We also attempt to account for school contexts by including an indicator of teachers' impressions of the school in which they are teaching as represented on a teacher survey. We obtained data from the 2004 North Carolina Teacher Working Conditions Survey. In this survey, teachers gave their agreement on a 5-point Likert scale with the following statement: "This school is a good place to work and learn." This item is not statistically significant in our models of mobility and left the coefficient on teacher effectiveness unchanged. Because this survey item is only available for one year of our panel, we find it to be a relatively weak representation of school context, and we do not include this item in our discussion models.

[34] Because the geographic location of districts on the state's border does not differ over time, these factors have been dropped from the school fixed effects models. Some of the coefficients on the school context differ from the model in column A, but it is important to note that these coefficients in column B are identified by within-school (over time) variation in these variables, which is quite limited.

[35] We also explore the issue of nonlinear effects by estimating models that include the squares and cubes of the teacher effectiveness measure. The cubic terms were not significant in any of the models, whereas the squared term was significant in the models of exits. These results are not presented in this paper but are available on request.

these transfers a somewhat different proposition than transfers within a district. We estimate cross-district moves utilizing the same four specifications as we utilized for our analysis of transfers within districts.

There are many similarities between the within-district moves in Table 2 and cross-district moves in Table 3. For instance, the likelihood of leaving for a school in another district decreases with teachers' effectiveness whether or not we include school fixed effects in the model (panel I, column B),[36] and teacher effectiveness is related to movement only in the extremes of the distribution (panel I, column C).

There are also some notable differences between within- and cross-district moves. The effect of labor market and school context factors on cross-district moves differs from the effects seen in models of within-district moves. Whereas advanced degrees and NBPTS certification are found to be significant predictors of within-district moves, these factors do not predict moves across districts. By contrast, college selectivity predicts cross-district, but not within-district, mobility. And teaching in an area with a high concentration of schools lowers the risk of a teacher moving across districts, as opposed to increasing it as in the within-district mobility models. These findings appear to confirm the hypothesis that a greater number of local options reduces the odds that a teacher seeks a position outside their current district.

Finally, we explore whether school and student characteristics influence cross-district moves. Here both the overall concentration of African American students and overall concentration of FRL students are associated with higher odds of transferring to new districts.[37] But, unlike the within-district models, the school's math score does not significantly predict cross-district transfers.

How do findings differ across the teacher effectiveness distribution? Panel II of Table 3 provides estimates from a model that allowed the effects of labor market and school context factors to vary across teacher effectiveness quintiles.[38] The odds of cross-district moves increase with college selectivity but only for teachers in the second, third, and fourth quintile. With regard to transfers out of disadvantaged schools, none of the school context factors correspond with statistically significant increases in the odds of cross-district moves for the highest quintile teachers. However, a higher concentration of African American students is marginally significant (at the 10 percent confidence level) and corresponds with slightly greater odds of cross-district moves by teachers in the second, third, and forth quintiles.

Consistent with prior research, the odds of cross-district moves tend to decrease with teachers' effectiveness. We also find that the selectivity of teachers' undergraduate institutions, as well as the racial and economic composition of the teachers' current schools, are associated with the odds of cross-district moves. The effects of these covariates are heterogeneous across the effectiveness distribution, with the most consistent effects among teachers in the middle of the effectiveness distribution.

Teacher Effectiveness and Exits from the North Carolina Public School System

Teachers leaving the North Carolina public education system reflect a net loss of public school teacher resources to the state. To the extent that North Carolina loses

[36] As in the models of within-district transfers, we built up to the specification presented in column A by first jointly adding the labor market factors and then the school context factors. In doing so, we found that these factors improved the overall fit of the model but changed the coefficient on the teacher effectiveness variable very little.
[37] Increases in the odds of transferring are about 6 percent with a 10 percent increase in FRL or African American students. As was the case in the models of within-district transfers, accounting for the teachers' classroom contexts does not eliminate the effects of the school-level conditions on teachers' odds of transferring districts.
[38] As above, we were able to reject the assumption of a linear relationship between teacher effectiveness and mobility.

Table 3. Panel I: Log odds estimates from models of teachers' across-district moves.

Parameter	Model A	Model B	Model C
Teacher effectiveness	−0.1267** (0.0216)	−0.1385** (0.0244)	
Lowest quintile			0.214** (0.0661)
Quintile 2			0.0982 (0.0675)
Quintile 3 (reference category)			
Quintile 4			0.0306 (0.0728)
Highest quintile			−0.1867** (0.0723)
Teacher demographic background			
African American	−0.0582 (0.0785)	−0.028 (0.0903)	−0.0516 (0.0782)
Other nonwhite	−0.1301 (0.2013)	−0.123 (0.2479)	−0.1248 (0.202)
Labor market factors			
Average district salary supplement/$100	−0.0064** (0.0029)	−0.002 (0.0054)	−0.0065** (0.0029)
Average county wage/$100	0.0017 (0.0017)	0.0127** (0.00540)	0.0018 (0.0017)
Number of schools within 5-mi. radius	−0.0136** (0.003)		−0.0135** (0.003)
Percent unemployment in county	−0.0075 (0.0143)	−0.0359** (0.0187)	−0.0078 (0.0143)
Average SAT at undergraduate college/100	0.0763** (0.0237)	0.0747** (0.0259)	0.0773** (0.0237)
Pre-service exam score	−0.0367 (0.0332)	−0.0364** (0.0371)	−0.0361 (0.0334)
Master's or higher degree	0.001 (0.0704)	−0.0008 (0.078)	0.003 (0.0702)
NBPTS certified	−0.1547 (0.3898)	0.2001 (0.4045)	−0.1762 (0.3893)
School context factors			
Percent FRL	0.0061** (0.0027)	0.0044 (0.004)	0.006** (0.0027)
Percent African American	0.0045** (0.002)	0.0094 (0.0108)	0.0046** (0.002)
Enrollment/10 students	0.0003 (0.0013)	0.0081** (0.0034)	0.0002 (0.0013)
School-wide math score	0.012 (0.1483)	−0.069 (0.3232)	0.015 (0.1484)
Z-score FRL	−0.055 (0.0571)	−0.0548 (0.0962)	−0.057 (0.0571)
Z-score African American	0.064 (0.0444)	−0.1519 (0.1375)	0.063 (0.0444)
Includes school fixed effects	No	Yes	No
Model log likelihood	−7,082.14	−7,076.17	−7,082.17

Notes: All models control for years of teaching experience. All models except those with school fixed effects control for the district's location on the state's border.

Standard errors are in parentheses.

* Indicates significance level of $p \leq 0.05$. ** Indicates significance level of $p \leq 0.01$.

Table 3. Panel II: Log odds estimates from models of teachers' across-district moves: Effects of labor market and school context factors by effectiveness quintile.

Parameter	Lowest Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
Teacher effectiveness	−0.1163	0.0642	0.5567	0.2588	−0.077
	(0.0953)	(0.5255)	(0.6271)	(0.339)	(0.052)
Labor market factors					
Average district salary supplement/$100	−0.0009	−0.0132**	0.002	−0.009	−0.0159**
	(0.0056)	(0.0057)	(0.006)	(0.006)	(0.006)
Average county wage/$100	0.0043	0.0037	−0.005	0.004	0.002
	(0.0027)	(0.0029)	(0.003)	(0.003)	(0.003)
Number of schools within 5-mi. radius	−0.0126**	−0.0154**	−0.01*	−0.0267**	−0.001
	(0.0057)	(0.0063)	(0.006)	(0.007)	(0.007)
Percent unemployment in county	0.0196	−0.0537*	0.029	−0.0667**	0.034
	(0.0256)	(0.0297)	(0.029)	(0.031)	(0.029)
Average SAT at undergraduate college/100	0.042	0.097**	0.1499**	0.0773*	0.018
	(0.037)	(0.041)	(0.04)	(0.042)	(0.045)
Pre-service exam score	0.0032	−0.1204	−0.095	−0.065	0.038
	(0.0619)	(0.0747)	(0.084)	(0.081)	(0.081)
Master's or higher degree	−0.0888	−0.1791	0.078	0.127	0.09
	(0.1406)	(0.182)	(0.165)	(0.155)	(0.158)
School context factors					
Percent FRL	0.0055	0.0058	0.006	0.004	0.007
	(0.0046)	(0.0055)	(0.005)	(0.006)	(0.005)
Percent African American	0.0002	0.0071*	0.008*	0.009**	0.001
	(0.0033)	(0.00420)	(0.0043)	(0.0045)	(0.004)
Enrollment/10 students	−0.0004	−0.001	−0.002	0.001	0.0051**
	(0.0021)	(0.0024)	(0.003)	(0.003)	(0.003)
School-wide math score	0.2627	0.0716	−0.37	−0.102	0.234
	(0.2915)	(0.2947)	(0.309)	(0.333)	(0.345)
Z-score FRL	−0.0352	0.1136	−0.124	−0.173	−0.034
	(0.1021)	(0.1112)	(0.121)	(0.127)	(0.113)
Z-score African American	0.0781	0.0859	0.098	0.092	0.099
	(0.0211)	(0.7392)	(0.626)	(0.3964)	(0.8796)
Model log likelihood	−7,050.5				

Notes: All models control for years of teaching experience. All models except those with school fixed effects control for the district's location on the state's border.

Standard errors are in parentheses.

* Indicates significance level of $p \leq 0.05$. ** Indicates significance level of $p \leq 0.01$.

its best teachers, these exits may reflect a productivity loss for the system as well. Our third set of models uses the same specifications as above to explore the exit of teachers from the North Carolina public education system. These specifications, given in Table 4, show that, on average, the most effective teachers are the least likely to exit the North Carolina system.

Column A of the table shows the odds of exiting the system decline by 22 percent with each additional standard deviation of effectiveness. As before, this effect persists even after accounting for school fixed effects (see Table 4, column B). Looking at the relationship between school context factors and exits from the system, an assortment of factors including enrollment, the concentration of FRL students, and the within-district standardized concentration of African American students all correspond with increases in the odds of exiting the system. The one notable difference

Table 4. Panel I: Log odds estimates from models of teachers' exits from the North Carolina public education system.

Parameter	Model A	Model B	Model C
Teacher effectiveness	−0.2543**	−0.2797**	
	(0.0292)	(0.0314)	
Lowest quintile			0.5427**
			(0.0696)
Quintile 2			0.0150
			(0.0767)
Quintile 3 (reference category)			
Quintile 4			−0.0948
			(0.0775)
Highest quintile			−0.1647**
			(0.0805)
Teacher demographic background			
African American	−0.0854	−0.0525	−0.0702
	(0.0769)	(0.0874)	(0.0786)
Other nonwhite	−0.3114	−0.3424	−0.2743
	(0.2298)	(0.2767)	(0.2254)
Labor market factors			
Average district salary supplement/$100	0.0172**	0.0272**	0.0173**
	(0.0031)	(0.0073)	(0.0031)
Average county wage/$100	−0.0025	0.0092	−0.0022
	(0.0017)	(0.0067)	(0.0017)
Number of schools within 5-mi. radius	0.0014		0.0008
	(0.0027)		(0.0027)
Percent unemployment in county	0.0335**	0.0187	0.0316**
	(0.0137)	(0.0199)	(0.0138)
Average SAT at undergraduate college/100	0.2396**	0.2609**	0.2403**
	(0.0252)	(0.0286)	(0.0252)
Pre-service exam score	0.0941**	0.083**	0.1058**
	(0.0383)	(0.0425)	(0.0385)
Master's or higher degree	−0.0489	0.0426	−0.0538
	(0.0705)	(0.0779)	(0.0711)
NBPTS certified	−0.5618	−0.309	−0.6017
	(0.4488)	(0.4727)	(0.4528)
School context factors			
Percent FRL	0.0106**	0.0151**	0.0097**
	(0.0025)	(0.0044)	(0.0025)
Percent African American	0.0006	0.0085	0.0008
	(0.002)	(0.0108)	(0.002)
Enrollment/10 students	0.002*	0.0095**	0.002*
	(0.0012)	(0.0036)	(0.0012)
School-wide math score	−0.0532	−0.1799	−0.0404
	(0.1367)	(0.3836)	(0.1366)
Z-score FRL	−0.134**	−0.1166	−0.1342**
	(0.0556)	(0.0985)	(0.0558)
Z-score African American	0.0723	−0.0122	0.0725
	(0.0447)	(0.1493)	(0.0451)
Includes school fixed effects	No	Yes	No
Model log likelihood	−6,312.76	−6,285.69	−6,294.1

Notes: All models control for years of teaching experience. All models except those with school fixed effects control for the district's location on the state's border.

Standard errors are in parentheses.

* Indicates significance level of $p \leq 0.05$. ** Indicates significance level of $p \leq 0.01$.

Table 4. Panel II: Log odds estimates from models of teachers' exits from the North Carolina public education system: Effects of labor market and school context factors by effectiveness quintile.

Parameter	Lowest Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
Teacher effectiveness	−0.4264**	−0.741	0.616	0.294	−0.1068*
	(0.0761)	(0.6174)	(0.7139)	(0.4011)	(0.0608)
Labor market factors					
Average district salary supplement/$100	0.0189**	0.0179**	0.0215**	0.011*	0.0191**
	(0.0055)	(0.0067)	(0.0063)	(0.0063)	(0.0069)
Average county wage/$100	0.001	−0.003	−0.004	0.000	−0.0058**
	(0.0026)	(0.0033)	(0.003)	(0.0034)	(0.0034)
Number of schools within 5-mi. radius	−0.007	0.007	−0.001	0.002	0.007
	(0.0048)	(0.0066)	(0.006)	(0.0065)	(0.0057)
Percent unemployment in county	0.014	0.037	0.043	0.036	0.057*
	(0.0225)	(0.0335)	(0.0312)	(0.0324)	(0.0319)
Average SAT at undergraduate college/100	0.2467**	0.1806**	0.2577**	0.2458**	0.2815**
	(0.0364)	(0.0472)	(0.0436)	(0.0464)	(0.0446)
Pre-service exam score	0.054	0.150	0.107	0.019	0.2539**
	(0.0567)	(0.0924)	(0.0944)	(0.1014)	(0.0889)
Master's or higher degree	0.002	−0.027	0.014	0.113	−0.6367**
	(0.1232)	(0.165)	(0.1618)	(0.1665)	(0.2109)
School context factors					
Percent FRL	0.0092**	0.0151**	0.0115**	0.007	0.009
	(0.0043)	(0.0058)	(0.0058)	(0.0058)	(0.0056)
Percent African American	−0.003	0.002	0.005	0.000	0.002
	(0.0032)	(0.0044)	(0.0048)	(0.0049)	(0.0047)
Enrollment/10 students	0.002	0.003	0.002	0.001	0.004
	(0.002)	(0.0026)	(0.0028)	(0.0029)	(0.0028)
School-wide math score	−0.422	−0.017	0.509	0.109	0.089
	(0.266)	(0.3212)	(0.3543)	(0.3211)	(0.3)
Z-score FRL	−0.011	−0.2309*	−0.136	−0.154	−0.2747**
	(0.0927)	(0.1371)	(0.1412)	(0.1305)	(0.1269)
Z-score African American	0.1335*	0.030	0.052	0.139	0.000
	(0.0774)	(0.0986)	(0.1089)	(0.1111)	(0.1102)
Model log likelihood:	−6,241.7				

Notes: All models control for years of teaching experience. All models except those with school fixed effects control for the district's location on the state's border.

Standard errors are in parentheses.

* Indicates significance level of $p \leq 0.05$. ** Indicates significance level of $p \leq 0.01$.

in our models of teacher exits from the system is that a high concentration of FRL students relative to the rest of the schools in the district corresponds with *lower* odds of exiting the system.

Our conceptual model suggests that the labor market factors predicting the exit of teachers from the profession will differ from those predicting the transfer of teachers between schools. It is worth emphasizing that the data do not include the reason for an exit; it may be because a teacher is accepting a teaching job in the private school sector or in a different state, because a teacher is taking a job outside of teaching, or because a teacher is leaving the labor market altogether.

Estimates from Table 4 show that college selectivity and pre-service licensure exam scores significantly predict the likelihood of teachers leaving the North Carolina system. For example, teachers who graduated from colleges where the average entering freshman SAT is 1000 are 27 percent more likely to leave the North Carolina system than are teachers graduating from colleges where the average entering freshman SAT is 900. Similarly, the odds of exiting the system increase by about 10 percent for each additional standard deviation in the pre-service licensure exam score.

The finding on college selectivity is not surprising because this factor is likely to be used to screen job applicants in non-teaching jobs. It is curious, however, to find that licensure exam scores are also associated with higher odds of exiting, as external employers are unlikely to ask about these scores. There are two potential explanations for the findings: Teachers may be leaving North Carolina for an out-of-state teaching position, or pre-service licensure exam performance may be a good proxy for cognitive or other skills that are observed and valued by employers outside of the education system.[39]

How do findings differ along the teacher effectiveness distribution? Consistent with both within- and cross-district transfers (see Table 4, column C), the attrition patterns for teachers in the middle of the effectiveness distribution are similar; the top quintile teachers are less likely to exit and the bottom quintile teachers are more likely to exit than are those in the middle of the distribution.[40]

Turning to the interactions between effectiveness and the labor market and school context variables (shown in panel II of Table 4), the effect of college selectivity does not vary much across the effectiveness distribution. The pre-service licensure exam score, by contrast, varies in both magnitude and statistical significance across the effectiveness distribution but lacks an intuitive pattern.[41] Increases in value-added estimates are associated with lower odds of teachers' exits from the system. However, we also find that exits from the system are associated with teachers' marketability, in particular, the selectivity of teachers' undergraduate colleges. Interestingly, the effect of college selectivity on teachers' exits is very similar for teachers across the effectiveness distribution.

TESTS OF ROBUSTNESS

The results described above reflect several decisions about the methods for estimating teacher effects and defining the analytic sample. To ensure that our results are robust to these decisions, we explore a variety of alternative specifications.

As we touched on briefly above, there is no consensus about the "best" way to measure teacher effectiveness in a value-added framework. In the results presented above, we utilize a specification that includes student fixed effects and pools all of the information available for a teacher into a single teacher career-effectiveness measure. This approach, however, raises some concerns.

First, critics may wonder if our approach truly captures the teachers' contributions to student learning and not the effects of systematic matching of students to teachers. We explore this issue in two ways. First, in line with work from Clotfelter, Ladd, and Vigdor (2007), we utilize the same specification as above (Equation 4) to estimate teacher effectiveness but restrict our analyses to a sample of students who

[39] The finding that the external market appears to place a higher value on measures of academic competence such as college selectivity and test performance is consistent with research on distribution of individuals across occupations (Ballou, 1996). This research also concludes that graduates from more selective colleges receive smaller pay premiums in teaching than in other occupations.

[40] It is conceivable that results for teachers at the bottom of the distribution may be a result of principals encouraging these teachers to leave teaching.

[41] The least effective teachers appear to be slightly more sensitive to school context than more effective teachers. For example, the percent of FRL students predicts greater attrition from the system for all but the fourth quintile of teachers, but only the least effective teachers appear sensitive to a school's math performance.

appear to be randomly assigned to their teachers based on a set of observable student characteristics.[42] Overall, these results are qualitatively similar to those in our original model, though there is some loss of significance in the estimates for teachers in the fifth quintile (Table 5, column B). The loss of significance is not surprising given the restricted sample size.

The second strategy we employ to address potential bias in our main specification is to estimate the VAM using a vector of prior student achievement scores. For this specification, we restrict our sample to 5th-grade teachers and substitute 3rd- and 4th-grade test scores in both math and reading for the student fixed effect, as specified in Equation (8):

$$y_{ij^{5th}} = \alpha + \sum_{1}^{N} yi,t-n \; + \; X_{it} + \Phi_{j^{5th}} + \varepsilon_{ij^{5th}} \tag{8}$$

where N = total number of years for which the student has prior data and j^{5th} indicates 5th-grade teachers (the only teachers in our sample who teach students with a vector of prior assessment scores) and $\Phi_{j^{5th}}$ = VAM for 5th-grade teacher j^{5th} over the teacher's career.

Rothstein (2009) suggests that this approach minimizes the potential of selection on unobservable characteristics because the vector of twice-lagged prior achievement scores explains a significant portion of the variation in 5th-grade achievement. Moreover, Kane and Staiger (2008) find that a specification similar to this produces teacher effect estimates that are similar to those produced under experimental conditions where teachers are randomly matched to their students.[43]

In the models of within- and cross-district moves, estimates in the lower end of the effectiveness distribution are similar in direction to the results presented in this paper but are greater in magnitude (Table 5, column C). However, estimates for the highest performing teachers are attenuated and less significant. The estimates from the model of exits from the system differ from the original models at both ends of the effectiveness distribution. Teachers in the highest quintile are about as likely to move schools or exit the system as teachers in the third quintile, whereas we previously found that they were less likely to move than teachers in the third quintile. As before, there is significant change in the sample size; the number of observations for which we have this alternative measure is less than 25 percent of the original sample.[44]

We estimate several other value-added specifications in addition to the alternative specifications described above. These specifications include a value-added measure

[42] To identify teachers who appear to be randomly matched with their students, we first identify schools with more than one classroom in the same grade and year. We then individually test whether the classroom proportions of students with various characteristics (gender, ethnicity, FRL status, English proficiency, and parents' education) are equal. We consider a teacher to be randomly assigned to her students if at least four of the five tests of sample proportion equality are not rejected.

[43] It is also worth noting that because this specification only includes teachers from one grade, the same students do not contribute to the effectiveness estimates across grade levels. Because this specification does not include student fixed effects, there is no concern that there is too little mixing of teachers and students to generate valid estimates (Abowd, Creecy, & Kramarz, 2002).

[44] We also estimated the basic attrition models using the pooled measure of teacher effectiveness that is presented in the paper (Table 5, column A) but limiting our sample to only the observations available from the vector of prior scores teacher effect specification (Table 5, column C). In the models of within- and cross-district moves, estimates from this reduced sample using the pooled specification more closely matched in direction and significance the results given in column C of Table 5 (the model using the vector of prior scores specification). The estimates for exits from the system, however, are different in their significance from the estimates given in column C. These results suggest that the differences between the results presented in the specifications in columns A and C are due in part, but not entirely, to sample differences.

Table 5. Primary effects from basic mobility models for alternative specifications of teacher effects.

		Column A Original Pooled Specifications	Column B Random Assignment Effect	Column C Vector of Prior Scores Effect	Column D Cumulative Effect	Column E Lagged Cumulative Effect
Move schools	Quintile 1	0.1657**	0.2196**	0.288**	0.1992**	0.1206
		(0.0616)	(0.0764)	(0.1496)	(0.0793)	(0.1051)
	Quintile 2	0.057	−0.0351	−0.0687	0.0495	0.0508
		(0.0632)	(0.0786)	(0.1551)	(0.0835)	(0.1022)
	Quintile 4	−0.088	0.0265	0.1489	0.0139	0.0378
		(0.0649)	(0.0733)	(0.1393)	(0.0796)	(0.1019)
	Quintile 5	−0.1584**	−0.1385*	0.0115	0.0468	−0.0051
		(0.0702)	(0.0768)	(0.1493)	(0.0826)	(0.1022)
Move districts	Quintile 1	0.214**	0.2287**	0.5146**	0.2528**	0.2937**
		(0.0661)	(0.0833)	(0.1565)	(0.0855)	(0.1221)
	Quintile 2	0.0982	−0.0087	−0.0465	0.0774	0.2135*
		(0.0675)	(0.0848)	(0.1856)	(0.0888)	(0.1238)
	Quintile 4	0.0306	−0.0408	−0.0162	−0.001	0.1986
		(0.0728)	(0.0890)	(0.1758)	(0.0949)	(0.1254)
	Quintile 5	−0.1867**	−0.1602*	−0.0563	−0.095	0.0096
		(0.0723)	(0.0903)	(0.1792)	(0.0947)	(0.1249)
Exit system	Quintile 1	0.5427**	0.415**	0.1519	0.2322**	0.0311
		(0.0696)	(0.0849)	(0.1309)	(0.0729)	(0.0933)
	Quintile 2	0.0150	0.0025	0.0852	0.0478	−0.1330
		(0.0767)	(0.0889)	(0.1322)	(0.0713)	(0.0930)
	Quintile 4	−0.0948	−0.1502	−0.1439*	−0.0537	−0.1538*
		(0.0775)	(0.0927)	(0.1406)	(0.0727)	(0.0913)
	Quintile 5	−0.1647**	−0.1033	0.0708	−0.1401*	−0.3234**
		(0.0805)	(0.0940)	(0.1307)	(0.0759)	(0.0969)
Number of observations available		34,429	23,299	8,078	24,322	15,096

Note: Standard errors are in parentheses.

* Indicates significance level of $p \leq 0.05$. ** Indicates significance level of $p \leq 0.01$.

that controls for teacher experience;[45] a measure that includes student fixed effects and just a single lagged, same-subject test score; a measure that includes observable student characteristics as covariates in place of student fixed effects; and a measure that estimates gains and includes student fixed effects. Because most of these value-added specifications are highly correlated with, and yield mobility coefficient estimates very similar to, at least one other value-added specification already provided in Table 5, these additional specifications are not included in our table.[46]

A different concern is whether it is appropriate to utilize a teacher performance measure that is based on a teacher's entire career (at least that portion of it in our sample). The career-based estimate may be a more reliable (less noisy) measure than teacher-year estimates of performance. It also might be more important to know whether generally effective or ineffective teachers tend to be more or less mobile. There are, however, at least two reasons to be wary about the career-based measure. First, teachers who make a transition may anticipate doing so, and this could influence their behavior. So, for instance, we might see an Ashenfelter dip (Ashenfelter, 1978), where teachers who expect to leave their schools lower their effort level and thereby influence student achievement and their VAM. Notably, Hanushek et al. (2005) report evidence of an Ashenfelter dip in their analysis of teacher transitions in a Texas school district. Because we are observing teachers over a relatively short span of their potential career (especially those who leave the profession early in their careers) in the classroom, this short-term dip could influence career-based measures of effectiveness. The same case could be made if a temporary poor fit between teachers and schools (or their students) causes a dip in effectiveness.[47]

We explore the Ashenfelter dip and match issues by estimating teacher-by-year effects to see whether effectiveness in pre- or post-move years appears to be different from the teacher's career effectiveness measures employed above. Overall, we only find evidence of an Ashenfelter dip among teachers who make cross-district moves;[48] the performance of teachers who moved to a new district dip in the year prior to their move, but the performance estimates largely recover from this dip in

[45] It is not clear to us whether value-added teacher effect estimates that incorporate the productivity gains associated with experience are desired or not, but we could imagine some arguments against their incorporation. For instance, one might imagine that teacher mobility is at least partially driven by administrator preferences (again, particularly early in a teacher's career) and that administrators are making comparisons of teachers within an experience category. So principals might, for example, want to keep their most promising novice teachers, even if they might be less effective than some of their more senior teachers (because they have not yet benefited from having a few years in the classroom under their belts).

[46] The teacher effects from the value-added model with student fixed effects and a single lagged, same-subject test has a correlation of over 0.93 with the original pooled specification reported throughout the paper. The value-added measure that includes student characteristics as covariates has a correlation of over 0.76 with the vector of prior scores specification reported in column C of Table 5. The exception is the value-added measure computed from gains in student scores controlling for student fixed effects. The teacher effects estimated in this specification were only weakly correlated with the other value-added measures we estimated. (It was most highly correlated with the specification that included a vector of prior scores, but the correlation was only about 0.5.) It is therefore not terribly surprising that the estimates from the mobility model utilizing this measure did not correspond well with our original pooled specification (Table 5, column A). We opted not to focus too much attention on this finding given that the teacher effectiveness estimates from the gains in student scores specification is estimated with considerably more error than the teacher effects from the other value-added specifications we tested.

[47] Jackson and Bruegmann (2009) find that teachers' performance can be influenced by the quality of their school colleagues. Of course, it is not clear that match effects should not be thought of as part of teacher effectiveness.

[48] There is no evidence of a shift in performance relative to their career average before or after teachers make a within-district move and no evidence of a dip in performance in the year before teachers exit the system.

the year after their move, so that they are not significantly different from the teacher's career average.

Finally, to the extent that decisions are based on performance to the point that a transition is made, one might argue that a cumulative measure of effectiveness is more appropriate to use in the survival models than the career measure. We explore this possibility by estimating a cumulative measure of teacher effectiveness, as specified in Equation (9):

$$y_{ijt} = \alpha + \Theta_{iT} + \Phi_{jT} + \varepsilon_{ijt} \tag{9}$$

where T reflects the number of years in the teacher's career up to time t and Φ_{jt} is the VAM for teacher j in year t based on T years of teacher–student data.

The results using a cumulative measure are qualitatively similar in many respects, though there is loss of significance in the coefficients for teachers in the highest quintile and the magnitude of effects is smaller in the model of teacher exits (Table 5, column D).[49]

The cumulative measure can also be used as a second check on the possibility that an Ashenfleter dip or match effects influenced our earlier results. This is done by estimating the models using the cumulative measure from the year prior to the year in which the teacher moves, presumably before any dip occurs. For example, we estimate the odds of a teacher moving at the end of the 2000–2001 school year given their cumulative teacher effect up to the 1999–2000 school year. Thus we are able to eliminate the hypothesized "slack-off" year from the teacher's estimated VAM. With this new measure, teachers in the lowest quintile are found to be more likely than more effective teachers to move to a new district (Table 5, column E). This lowest quintile, however, is not more likely to move to a new school or to exit the system than teachers in the middle of the distribution. (The coefficients remain positive but are no longer statistically significant.) Teachers in the highest quintile are less likely to exit the system, but their odds of moving schools (within or across districts) are not significantly different from teachers in the middle of the distribution. Thus, this exercise again provides some evidence of an Ashenfelter dip, but the Ashenfelter dip does not seem to affect the basic direction of the results in most respects.[50]

In addition, we estimate the mobility models with two different restricted samples. First, to address any concern that the sample of teachers do not have enough students in common over time to yield precise estimates, we use an analysis that is based on an algorithm offered by Abowd, Creecy, and Kramarz (2002) to identify a main stratum of teachers who, at least indirectly, shared students over time. We then estimate the mobility models using only those teachers in this main stratum, which includes almost 97 percent of our original teachers. Finally, we utilize a sample of teachers whose value-added observations are derived from 10 or more student scores in order to address the concerns that might arise due to low reliability of the value-added measure.[51] When we replicate the basic quintile models from column C of Tables 2 through 4 (and column A of Table 5), the estimates from the restricted sample mirror the pooled estimates in magnitude and direction. There is, however, some loss of significance in estimates for the lowest and highest quintiles.

[49] Although we are not reporting these results, in addition to using the cumulative measure, we explored whether the findings were different if we restricted our sample to tenured teachers. (Teachers in North Carolina generally receive tenure in their fifth year, so we restrict our analyses to teachers with five or more years of experience.) The thought here is that a career transition for a tenured teacher is far more likely to be reflective of a teacher's rather than an administrator's preferences. The findings with this subsample of teachers (available on request) differ little for the key coefficients of interest, suggesting that our findings are unlikely to be driven by pre-tenure exits.

[50] In sum, we are not surprised that the different teacher effect specifications yielded similar results because these measures are highly correlated, with Pearson's r-values ranging from 0.71 to 0.88.

[51] This restriction reduced the number of observations from 34,429 to 20,146 observations.

POLICY IMPLICATIONS AND CONCLUSIONS

We argue that when focusing on teacher attrition, it is important to consider both the type of exit and whether the influence of individual teacher, school, and labor market conditions vary across the teacher effectiveness distribution. Consistent with the broad story from prior research, more effective teachers are less likely to leave their schools and the public school system. This result seems to be good news for schools, districts, and states, but the complex set of results described above also offers some more nuanced lessons.

To help explore these policy issues, Table 6 summarizes the key results by displaying the predicted probability of moves and exits across the effectiveness quintiles for teachers under several scenarios. The first row displays the predicted probability of moves and exits across all teachers displaying average characteristics in each quintile. The next two rows illustrate the role of teachers' external marketability by comparing the predicted probability of moves and exits between teachers with varying individual characteristics. Teachers who graduate from colleges in the top quartile of college selectivity and have top-quartile pre-service licensure exam scores are categorized as being highly marketable. Teachers with low marketability fall in the lowest quartile for college selectivity and pre-service exam scores. Finally, the last two rows illustrate the role of school context factors in teacher mobility by comparing the probability of moves and exits using the full interaction specification from schools with advantaged and disadvantaged contexts. We define advantaged and disadvantaged schools based on the quartile they fall into for enrollment, percent FRL, percent minority students, relative within-district concentration of minority and FRL students, and math scores.

The results presented in the first row of the table suggest that ineffective teachers appear to "churn" through the public school system, a finding consistent with the colloquial phrase "the dance of the lemons." Specifically, the most ineffective teachers are the most likely group to leave the school system, but they are also the most likely group to leave their schools for another school, either in their own or in another district.[52] We illustrate the issue of churn further, using teachers from the 1996 cohort. Only 65 percent of teachers in the lowest quintile stay in the state's classrooms through the end of the 2002 school year, which is about 8 percentage points lower than all other teachers in the 1996 cohort. However, of the lowest ranked teachers who remained in North Carolina schools through 2002, 44 percent made at least one move. By contrast, only 35 percent of teachers who remained in the system through 2002 and had performance rankings above the lowest quintile moved to a new school at least once.[53]

The churn finding suggests that schools could do a more effective job of culling poor performers. It is beyond the scope of this paper to delve too deeply into the issue, but some research (Goldhaber & Hansen, 2010; Gordon, Kane, & Staiger, 2006; Hanushek, 2009) suggests that incorporating measures of a teacher's effectiveness as part of the portfolio of information when making employment or compensation decisions could have significant implications for teacher workforce quality.

A second key result relates to the effect of marketability on teacher mobility. Research suggests that college graduates with high standardized test scores are less

[52] Hanushek et al. (2005) raise the concern about the quality of hiring decisions as they find that advantaged schools in a Texas district, despite having fewer minority students and offering higher salaries, did not seem to exploit this advantage to hire more effective teachers.

[53] We find a similar pattern of results when we look at the 1997 and 1998 cohorts, the two other cohorts for which we have lengthy employment history. However, it is important to recall that we are identifying elementary teachers who were least productive in their students' math performance. As Goldhaber and Hansen (2008) show, the correlation between teachers' value-added math and reading scores is just above 0.5, which means that some of the teachers we identify as having low productivity may be more productive in reading and win new jobs on the merits of their reading instruction.

Table 6. Probability of moves by quintile.

	Move Schools Within District					Move Schools Across Districts					Exit NC System				
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
P(move)	0.112	0.094	0.094	0.090	0.099	0.107	0.087	0.085	0.079	0.075	0.142	0.099	0.085	0.076	0.090
P(move) $\mid$ high marketability	0.112	0.097	0.091	0.085	0.096	0.109	0.086	0.153	0.080	0.089	0.160	0.113	0.099	0.085	0.112
P(move) $\mid$ low marketability	0.112	0.092	0.097	0.095	0.101	0.105	0.087	0.083	0.078	0.085	0.127	0.088	0.074	0.068	0.073
P(move) $\mid$ advantaged school	0.092	0.064	0.081	0.071	0.076	0.096	0.061	0.062	0.064	0.057	0.113	0.080	0.065	0.066	0.083
P(move) $\mid$ disadvantaged school	0.133	0.132	0.108	0.110	0.123	0.117	0.116	0.095	0.093	0.093	0.175	0.119	0.098	0.085	0.095

Note: School advantage is based on the percent of students with FRL status, percent of minority students, total enrollment, and school-wide math scores. Teacher marketability is determined by college selectivity and teacher pre-service exam scores.

likely to become teachers (Goldhaber & Liu, 2003; Hanushek & Pace, 1995; Henke et al., 1996; Hoxby & Leigh, 2004; Lakdawalla, 2001) and are more likely to leave teaching (Murnane & Olsen, 1990; Podgursky, Monroe, & Watson, 2004; Stinebrickner, 2002). This research fuels the concern that the financial rewards in teaching are not large enough to attract and keep the most talented graduates. Assuming that those leaving the North Carolina system are in fact leaving the teaching profession, our analyses (illustrated by the findings reported in rows 2 and 3 of Table 6), confirm the findings that more academically talented individuals, regardless of estimated effectiveness level, are more likely to leave the teaching profession. However, they are not systematically more likely to move from one school to another, either within or between districts.

Finally, teachers across the effectiveness distribution are more likely to leave schools serving disadvantaged and lower performing student populations (Table 6, rows 4 and 5). Although challenging school contexts do not disproportionately drive the most talented teachers out of the teaching profession, many of these teachers do seem to seek out better school contexts. The probability of a teacher in the highest quintile moving from a disadvantaged school to a new school in the same district is 0.12, compared to 0.08 for a similar teacher moving from an advantaged school. Similarly, the probability of a teacher moving from a disadvantaged school to a new school outside the district is 0.10, and the probability of moving from an advantaged school is only about 0.06. These findings are not new, as the flight of new teachers from arguably more difficult school settings has been well documented (Lankford, Loeb, & Wyckoff, 2002), but they reinforce a need to address this issue, perhaps, as some have suggested, through targeted incentives to keep effective teachers in challenging schools (Clotfelter et al., 2006; Kirby, Berends, & Naftel, 1999).

If the goal is to minimize the churn of the least effective teachers and to maximize the number of highly effective teachers staying in the system and staying in schools that most need them, our results suggest that some of the hard debates about teacher pay and incentives, tenure, evaluation, and working conditions are worthwhile. In moving forward, the policy community will be well served by research that focuses specifically on the relationship among all of these issues and teacher effectiveness and retention.

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