The Determinants of Teacher Attrition in Upstate New York

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Abstract

Policy makers and scholars have long been interested in the issue of teacher attrition, particularly in poor, urban schools. We contribute to this literature by investigating the determinants of teacher attrition in five large metropolitan areas in upstate New York State. We focus on a teacher's decision to leave a school district or to leave teaching using the Prentice-Gloeckler-Meyer technique for grouped proportional hazards with unobserved heterogeneity. Of primary interest are two measures of teacher salary: a teacher's salary relative to the salary of other college graduates in the region, and the salary in a teacher's district relative to the salary in the highest paid district in the region. These measures address alternative teaching and non-teaching opportunities. We find that teachers in districts with higher salaries relative to non-teaching salaries are less likely to leave teaching, and that a teacher is less likely to change districts when her or she teaches in a district near the top of the teacher salary distribution in that county.

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1. Introduction

Problems recruiting and retaining teachers are of great concern to school officials, policy makers, and researchers. This paper contributes to the debate on these issues by examining the determinants of teacher attrition in Upstate New York. Using a large sample of teachers over a fourteen-year period, we find that teachers are less likely to leave teaching the more their district pays relative to the salaries of other college graduates in the region. We also find that teachers are less likely to transfer to another school district the higher the salary schedule in their district relative to other districts in the county.

Nationally, 11 percent of teachers leave the profession after the first year and 39 percent leave within 5 years. In recent years, over 90 percent of new hires are replacements for recent departures, with departures for retirement accounting for only 12 percent of turnover.[1] In New York State, 13 percent of elementary school teachers leave their initial school after the first year, and only 48 percent of elementary school teachers are still at their original school after 5 years.[2] These average numbers mask differences across schools and districts. In particular, high poverty urban districts are more likely to have high turnover rates. Nationally, high poverty public schools have much higher annual turnover rates (16 percent) than low poverty schools (9 percent).[3]

Evidence that state policy makers are concerned with these facts can be seen in the variety of programs aimed at recruiting and retaining teachers, including education assistance, housing assistance, signing bonuses for new teachers, and retention bonuses for highly qualified

[1] Ingersoll (2002).
[2] This is an average of teachers of academic subjects who started teaching from 1993 to 1999. Numbers are similar for recent years.
[3] Ingersoll (2002).

or veteran teachers.[4] In most cases, however, these programs are not targeted toward teachers in high-need districts. For example, thirty-four states and the District of Columbia offer retention bonuses to veteran or highly qualified teachers, but only five of them target these bonuses at teachers in high-need districts.[5]

In New York State, several recent policies have been targeted towards the districts with the most difficulties recruiting and retaining teachers. The New York State Education Department's Teachers of Tomorrow initiative is designed to help recruit teachers for districts experiencing shortages. Annual awards of $3,400 are provided to teachers who teach in subject areas with shortages or in communities without enough qualified teachers.[6] Moreover, teacher-candidates who complete internships in urban schools in New York City, Buffalo, Rochester, Syracuse, and Yonkers, can receive stipends of up to $2,000. In addition, in 2002 the state legislature approved funding for a pilot program targeted at New York City and other urban districts that pairs new teachers in internships with experienced teachers.[7]

The high rates of teacher attrition and the resulting teacher turnover have implications for the quality of education students receive. Teacher turnover costs the school money that could be spent elsewhere. Turnover costs can include separation costs (exit interviews, etc.), hiring costs, vacancy costs (hiring substitutes), and training costs. One study (Texas Center for Educational Research 2000) used detailed information on Texas school districts to estimate the cost of

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[4] Although policy makers believe turnover rates in some districts are too high, research suggests that among recent college graduates, on average teachers stay in the same occupation longer than individuals in other occupations. U.S. Department of Education (2001).

[5] "Quality Counts 2003: To Close the Gap, Quality Counts," Education Week, January 9, 2003. http://www.edweek.com/sreports/qc03/templates/article.cfm?slug=17exec.h22

[6] The program was first put in place during the 2000-2001 school year. Districts submit requests for recruitment funding indicating the number of teachers they hope to hire in specific subjects with teacher shortages.

[7] "Quality Counts 2003: The Teacher Gap: New York," Education Week, January 9, 2003. http://www.edweek.com/sreports/qc03/templates/state.cfm?slug=17qcny.h22 Some mentoring programs have proven effective in reducing teacher attrition (National Governors Association Center for Best Practices 2002). Clotfelter et al. (2005) examine the effects of bonuses on teacher retention in North Carolina.

replacing one teacher and total costs for current turnover rates. This study estimated costs per teacher of at least 25 percent of salary and benefits.

Teacher turnover also affects the distribution of experienced teachers across schools. It is widely believed that more experienced teachers do a better job than novice teachers. If so, students in schools with more inexperienced teachers will learn less than students in schools with a greater percentage of experienced teachers, all else equal, and high teacher turnover can lower student performance.[8]

Teacher turnover also can affect how teachers with certain skills or qualifications are distributed across schools or school districts. Some studies have found, for example, that turnover has a particularly severe impact on poor, urban districts. Lankford et al. (2002) find that teacher moves increase inequities in teacher qualifications across schools; teacher qualifications include having passed the teacher certification exam on the first try and quality of undergraduate college. Recent work by Boyd, Lankford, Loeb, and Wyckoff (2005b) finds that teachers who score the highest on the general knowledge certification exam are substantially more likely to leave schools having the lowest achieving students. However, research using other measures of teacher skill has not found that the most skilled teachers are more likely to leave. Hanushek, Kain, O'Brian, and Rivkin (2005) find that teachers with greater student test score gains are not more likely to leave urban schools, and Murnane (1984) finds that teachers with lower student test score gains and worse supervisor's evaluations are more likely to leave teaching after one or two years. The relative quality of teachers who are leaving a school may

[8] Several studies seeking to explain student test scores or test score gains have included measures of the percent teachers with certain experience levels (e.g., Ferguson and Ladd 1996 and Rivkin, Hanushek, and Kain 2005) or individual teacher's experience levels (e.g., Goldhaber and Brewer 1997). However, none of the papers that we have seen address selection issues, i.e. the bad teachers might leave teaching earlier so that the sample of teachers changes by experience level. If the bad teachers are leaving, estimates based on these teacher experience measures would overestimate the true effect of experience.

also vary across schools. An "optimal" turnover rate for a particular school depends on the skills of those leaving, the skills of those being hired, and the costs of turnover, none of which is easy to quantify.

Overall, high rates of teacher turnover have direct monetary costs and alter the distribution of teacher experience and skill across districts. These findings suggest that identifying ways to reduce teacher attrition will increase the quality of education and improve students' outcomes in later life. As a result, reducing teacher attrition could pay large dividends, particularly to poor school districts. In this context, we believe it is important to estimate the extent to which teacher attrition is affected by salary and other job characteristics.

2. Data

We investigate the impact of teacher and job characteristics on teacher attrition in upstate New York using two data sets collected by the New York State Education Department, the *Personnel Master File* (PMF) and the *Institutional Master File* (IMF). Both data sets contain information collected annually from surveys. The PMF is composed of information on most public school teachers in New York State based on surveys of teachers that include questions on personal characteristics and working conditions. The IMF is based on surveys sent to school administrators and contains information on school characteristics such as enrollment, student characteristics, race and ethnicity of teaching staff, and school facilities.

In the PMF, the data are originally presented at the teacher-class level. For the purposes of this study, however, the data are converted so that each observation corresponds to a teacher in a given year. For variables that vary over classes, including subject taught, information was consolidated across classes. Variable definitions are presented in Table 1. The data are

comprised of all first teaching spells for teachers who started teaching between 1985 (1985-1986 school year) and 1998 (inclusive).[9] Academic and non-academic teachers (such as gym and music teachers) are included. Table 2 presents summary statistics for the samples used in the analyses.

Our analyses focus on school districts in Albany, Broome, Erie, Monroe, and Onondaga counties, the counties that contain Albany, Binghamton, Buffalo, Rochester, and Syracuse, respectively.[10] These counties all include large, poor city school districts and wealthy suburban school districts, so they allow us to examine teacher attrition across a wide range of school conditions within five large metropolitan areas.

Salary Variables

While many district characteristics, such as the socioeconomic background of students, are outside the control of school officials, districts can determine teachers' salaries. Some prior research has investigated the relationship between salary, the most obvious policy instrument, and teacher attrition, after accounting for other school characteristics. Studies along these lines include Mont and Rees (1996), Hanushek et al. (2004), Imazeki (2002), Scafidi, Sjoquist, and Stinebrickner (date unknown), and Stinebrickner (1998, 1999). A series of papers using Washington State data that included school district characteristics (Theobald 1990, Gritz and Theobald 1996, Theobald and Gritz 1996) also found that the spending priorities of a district affect teacher attrition. In general, these studies have found that higher salaries significantly lower teacher attrition, all else equal.

We use two variables to capture a teacher's salary relative to alternative opportunities. The first variable addresses non-teaching opportunities and is the natural log of the ratio of

[9] 1999 was used to calculate exit states for teachers teaching in 1998, but was otherwise not included in the analyses.
[10] Some districts overlap county lines. In those cases, we use the county that is listed for the district on the New York State Education Department website.

predicted individual salary divided by an estimate of non-teaching salary. This variable measures where a teacher's salary is relative to a non-teaching salary, one estimate of the opportunity cost of teaching. Each district has its own pay scale, usually with pay increases for additional years experience or additional education, such as a Master's degree.[11] Predicted individual salary is calculated, for each district year, by regressing the log of teachers' salaries (in 2001 dollars) on a spline of teaching experience and indicator variables for degree. Returns to experience may also differ between teachers with bachelor's degrees and teachers with Master's degrees; we account for this possibility by interacting degree and teaching-experience splines.[12] We then predict each teacher's salary based on their actual experience and degree. Teachers' predicted salaries will differ due to both where each teacher is on the pay scale in their particular district and the pay of that district relative to other districts. We use predicted salary instead of actual salary for two reasons. First, actual salary includes payment for coaching and other extra-curricular activities that are not relevant to our analysis. Second, data on actual salary is missing for a small share of our observations.

Non-teaching salary is estimated using earnings of college graduates in each of the five metropolitan statistical areas corresponding with the five counties. Using decennial Public Use Microdata Samples (PUMS) data, we calculated the median income of college graduates who were not teachers, between the ages of 22 and 55 (inclusive), and who were in the labor force full time. This was done separately for men and women.[13] Since our data is on an annual basis, we

[11] Districts do not determine pay for individual teachers, and therefore cannot reward (with pay) effective teachers or teachers in subject areas experiencing shortages (at least without specific policies in place).

[12] Specifically, we used three teaching experience variables, total teaching experience, experience in the district, and experience in other public schools. Districts may reward teaching experience in other schools, and teaching experience in other schools may not be equivalent to teaching in the district. Total teaching experience could include teaching in private schools, which may also be rewarded by districts.

[13] Our measure of non-teaching wages is similar to the approach used in Loeb and Page (2000). Loeb and Page (2000) however use change in teacher wages and change in non-teacher wages, while we use wage levels. In addition, since we are considering individual teacher's exit decisions we use individual predicted teacher salaries

estimated annual median earnings by calculating the growth in median earnings between decades and adding one tenth of that growth for each intermediate year.[14] We expect that the larger the ratio of teaching salary is to non-teaching salary, the less likely a teacher would be to leave teaching for other non-teaching labor market opportunities. This variable allows for changes in alternative salaries relative to teaching salaries to influence teacher attrition.

Our second salary variable addresses other public school teaching opportunities in the same county. It is the natural log of the ratio of the maximum teaching salary in the county for a teacher with 10 years experience and a Master's degree divided by the salary in a teacher's district for a teacher with a Master's degree and 10 years teaching experience. Using the same predicted returns to experience and degree that were used to predict individual teacher's salaries, we predict the salary each district would pay each year to a teacher with 10 years experience and a Master's degree.[15] Therefore, this ratio compares salaries across districts at the same point on the salary schedule. We expect that teachers who are in districts near the top of the salary distribution for their county would be less likely to transfer districts than teachers in districts closer to the bottom of the teacher salary distribution.

Teacher Characteristics

Teacher specific attributes, including subject specialty and academic ability, may also affect a teacher's alternative employment opportunities. In previous research, subject specialties, particularly math or science, have been found to be related to teacher turnover (Murnane and Olsen, 1989, 1990; Murnane, Singer, and Willett, 1989). We created two variables to capture

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instead of average teacher salaries. An alternative approach would be to use wages for occupations that are believed to be similar to teaching. Allegretto, Corcoran, and Michel (2004) identify some occupations that use skills similar to teaching. We prefer aggregate information on college graduates to occupation information since we are focusing on relatively small geographic areas.

[14] It would have been ideal to have county earnings data for college graduates on an annual basis. This data does exist in the Outgoing Rotations Groups from the Current Population Survey, but the geographic areas we focus on had extremely small sample sizes and the data did not appear reliable for our purposes.

[15] We assume no teaching experience outside the district.

potential differences in opportunity cost across grade level and subject taught. The first (labeled mthscihs) indicates that a teacher teaches math or science at the high school level; the second (labeled othhs) indicates that a teacher teaches some high school subject other than math and science. The omitted category is teaching elementary school.

Researchers have also hypothesized that teachers with greater academic ability will have better job opportunities outside of teaching, and some studies have found that teachers with higher test scores leave teaching sooner (Murnane, Singer, and Willett, 1989, Murnane and Olsen, 1990).[16] Unfortunately, our data do not include any information on teachers' academic ability.[17]

In addition to subject specialty and grade level, other teacher characteristics may be related to a teacher's propensity to transfer districts or leave teaching. The PMF includes information on each teacher's sex, education, and type of certification.[18] We estimate results separately for men and women, because family obligations or differences in preferences could cause men and women to value certain job characteristics differently.[19] For example, men may value salary differently than women if they are less likely to take time off to raise children. A limitation of this data set is a lack of information on teachers' marital status or number of children. Stinebrickner (1998, 1999, 2001) finds that marriage and fertility variables are important predictors of length of stay in teaching.

[16] Subject specialty or academic ability may be related to both current and life cycle measures of opportunity cost.
[17] A method for estimating individual opportunity costs, which our data also do not allow, was used by Dolton and van der Klauuw (1995, 1999) who estimated, in a regression framework, individual level measures of opportunity cost based on the wages of those who left teaching and teacher characteristics.
[18] Some studies have found that attrition patterns differ by teacher's race or ethnicity or that teacher's race/ethnicity is important when interacted with the race/ethnicity of the students in a school (Murnane and Olsen, 1989; Hanushek et al., 2004). Unfortunately, the PMF does not have information on a teacher's race. We do know the percentage of teachers in different racial and ethnic groups in each school, but the share of minority teachers is highly correlated (correlation = 0.8) with the share of minority students, so we did not include this variable in our analysis.
[19] We also test whether men and women should be in different models using the likelihood ratio test, and we find that men and women should be analyzed separately.

Our regressions include a measure of type of certification, which may reflect commitment to teaching. We include indicator variables for having regular certification (provisional or permanent, not temporary or none), and we expect teachers with regular certification to be less likely to leave teaching. In New York State, permanent certification requires a Master's degree, but the timing to certification does not necessarily coincide with the timing of education. As a result, we also include a variable to indicate whether a teacher has an advanced degree (a Master's or Ph.D.).[20] Boyd et al. (2005a) find that teachers in New York search for jobs near their hometown or in districts similar to their hometown. The value teachers' place on being near their hometown may also affect their quit behavior, but we do not have information on hometowns in our data set.

Because sample size in the likelihood function is the number of teaching spells rather than the number of teaching spell-years, missing spell-year information must be filled in some way. It is not permissible to simply drop the affected spell-year. For teaching spell-years with missing information for these variables, we impute values based on information in years surrounding the teaching spell. If degree is missing in one year, for example, but the teacher has a Master's degree the previous year and a Master's degree the following year, we fill in the missing variable as a Master's degree.[21]

School Characteristics

Schools with disadvantaged students may present a more challenging working environment than schools with relatively advantaged students, and these differences in working

[20] The PMF also contains information on the number of pupils in each teacher's class. We are not including any measure of class size because of concerns about missing data.

[21] Details of the data imputation method are available upon request. We do not consider these values to be estimated with error, as would be the case for other imputation methods, since we base imputed information not on a model, but on information provided in other years for the same individual. Therefore we do not adjust coefficient estimates or standard errors.

conditions could affect teacher mobility.[22] The IMF contains information on the socioeconomic status and racial and ethnic background of a school's students. We explore the impact on teacher attrition of variables indicating the concentration of minority students (defined as black, Hispanic, or Native American) and the share of students who are "members of families whose primary means of support is a public welfare program."[23] As in the case of teacher characteristics, we impute missing student characteristic data for a school year based on observed values of the data in other years for the same school.

3. Estimation Technique

In this study we focus on the determinants of the quit behavior of teachers in five major metropolitan areas in New York State (excluding New York City) between 1985 and 1998. The term "quit" can be defined in several ways, and we use two definitions and corresponding sets of teaching spells in our study. The first quit definition is leaving a given school district while remaining a teacher (in New York State), a behavior referred to as "switching districts." In this case, a teaching spell consists of years in a teacher's first district. The cell is censored if a teacher leaves the district but does not transfer to another district.

The second quit definition is leaving teaching in New York State. The teaching spell consists of continuous years in any districts in the five metropolitan areas. If a teacher leaves these metropolitan areas, but continues teaching in New York State, the spell is censored.

Other studies have found that salary has differential effects on the length of time in an initial teaching job for teachers who transfer districts and those who leave teaching (Hanushek et

[22] A number of previous studies have found that the racial or ethnic composition of the district or school is related to teacher mobility. See Gritz and Theobald (1996), Hanushek et al. (2004), Imazeki (2002), Mont and Rees (1996), Murnane and Olsen (1989, 1999), and Scafidi, Sjoquist, and Stinebrickner (2003).

[23] The IMF also has data on percent of students eligible for free or reduced price lunches, but those data are only available from 1993 on.

al. 2004, Imazeki 2002). We hypothesize that quits by the first definition (switching districts) will be influenced by a teacher's salary relative to the salaries for comparable teachers in other nearby districts. We also hypothesize that quits by the second definition (leaving teaching) will depend on a teacher's salary relative to salaries in the private sector.

In this section, the term quit refers to either of these two types of quit. For each quit definition, we determine durations to the first quit, for a sample of male teachers and a sample of female teachers. Spells that do not end with an exit in 1998 are censored.[24] Because our primary focus is on teacher salary, which is a district-level variable, we do not consider transfers within a district to be an "exit." The causes of within-district transfers are certainly worth studying, but they are not addressed in this paper.

Teachers are defined as leaving teaching if they are absent from the data for at least one year.[25] Unfortunately, we face the same constraint as most other studies, namely, that we are not able to distinguish between teachers who leave teaching temporarily, to stay at home with their children, for example, and those who have switched careers. Increases in salary could potentially have quite different affects on these two categories of teachers.[26]

Our goal is to find the determinants of the conditional quit rate (quit hazard rate). Some care must be taken with the statistical terminology being used. The quit rate might be defined as the quit rate at a point in time within the calendar year or as the quit rate for a given year. Somewhat arbitrarily, we refer to the first possibility as the quit rate and the second possibility as the quit probability.

[24] Transfers to administrative positions are also censored.
[25] In other analyses with this data, we also created exit state variables that allowed for one or more year absences from the data. Alternative definitions of the exit state variable did not substantively change the results.
[26] Dolton and van der Klaauw (1999) show that salary and other factors affect exits from teaching differently for teachers who exit to the nonteaching sector and teachers who exit to the nonworking state. Stinebrickner (2002) finds that the presence of a newborn child is an important determinant of exit decisions, and Scafidi et al. (2003, date unknown) find that the effect of salary varies depending on whether teachers leave the work force or switch to a non-teaching job.

A given sample in our study is assumed to consist of *N* independent teaching durations. Let T_i be the duration of the first teaching spell for $i = 1, \ldots, N$. The duration T_i is properly considered to be a continuous variable. Accordingly, the quit hazard rate for teaching spell *i* is defined as:

$$\lambda_i(t) = \lim_{\Delta t \to 0+} \Pr[t \le T_i < t + \Delta t \mid T_i \ge t] / \Delta t \quad . \tag{1}$$

We assume that the quit hazard rate takes the proportional hazard form developed by Cox (1972):

$$\lambda_i(t) = \lambda_0(t) \exp(z_i(t)'\beta) , \tag{2}$$

where $\lambda_0(t)$ is the unknown baseline hazard at time *t*, $z_i(t)$ is the vector of time-varying covariates, and β is the coefficient vector.

Cox (1975) discusses a partial likelihood technique to estimate the coefficient vector. Unfortunately, partial likelihood for proportional hazards can have two major problems. The first is that the correct treatment of tied failure times is computationally burdensome. The second problem is that individual-specific unobserved heterogeneity cannot be incorporated in single spell data. (See Ondrich 2005 for the case of multiple spell data.)

These two problems are resolved in Meyer's (1990) adaptation of the technique proposed by Prentice and Gloeckler (1978). In the Prentice-Gloeckler technique, the parameters of the log-integrated baseline hazard are non-parametrically estimated simultaneously with the coefficient vector. The estimation method does not use the continuous quality of the duration variable—it discretizes this variable into time intervals. This technique is particularly appropriate for the current study because in the teaching duration samples quits only occur at yearly intervals. (This type of data is called interval-censored.) Generally, when the Prentice-Gloeckler technique is

used, a parameter is estimated for each interval. Parameters for intervals in which no quits occur are not estimated and all such intervals are dropped from the sample.

The conditional survivor function at age $t+1$ is the probability that the completed teaching duration is greater than or equal to $t+1$, given that it is greater than or equal to *t*:

$$\begin{aligned} &\Pr[T_i \geq t+1 \mid T_i \geq t] \\ &\quad = \exp(-\int_t^{t+1} \lambda_i(u)du) \\ &\quad = \exp(-\exp(z_i(t)'\beta)\int_t^{t+1} \lambda_0(u)du), \end{aligned} \tag{3}$$

where the covariate vector $z_i(t)$ is assumed to remain constant over the period from *t* to $t+1$. (When *t* takes on an integer value, the period is associated with an annual interval.)

If we define

$$\gamma(t) = \log(\int_t^{t+1} \lambda_0(u)du), \tag{4}$$

then equation (3) can be re-written as:

$$\Pr[T_i \geq t+1 \mid T_i \geq t] = \exp(-\exp(z_i(t)'\beta + \gamma(t))). \tag{5}$$

The probability that a teaching spell ends before $t+1$ given that it survives to *t* is given by the complementary probability.

The estimation strategy must take into account that some of the teaching spells will be ongoing (censored) in the final year of the sample period. Meyer (1990) takes care of this possibility by associating with each spell a censoring time C_i as well as a duration T_i. An indicator variable δ_i equals one if $T_i \leq C_i$, i.e., the spell is uncensored, and equal zero otherwise. For any *x*, define the function $\text{int}(x)$ to be the largest integer less than or equal to *x*. Furthermore, define $k_i = \min(\text{int}(T_i), C_i)$. Thus, if the spell is uncensored, k_i represents the start of the last

sample year for the teaching spell, and if the spell is censored, k_i represents the end of the last sample year for the teaching spell.

Using these definitions, the Prentice-Gloeckler likelihood for a sample of *N* first teaching spells can be written as

$$\mathscr{L}(\gamma,\beta)=\prod_{i=1}^{N}[1-(\exp\{-\exp(\gamma(k_i)+z_i(k_i)'\beta)\})]^{\delta_i} \times\prod_{t=0}^{k_i-1}\exp\{-\exp(\gamma(t)+z_i(t)'\beta)\} \quad . \tag{6}$$

Note that the first factor in the product in the Prentice-Gloeckler likelihood function equals one when the teaching spell is censored and in this case provides no information to the likelihood. The first factor provides information to the likelihood only when the teaching spell ends between k_i and k_i+1. The final product in the Prentice-Gloeckler likelihood is simply the probability that the teaching spell lasts at least until time k_i. The log-likelihood function associated with the Prentice-Gloeckler likelihood is:

$$L(\gamma,\beta)=\sum_{i=1}^{N}\delta_i\log\left(1-(\exp\{-\exp(\gamma(k_i)+z_i(k_i)'\beta)\})\right) -\sum_{t=0}^{k_i-1}\exp(\gamma(t)+z_i(t)'\beta) \quad . \tag{7}$$

The interpretation of parameters is an important component of presenting the results of maximum-likelihood or other non-linear estimation. The interpretation of the β coefficients is similar to the interpretation of the regression coefficients of a log-linear or semi-log regression model. In a log-linear model, where both the dependent variable and the regressors are logged, a regression coefficient can be interpreted as an elasticity. Similarly, if a regressor is logged in the Prentice-Gloeckler likelihood, its coefficient can be interpreted as a hazard elasticity. In semi-log regression, in which the dependent variable is logged but the regressors are not, the elasticity of

the dependent variable with respect to a regressor is given by the value of the regressor times the coefficient. Similarly, if a regressor is no logged in a Prentice-Gloeckler likelihood, its hazard elasticity is given by the value of the regressor times the coefficient.

Interpretations of the coefficients of categorical variables remain problematic, but even these can be handled using the hazard-ratio transformation of β. The hazard ratio for component β_j of β is $\exp(\beta_j)$. The hazard ratio is the percentage change in the hazard due to a unit increase in the *j*th regressor. Using hazard ratios, the effect of the *j*th regressor on the hazard is significantly positive if the hazard ratio significantly exceeds one and significantly negative if the hazard ratio is significantly less than one. Defining s_j to be the (estimated) standard error of the maximum likelihood estimate $\hat{\beta}_j$ of β_j, the relevant asymptotic t-statistic for a test of $H_0: \exp(\beta_j) = 1$ is $(\exp(\hat{\beta}_j) - 1)/(\exp(\hat{\beta}_j)s_j)$. In many packages that estimate the Prentice-Gloeckler likelihood, hazard ratios are an alternative format for the estimation results.

The theoretical contribution of Meyer (1990) is to use random effects to incorporate unobserved heterogeneity into the Prentice-Gloeckler likelihood. The resulting likelihood is called the Prentice-Gloeckler-Meyer likelihood. The random effect summarizes the effects of all (unobserved) excluded regressors that are constant over the teaching spell and orthogonal to included regressors. Incorporating the multiplicative random effect θ_i into the hazard results in a new hazard of the form

$$\lambda_i(t) = \theta_i \lambda_0(t) \exp(z_i(t)'\beta) \quad . \tag{8}$$

Meyer (1990) assumes that the random effects θ_i are independent of the $z_i(t)$ and are i.i.d. Gamma variates with mean one and variance σ^2. Conditioning on the unobserved θ_i and

integrating out over their (joint) distribution leads to the following log-likelihood, derived by Meyer (1990):

$$L(\gamma,\beta,\sigma^2)=\sum_{i=1}^{N}\log\Big(\big(1+\sigma^2\sum_{t=0}^{k_i-1}\exp\{\gamma(t)+z_i(t)'\beta\}\big)^{-\sigma^{-2}} - \delta_i\big(1+\sigma^2\sum_{t=0}^{k_i}\exp\{\gamma(t)+z_i(t)'\beta\}\big)^{-\sigma^{-2}}\Big) \quad . \tag{9}$$

The variance σ^2 must now be estimated together with the coefficient vector β and the $\gamma(t)$'s. Testing the significance of the estimate of σ^2 is complicated by the fact that zero is on the edge of the parameter space. Chernoff (1954) demonstrated that under these conditions the appropriate critical value for a test of size α is the critical value for a test of size 2α under standard conditions. Finally, note that when θ_i equals one, the value of the hazard is the same in equations (2) and (8). This means that, conditional on the random effect assuming its mean value, the regressor coefficients and hazard ratios have the same interpretation in Prentice-Gloeckler-Meyer likelihood as in the Prentice-Gloeckler likelihood.

4. Results

Descriptive Statistics

Figures 1-4 show the hazard rates for the 4 samples (two exit states and two genders) used in our analyses. These smoothed hazard graphs are created using the "sts graph, hazard" command in Stata.[27] In general, the hazard rates increase over the first several years, and then decrease over subsequent years. For men, hazard rates are higher in the first four or five years than any later years. For women, hazard rates for switching districts are highest in the first three years and then decline markedly over the remaining years. Hazard rates for women leaving

[27] The hazard estimate is calculated as a weighted kernel density estimate utilizing the estimated hazard contributions. See Stata Corporation (2005).

teaching are similar in the first years to the hazard rate in the last years. The hazard rate increases over the first four years, decreases somewhat until year 11, and then decreases much more rapidly.

Estimation Results

Estimation results are presented in Tables 3 to 6. The Prentice-Gloeckler and the Prentice-Gloeckler-Meyer results are estimated using the "pgmhaz8" command written by Stephen Jenkins for Stata 8.2 (Stata Corporation, 2005).[28] Both sets of results are presented for the exit state leaving teaching. We were not able to obtain estimates for the Prentice-Gloeckler-Meyer model for the exit state transferring districts, because the models did not converge. We tried many starting values for the log of the Gamma variance in pgmhaz8. We also programmed the log-likelihoods in GQopt, where we could use analytic partial derivatives to attempt to maximize the log-likelihood, but our models still did not converge. For transferring districts, therefore, we only present results for the Prentice-Gloeckler model.

Tables 3 to 6 present results in the form of hazard ratios, $\exp(\beta_j)$; a number less than one indicates that a variable is negatively related to teachers' quit rate. Hazard elasticity results for the logged salary variables are presented in the text. Years in the teaching spell with no quits are excluded from the analyses, and the spell duration dummy variables for those years are then excluded as well. For men leaving teaching, for example, there were no quits in year 13 of the teaching spells, so all observations in year 13 were excluded from the analyses and the spell duration indicator for that year was dropped.

The logged ratio of predicted individual salary to non-teaching salary is used in analyses for teachers leaving teaching. The logged ratio of predicted maximum teaching salary in a

[28] The Prentice-Gloeckler estimates from pgmhaz8 without the eform option are equivalent to results using the cloglog command. See Stata Corporation (2005).

county divided by district salary, both for teachers with a Master's degree and 10 years experience, is used in analyses for teachers transferring districts.[29] For conciseness, these two variables are called the relative salary of teachers and the relative salary of nearby districts, respectively.

As shown in Tables 3 (for men) and 4 (for women), the relative salary of the district has the expected impact on the probability of transferring districts, but this variable is statistically significant only for women. The estimated coefficients (expressed as hazard ratios) are greater than one, which indicates that a higher the salary of nearby districts relative to a teacher's salary, the more likely the teacher is to transfer to another district. When the coefficient is not exponentiated, the coefficient of this salary variable can be interpreted as a hazard elasticity. For men transferring districts, the elasticity of this salary variable is 0.78, which implies that a one percent increase in the relative salary of nearby districts leads to a 0.78 percent decrease in the hazard rate. This elasticity applies to the hazard or quit *rate*, not the annual quit probability, as defined earlier. We provide simulations for the impact on annual quite probabilities in a later section. The elasticity of the salary ratio for women transferring districts is 0.84.

Tables 5 and 6 show that the relative salary of teachers generally has a statistically significant impact on the probabilities that both male and female teachers will leave teaching.[30] The coefficient is statistically significant in both models for women and for men in the Prentice-Gloeckler model, but it is not statistically significant for men in the Prentice-Gloeckler-Meyer model. The estimated hazard ratios are all less than one, which indicates that relatively higher

[29] Our model assumes that leaving teaching and transferring districts are independent decisions. Therefore alternative non-teaching salaries should not effect teachers' decisions to transfer districts, and alternative teaching salaries should not effect teachers' decisions to leave teaching.

[30] We also estimated our four Prentice-Gloeckler models with school-district fixed effects. These effects have a relatively small impact on the estimated coefficients, but they raise the estimated standard errors, so that the salary variable is no longer significant for men for either quit definition. The salary variable is still significant for women, however, at the 1 percent level for leaving teaching and at the 10 percent level for transferring districts.

teachers' salaries, or, alternatively, relatively lower non-teaching salaries, lead, as expected, to lower quit rates. In the Prentice-Gloeckler specification for men, the hazard elasticity is -0.43, which indicates that a one percent increase in the relative salary of teachers leads to a 0.43 percent decrease in the hazard rate for leaving teaching. The hazard elasticity in the Prentice-Gloeckler-Meyer model for men is -0.59. The hazard elasticities for women are -0.49 in the Prentice-Gloeckler model and -0.36 in the Prentice-Gloeckler-Meyer model.

Tables 3 to 6 also present estimated hazard ratios for the categorical variables, teaching math or science in high school, teaching a subject other than math or science in high school, having advanced degree, having regular certification, and teaching in a school with at least 80 percent minority students. In general, high school teachers of math or science and high school teachers of other subjects are more likely to leave teaching or transfer districts than elementary teachers (the omitted category). These coefficients are statistically significant in most specifications, but the coefficients for teaching math or science in high school are not statistically significant in the models for leaving teaching. Even when significant, these impacts are not large. In the Prentice-Gloeckler model for men transferring districts, for example, the hazard rate is 1.65 percent higher for a high school math or science teacher than for an elementary teacher.

Men and women with an advanced degree are less likely to leave teaching, although this result is not significant for women with the heterogeneity correction. These results suggest that a teacher's advanced degree is more closely associated with advancement within teaching than with a broadening of employment opportunities outside teaching. In contrast, women with an advanced degree (but not men) are *more* likely to transfer districts, perhaps because an advanced degree makes them more attractive in the market for teachers. Certification does not have a

significant impact on transfers between districts, but both men and women teachers with regular certification are less likely to leave teaching than are teachers with temporary or no certification. These results suggest that certification, like a Master's degree, contributes to advancement within the teaching profession.

In all specifications the estimated hazard ratio for teaching in a school with at least 80 percent minority students is greater than one, which indicates that a high minority concentration leads to more quits, but this variable is never statistically significant. Models that that included a continuous percent minority variable or the percent of students whose families were on welfare or variables to measure both minority and welfare concentration also produced statistically insignificant results.[31] Overall, therefore we find little support for the view that a concentration of disadvantaged students leads to more rapid teacher attrition. As noted earlier, however, we do not have information on an individual teacher's race or ethnicity, so we cannot rule out the possibility that a concentration of disadvantaged students affects attrition for teachers in some racial or ethnic groups.

Simulations

For more perspective on the extent to which salaries affect teacher's quit behavior, we also have conducted some simple simulations based on our estimates. More specifically, we use the analyses that do not incorporate unobserved heterogeneity to determine the effect of changes in teaching or non-teaching salaries on quit probabilities. Our procedure consists of two steps. First, we define representative male and female teachers and baseline salaries and then calculate the probability that a teacher will transfer districts or leave teaching. Second, we calculate the

[31] Switching to one of these alternative measures of student disadvantage also had virtually no impact on the estimated coefficient of the salary variable for either quit definition.

impact on these probabilities of a 20 percent increase in the salary schedule in the representative teacher's district.

Our representative teacher taught a subject other than math or science at the high school level, had regular certification, and earned an advanced degree in the fifth year of teaching. Because policy makers are particularly concerned about teacher attrition in schools with disadvantaged students, we assume the teacher is teaching in a school in which more than 80 percent of the students come from a minority group.

For the analyses of teachers leaving teaching, the baseline non-teaching salary is set equal to the non-teaching salary in Onondaga County in 1998 (with different values for men and women). For the analyses of teachers transferring districts, we set the baseline maximum teaching salary at the maximum teaching salary in Onondaga County in 1998. The baseline teaching salaries are calculated from teachers in Onondaga County in 1998. The salary for the first year of teaching is the mean salary for teachers in their first year. Salary for additional teaching years are the starting salary plus the coefficient from regressing salary on time in teaching, which is equivalent to the average salary increase from an additional year of teaching. This approach does not directly consider change in certification or earning a Master's degree, but instead picks up those factors as they show up in average salaries.

These definitions of representative teachers and baseline salaries lead to predicted quit probabilities for the first 14 years of teaching—the first step in our simulation procedure. We then increased a representative teacher's salary schedule by 20 percent. Because the salary variables in our analysis are ratios, this approach is equivalent to decreasing non-teaching salary (for the analysis of leaving teaching) or maximum teaching salary (for the analysis of changing districts) by 20 percent.

These simulations indicate that the impact of salary on quit behavior is relatively small. First, a 20 percent salary increase cuts the (small) annual probability of transferring districts by about 13 percent for men and 14 percent for women. A 20-percent increase in salary also raises the probability that a teacher will remain in a district for 14 years without transferring from 67.9 to 71.5 percent for men (a 4.38 percent increase) and from 74.0 to 77.2 percent for women (a 5.27 percent increase). Second, a 20 percent salary increase lowers the annual probability of leaving teaching by about 7 percent for men and 8 percent for women. The cumulative impact of this salary increase is to raise the probability that a teacher will not leave teaching during his or her first 14 years of teaching from 49.0 to 51.7 percent for men (a 5.59 percent increase) and from 26.8 to 30.0 percent for women (a 12.03 percent increase).

5. Conclusion

This research focused on the importance of teachers' salaries relative to non-teaching and alternative teaching salaries on teachers' decisions to quit teaching or transfer districts. We find that teachers in districts with higher salaries relative to non-teaching salaries are less likely to leave teaching. We also find that a teacher is less likely to transfer to another district if the district in which he or she teaches has high salaries relative to other districts in the same county.

Other teacher characteristics, included education level, grade level and subject taught, and certification also are related to teachers' transfer and quit decisions. We did not find that teachers' transfer and quit decisions are significantly affected by a concentration of

disadvantaged students. This result differs from results in some previous studies, and more research on this topic clearly is warranted.[32]

Our results indicate that districts could reduce the probability that teachers quit teaching by increasing teaching salaries relative to the regional non-teaching salaries for college graduates. In addition, districts could reduce the probability that teachers transfer districts by increasing their salary relative to surrounding districts. If other districts respond to one district's salary increases by increasing salaries themselves, however, it may be difficult for a district to move up the teacher salary distribution. Moreover, our simulations reveal that a district must increase its salaries by a substantial amount in order to have a noticeable impact on the share of its teachers who leave teaching or transfer to another district (holding other districts' salaries constant). As a result, relatively poor districts may not be able to boost teacher retention through salary increases without additional resources from their state.

[32] For example, Hanushek, Kain, and Rivkin (2004) and Scafidi, Sjoquist, and Stinebrickner (date unknown) find that student characteristics are significant predictors of teacher mobility. However, not all studies, or all specifications, have found these variables significantly related to teacher exit decisions.

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I CAN’T ERASE THE FOLLOWING WITHOUT INTRODUCING A HEADER I DO NOT WANT. CRAZY WORD!!!!!!!!

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Table 1: Description of Variables

Teacher Characteristics	
advdeg	Indicator for having a Master's degree or Ph.D.
crtreg	Indicator for having provisional or permanent certification (i.e. not temporary or no certification)
mthscihs	Indicator for teaching more than half of classes in math or science in grades 7-12
othhs	Indicator for teaching subjects other than math or science in grades 7-12
elemtch	Indicator for teaching in grades k-6
School Characteristics	
pctwfare	Percent of students who are "members of families whose primary means of support is a public welfare program," values based on categorical variable
pwelgt81	Indicator for at least 81 percent of students who are "members of families…"
pmin	Percent of students who are American Indian, black, or Hispanic
pmingt80	Indicator for at least 80 percent of students being American Indian, black, or Hispanic
District Characteristics	
masal	Predicted salary for a teacher with a master's degree and 10 years teaching experience, for each district-year
Region Variables	
monroe	Indicator for teaching in Monroe county (which includes Rochester)
erie	Indicator for teaching in Erie county (which includes Buffalo)
onondaga	Indicator for teaching in Onondaga county (which includes Syracuse)

Table 2: Summary Statistics

	Women				Men			
All Teacher-Years								
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
masal	13.02	1.41	9.43	17.27	12.87	1.36	9.43	17.27
advdeg	0.53	0.50	0.00	1.00	0.46	0.50	0.00	1.00
crtreg	0.91	0.29	0.00	1.00	0.90	0.30	0.00	1.00
mthscihs	0.09	0.29	0.00	1.00	0.19	0.39	0.00	1.00
othhs	0.27	0.45	0.00	1.00	0.45	0.50	0.00	1.00
elemtch	0.62	0.49	0.00	1.00	0.34	0.47	0.00	1.00
pctwfare	0.26	0.29	0.00	0.95	0.26	0.28	0.00	0.95
pwelgt81	0.08	0.28	0.00	1.00	0.07	0.26	0.00	1.00
pmin	0.23	0.30	0.00	1.00	0.24	0.31	0.00	1.00
pmingt80	0.08	0.27	0.00	1.00	0.08	0.27	0.00	1.00
monroe	0.39	0.49	0.00	1.00	0.40	0.49	0.00	1.00
erie	0.35	0.48	0.00	1.00	0.36	0.48	0.00	1.00
onondaga	0.26	0.44	0.00	1.00	0.24	0.43	0.00	1.00
Observations	11,586				3,957			
First Year of Teacher Spell								
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
masal	13.74	1.68	9.43	17.27	13.46	1.65	11.31	17.27
advdeg	0.29	0.45	0.00	1.00	0.21	0.41	0.00	1.00
crtreg	0.84	0.37	0.00	1.00	0.85	0.36	0.00	1.00
mthscihs	0.10	0.30	0.00	1.00	0.19	0.39	0.00	1.00
othhs	0.31	0.46	0.00	1.00	0.46	0.50	0.00	1.00
elemtch	0.57	0.50	0.00	1.00	0.32	0.47	0.00	1.00
pctwfare	0.24	0.28	0.00	0.95	0.22	0.26	0.00	0.95
pwelgt81	0.07	0.25	0.00	1.00	0.06	0.24	0.00	1.00
pmin	0.22	0.30	0.00	1.00	0.21	0.29	0.00	1.00
pmingt80	0.07	0.26	0.00	1.00	0.07	0.26	0.00	1.00
monroe	0.41	0.49	0.00	1.00	0.42	0.49	0.00	1.00
erie	0.34	0.47	0.00	1.00	0.34	0.47	0.00	1.00
onondaga	0.25	0.43	0.00	1.00	0.25	0.43	0.00	1.00
Observations	2,413				869			

Figure 3. Hazards of Leaving District – Women Only

Figure 4. Hazards of Leaving District – Men Only

Figure 5. Hazards of Leaving District – Women Only

Figure 6. Hazards of Leaving District – Men Only

Figure 7. Hazards of Leaving District – Women Only

Figure 8. Hazards of Leaving District – Men Only