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Teacher salaries and teacher attrition

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Abstract

This paper examines teacher labor mobility within and out of the teaching profession. Previous studies of teacher mobility treat attrition as a binary choice where inter-district transfers are grouped with stayers or exits. Either case ignores the possibility that transfer attrition may be influenced by different factors than exit attrition. Using data for new teachers in Wisconsin, I estimate separate hazard rates for transfers and exits. Transfers are found to respond most strongly when district salaries are increased relative to nearby districts. Salary increases for more experienced teachers may also reduce exit attrition among newer female teachers. Simulations suggest that fairly large salary increases are needed to reduce attrition out of Milwaukee down to the levels experienced by the average Wisconsin district.

JEL classifications: I22; J45

Keywords: Teacher salaries; Human capital

1. Introduction

Each fall, shortages of elementary and secondary-school teachers make headlines across the country as districts scramble to fill vacancies created by increasing student enrollments, a wave of retiring baby-boom teachers, and class-size reduction policies. These shortages can have serious consequences for the quality of education that students receive and have prompted a number of policy proposals designed to attract and retain teachers. The most common proposal is to increase salaries, particularly in high-need subjects or districts. To shed light on the likely effectiveness of such policies, this paper examines the determinants of teacher mobility between districts and exits out of the teaching profession. Specifically, a competing risks duration model is used to explore the influence of teacher and district characteristics, including various measures of salary, on the duration of time spent in a district and the reasons for leaving. The results are then used to simulate the effect of salary increases on teachers' mobility decisions.

Separating transferring teachers and exiting teachers can add important insights for policymakers. If these differences are small, policymakers can have more confidence in state-wide policies that affect all districts in similar ways. On the other hand, if inter-district transfers look significantly different from exits, then policymakers may want to consider different policies for districts that have relatively higher transfer attrition than exit attrition.[1] The empirical work suggests that exit attrition and transfer attrition *are* influenced by

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[1]Throughout the paper, I use 'transfer attrition' or simply 'transfers' to refer to teacher exits from a district that are due to transfers to another district. I use 'exit attrition' or 'exits' to refer to teachers that leave the teaching profession entirely.

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Table 1
Attrition of 1992–93 entering cohort, by urban category

	Number of districts	Total number of teachers	Stay in same district (%)	Exit teaching (%)	Student characteristics			
					Transfer (%)	Poor (%)	Non-white (%)	Enrollment
Milwaukee	1	122	29.5	61.5	9.0	71.1	71.4	94,300
Other cities	17	179	46.3	40.5	13.2	25.3	15.6	12,638
Suburbs	36	126	41.3	46.2	12.5	10.3	10.4	3109
Towns	133	357	63.8	28.5	7.8	18.1	3.7	2141
Rural	235	391	48.5	32.4	19.0	25.1	4.8	957
Total	422	1175	53.11	34.55	12.34	21.5	5.7	2399

Full-time teachers only.

different factors and may respond differently to salary increases. Specifically, separating transfers and exits highlights the role of alternative wages within the profession; the results here suggest that among women, transfers respond most strongly to increases in wages when such a raise increases district salaries relative to nearby districts. This gives policymakers warning that wage increases across all districts, that do not change relative wages, could have little direct effect on female transfer attrition rates. Since transfer rates are found to be higher than exit rates for teachers of math and science, these salary results could be particularly important for districts trying to retain teachers in these high-need fields. However, at the same time, higher relative wages may make it more likely that a teacher who leaves a particular district will exit teaching altogether. How these transfer and exit effects interact will depend on the district's ratio of men and women, and other characteristics of the teaching force.

In addition, it is found that salary increases for more experienced teachers, rather than just for beginning teachers, may also reduce exit attrition among new female teachers. It is often assumed that salary increases for veteran teachers are simply union rents and have little impact on the quality of the teaching force. This paper is the first to present evidence that higher salaries for experienced teachers may play some role in retention of less experienced teachers.

2. Background and related research

In a recent report, the National Commission on Teaching and America's Future (NCTAF, 2003) states, "If we know that high quality teaching makes a difference, why isn't every child in America getting it? The conventional wisdom is that we lack enough good teachers. But the conventional wisdom is wrong. *The real school staffing problem is teacher retention* (emphasis in original)." (NCTAF, 2003, p. 6). The report goes on to point out that there has been an increasing number of teachers entering the teaching force each year of the last decade, but the rate of attrition has simply been higher, and less than a third of that attrition is due to retirement.

Turnover rates are particularly high in urban and rural districts that serve the most low-income students. It is believed that this is due partly to the fact that while all districts must worry about losing teachers to other professions, urban and rural districts must also be concerned about losing teachers to jobs in other districts. For example, among the cohort of teachers who began teaching in Wisconsin in 1992–93, those who began their careers in rural districts were much more likely to transfer to another district within their first 6 years than those who began in a suburban district (see Table 1). However, in Milwaukee, the transfer rate is lower than in the suburbs, though the exit rate is significantly higher so that only 30% of the 1992–93 cohort is still teaching in Milwaukee after 6 years.[2]

This turnover can have serious repercussions for the quality of education received by students in these districts since urban districts are more likely to fill vacancies by simply increasing class size, or by hiring substitute teachers or teachers that principals identify as "less than qualified" (US Department of Education, NCES, 1997b). Inter-district mobility affects the distribution of teacher experience across districts, often with experienced teachers moving from urban and rural

[2]It should also be kept in mind that the focus in this paper is on attrition *rates*, but rates may translate into very different *levels* for various districts. In particular, because Milwaukee is four times as large as the next largest district in Wisconsin, attrition rates that look lower than other districts may still imply that Milwaukee is losing higher *numbers* of teachers.

Table 2
Sources of new full-time hires, 1992–98, by urban category

	Number of districts	Full-time teachers who are new hires (%)	New hires with no experience (%)	New hires with some experience (%)
Milwaukee	1	8.9	99.7	0.3
Other cities	17	5.4	59.9	40.1
Suburbs	36	5.8	51.6	48.4
Towns	133	6.4	58.0	42.0
Rural	235	6.9	59.5	40.5

districts to suburban districts (e.g., Loeb, 2000). Almost none of the new teachers hired by Milwaukee in the early 1990s were experienced teachers, while almost half of the new hires in suburban districts were experienced teachers transferring from other districts (see Table 2). Given that surveys of educational production function research (e.g., Hanushek (1986); Greenwald, Hedges and Laine (1996)) find teacher experience to be one of the few characteristics that is fairly consistent in holding a positive correlation with student performance,[3] high rates of teacher mobility may be associated with lower student achievement in the urban and rural districts that have the most inexperienced teachers.

Because teacher mobility raises issues about educational quality, several studies have analyzed non-retirement exits out of teaching.[4] In these studies, attrition is viewed from the perspective of the profession and all teachers who remain in teaching, regardless of whether they remain in the same district or switch districts, are contrasted with those who leave teaching.[5] While this perspective is useful for state or federal policymakers concerned with retaining teachers overall, it is likely to be less useful for specific districts that lose many teachers to other districts. There is little empirical evidence on the reasons why teachers transfer districts and how to reduce the number of these transfers. The small number of studies that do examine attrition from the perspective of the district (see Mont & Rees, 1996; Theobald, 1990) group transfers with exits so that all teachers who leave a given district are contrasted with those who stay. This approach assumes that transfers and exits have the same preferences and characteristics. Yet surveys of departing teachers suggest that this is not the case.[6] Thus, one objective of this paper is to explore the validity of this assumption.

Theobald and Gritz (1996) is the only recent study to discuss transfer and exit attrition separately, and they find some important differences in how transfers and exits respond to salary changes. However, their procedure still essentially treats attrition from a given district as a binary choice in that they estimate the overall probability that a teacher will leave a district and then, in a separate stage, estimate the probability that a teacher will transfer or exit the profession, conditional on leaving the district. This procedure assumes that the decision to transfer or exit is independent of the decision to leave a district. Although this assumption is not entirely implausible, one could also imagine that these decisions are made jointly, or in a different order (e.g., a teacher decides whether to stay in the profession or not and then decides to stay or leave the district, conditional on remaining in the profession). In this paper, the decisions are treated as inter-related and estimated jointly.

3. Empirical strategy

A common way to represent voluntary teacher attrition is with a utility model in which an individual teacher i evaluates her utility in each period t from three alternatives, $j = 1, 2, 3$: teaching in her current district, teaching in another district, and not teaching. Utility is a function of the monetary and non-monetary attributes

[3]Though Murnane and Phillips (1981) also point out that this relationship may be non-linear.

[4]See Dolton and van der Klaauw (1994), Baugh and Stone (1982), Rickman and Parker (1990) for analyses focusing on the salary differential between teaching alternative occupations. Murnane and Olsen (1989, 1990), Grissmer and Kirby (1992), Bempah, Kaylen, Osburn, and Birkenholz (1994), and Kirby et al.(1999) Kirby, Naftel, and Berends (1999) focus on the influence of teacher and district characteristics.

[5]Dolton and van der Klaauw (1994) use a competing risks duration model to differentiate between reasons for leaving the profession, so those who exit are further divided into those who leave for another job and those who leave the labor force entirely; however, they still group transfers together with stayers.

[6]For example, a survey by the Wisconsin Education Association Council found that teachers who are interested in leaving the profession are more likely to cite inadequate income as their primary reason for leaving, while teachers who are considering transferring often state that working conditions are their chief concern (Allen and Helming, 1992).

of a particular job:

$$U_{ijt} = U(W_{ijt}, X_{ijt}) \quad (1)$$

here, W_{ijt} represents teacher i's expected wages, from alternative j at time t. X_{ijt} represents the non-pecuniary attributes of alternative j at time t, such as working conditions, the geographic location, the kind of students in a district, etc. X_{ijt} may also include characteristics of the teacher that influence how she evaluates utility from job attributes, such as her age, marital and family status or education level. Teachers are assumed to maximize their utility subject to the costs of each alternative and voluntary mobility occurs whenever the net expected utility from one alternative exceeds the net expected utility from the current state.[7]

Most empirical studies of teacher attrition build on this behavioral framework. Eq. (1) is expanded to posit a random utility model with two alternatives (i.e., stay or leave the district, or stay or leave the profession) and the probability of attrition is estimated using traditional binary limited dependent variable techniques (that is, logit or probit models). As discussed earlier, these models fail to distinguish between the influence of variables on transfers and exits separately. In this paper, the probability that a teacher transfers districts or leaves teaching entirely is estimated with a competing risks duration model that allows the probability of transition between districts to be estimated separately from the probability of an exit out of teaching.

Duration models estimate the conditional probability that a teacher leaves her original district, given that she has not left prior to the year under investigation. This is represented in the most general form by the hazard function for exits from a district, $\lambda(t)$. The competing risks model further distinguishes exits to another district (D) and exits out of the profession (E) by specifying a separate transition intensity for each type of exit, $\lambda_D(t)$ and $\lambda_E(t)$. The total hazard of leaving a district is thus the sum of the transition intensities. For estimation, I assume that λ_D and λ_E take the form of Cox' proportional hazard, which allows the inclusion of time-varying district and teacher characteristics, denoted by the vector X_{it}. The state-specific transitions are thus specified as

$$\lambda_{ij}(t|X_{ijt}) = h_j(t)\exp(X'_{ijt}\beta_j), \quad j = D, E, \quad (2)$$

where $h_j(t)$ is the baseline hazard function for state j. The Cox specification does not assume any particular form for the baseline hazard but does assume that the independent variables have the same proportional effect on the hazard rate over the duration of the spell. That is, a one-unit increase in a variable X increases the baseline hazard by $\exp(\beta)$ and this shift is assumed to be the same in very period. This is a fairly strong assumption and is discussed in more detail below.

The Cox proportional hazard model has been used in a small number of other teacher attrition studies. Grissmer and Kirby (1992) and Kirby, Naftel and Berends (1999) use the single-risk model to analyze exit attrition in Illinois and Texas, respectively, while Dolton and van der Klaauw (1994) and Stinebrickner (2002) use the competing risk model to estimate hazards for teachers who leave the profession (i.e., exits are divided into those who take a job in a different field and those who leave the labor force entirely). In each case, higher salaries are significantly related to longer spells in teaching (although, since transfers are grouped with stayers, teaching spells are not all necessarily in the same district). In the Results section, I present estimates from two binary-choice models and contrast them with the results from the competing risks model.

4. Data

The model is estimated with data on teachers in Wisconsin from the Wisconsin Department of Public Instruction (DPI). The DPI compiles an annual dataset of all teachers and staff in the public school system, collected on the third Friday in September. The base sample includes anyone who became a full-time teacher in a public school in Wisconsin between the 1992–93 school year and 1997–98, and follows them for as long as they are in the Wisconsin system, or until 1998–99. Only teachers who begin their first teaching spell in or after 1992–93 are used. Although this does not address attrition among a large percentage of the teaching force, it does capture those individuals who are most mobile. For example, among all transfers in Wisconsin, roughly half occur in the first 2 years of the career, and over three-quarters occur in the first 5 years. The DPI data include information on each teacher's gender, race, age, education level and year of degree, years of local (within district) and total experience, full-time equivalency, subject assignment, grade levels taught and salary.

Teachers are defined as 'exits' as soon as they leave the Wisconsin public school system and are defined as 'transfers' as soon as they leave their beginning district

[7] This behavioral framework implicitly assumes that all observed mobility is a result of a teacher's utility-maximizing choice; however, some attrition is surely involuntary. Ideally, the model would incorporate this possibility, but in the administrative data used for most mobility studies, it is rarely revealed whether a job separation is voluntary or involuntary. Thus, teacher attrition is almost always estimated in a reduced-form framework. It can be argued that since involuntary separations comprise a relatively small portion of teacher attrition, particularly for the time period in Wisconsin covered by these data, reduced-form estimation is still likely to reveal useful results.

to teach in another district in Wisconsin.[8] It would also be interesting to examine teacher transfers across schools within districts. However, because the primary focus of this paper is on the effects of salary on teacher mobility, and salaries are set at the district level with little variation across schools, I restrict my definition of transfers to transfers between districts. The focus here is on *annual* attrition and the model specifically estimates the probability that a teacher's *first spell in teaching* will end in a given period. Although some of these departing teachers do return to teaching in the future (for example, they are taking a short time off for maternity), from the perspective of the district, these exits still create teaching positions that must be filled in the next year.[9,10] It should also be noted that the data contain no information on where teachers go when they leave the Wisconsin public school system. It is possible that some individuals labeled as exits are continuing to teach in the private sector or another state and are, therefore, actually transfers. An alternative approach would be to treat *all* these teachers as transfers and this would generate a binary model (i.e., stay or transfer). Thus, the estimates from the binary-choice model of stay or leave the district could be considered an outer bound on the behavior of these teachers.

Among teachers who began teaching in Wisconsin between 1992–93 and 1997–98, the unconditional exit rate is higher than for inter-district transfers at all durations, and women are more likely to exit than men, though less likely to transfer. Fig. 1 shows the empirical Kaplan–Meier survivor functions for all new teachers, 1992–93 to 1997–98.[11] Although some of this attrition is possibly involuntary (particularly after the first 2 or 3 probationary years), the 1990s were a time of high teacher demand in Wisconsin. There were very few wide-scale layoffs during this time and many districts experienced shortages, particularly in fields such as science and special education (Lauritzen, 1998). Thus, attrition (either exit or transfer) was more likely to be a teacher's choice.[12]

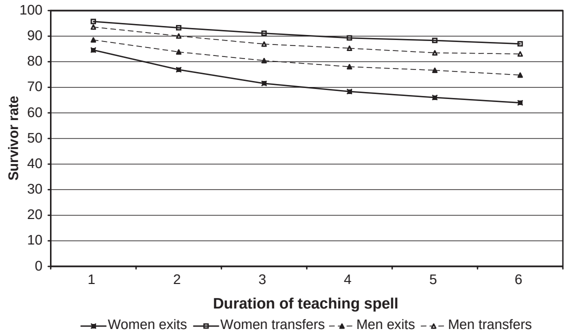

Fig. 1. Kaplan–Meier survivor functions new teachers 1992–93 to 1997–98.

5. Specific determinants of attrition

Summary statistics for the variables used in estimation are presented in Table 3. Previous empirical work on attrition suggests several teacher characteristics that should be included, such as gender (Stinebrickner, 1998), race (Antos & Rosen, 1975), and educational attainment (Greenberg & McCall, 1974; Theobald, 1990). Murnane and Olsen (1989, 1990) determined that subject specialty is also an important influence on teacher attrition and I include indicators for whether an individual teaches math or science or in a special education program. Murnane and Olsen (1989) also found that individuals who begin teaching after age 30 have longer spells in teaching and I include an indicator variable for this as well.

Changes in family or marital status might also be expected to affect attrition as teachers may leave in order to have children or because a spouse needs to

[8]Among full-time teachers who began teaching between 1992–93 and 1997–98, fewer than 30 had left teaching for administrative positions before 1998–99 and these individuals have been excluded from the sample. The most appropriate way to treat these individuals would be to include movement to a different education sector as a separate exit alternative; however, the small number of these observations makes such estimation impossible with these data.

[9]See Grissmer and Kirby (1992) for a fuller discussion of annual vs. permanent attrition.

[10]Individuals who leave for a period of one or more years and then return to the same district are considered exits when their first spell ends. If they return to the system but are teaching in a different district, they are considered transfers. Note that this may create upward bias in the exit count among later cohorts; since I cannot observe whether they return to the system after my sample ends, they will be counted as exits, though they may return to a different district and should therefore be considered transfers. Cohort effects are included to try and capture some of this bias. In addition, the number of individuals with gaps in service is fairly small (from 25 in the 1992–93 entering cohort to eight in the 1996–97 cohort).

[11]It is important to point out that the longest spell in the sample is 6 years whereas many districts in Wisconsin allow a teacher to carry up to 7 years of tenure with her when moving to a new district. It is likely that in response to these carryover rules, the hazard for transfers after 7 years looks more similar to exits. However, the results here could also then be interpreted as indicating what mobility behavior might look like if these carryover rules were relaxed further.

[12]Nationally, results from the Schools and Staffing Survey suggest that only 3.2% of teachers who left the teaching in profession in 1994 were involuntary exits (US Department of Education, NCES, 1997a).

Table 3
Summary statistics, new (Wisconsin teachers, 1992–93 to 1997–98)

		Women		Men	
Total teaching spells		6319		2619	
Spells ending with exit		1658		455	
Spells ending with transfer		529		322	
Number of teaching years[a]		19118		8168	
		Mean	Std	Mean	Std
Time-invariant teacher characteristics					
Race	1 = non-white	0.05	0.22	0.05	0.21
Advanced degree	1 = advanced degree beyond bachelor's	0.06	0.23	0.07	0.25
Entry age	1 = entered teaching after age 30	0.25	0.43	0.24	0.43
Time-invariant district characteristics					
Milwaukee		0.18	0.39	0.14	0.35
Rural		0.25	0.43	0.31	0.46
Cost of living index		100	4.12	100	4.03
Time-varying teacher characteristics					
Math	1 = teaches math or science course	0.09	0.29	0.23	0.42
Special education	1 = teaches special education	0.21	0.4	0.11	0.32
Elementary	1 = teaches grade preK-6	0.54	0.5	0.22	0.41
High school	1 = teaches grade 9–12	0.17	0.38	0.39	0.49
Time-varying student characteristics					
Poor	% students eligible for free and reduced price lunch program	29.20%	23	27.60%	21
Nonwhite	% students non-white	19.70%	27	16.40%	25
Nonwhite teacher × nonwhite students		3.10%	14.9	2.60%	13.6
Enrollment		20318	35607	16336.6	32223
Time-varying district characteristics					
Unemployment rate		4.06%	1.3	4.10%	1.3
Total spending per pupil	$1,992	$5638	716	$5608	693
Instructional spending	$1992	$3576	451	$3544	431
Salary data					
Teacher salary		$25,048.97	3349	$25,452.84	3468
Relative wage ratio	% of average salary in region[b]	104.4	10.5	106.3	10.88
MA + 10 years benchmark	$1992	$35,081.80	2796	$34,835.55	2890
Relative MA + 10 benchmark ratio	% average MA + 10 in region	103.1	7.16	102.9	7.52
Average county earnings in service industries	$1992	$19,293	3729	$18,837	3790

Source: Wisconsin Department of Public Instruction.
[a]Means of time-varying variables taken over all years.
[b]Regional average weighted by vacancies in a teacher's subject.

relocate. Stinebrickner (1998) finds that women are much more likely than men to leave teaching because of personal and family reasons. Unfortunately, the DPI data contain no information about teacher marital or family status. In an effort to minimize this problem, hazards for men and women are estimated separately.[13]

[13]As a further check that estimation should be separated by gender, the model was estimated using the full sample of both

Annual data on student and district characteristics, also provided by the DPI, have been attached to the teacher data. These include the racial composition of the student body, the percent of poor students (proxied by the percent eligible for the federal free and reduced price lunch program), and total enrollment. Other attrition studies have focused on the role of district financial characteristics such as total spending, and patterns of spending (Theobald & Gritz, 1996). I include total per-pupil spending as well as total instructional spending (in 1992 dollars).[14]

Several variables are included to describe the district environment: the annual county unemployment rate, a cost-of-living index, and an indicator for whether the district is in a rural area. The cost-of-living index is from McMahon (1996) and is based on district-level data from the 1990 census (and therefore does not change over the time period of the sample). A dummy variable is also included for Milwaukee, a district whose size, urban environment, and educational programs make it unique in Wisconsin.

Of primary interest is the effect of wages on teacher attrition. All salary variables are deflated to 1992 dollars using the Consumer Price Index.[15] In addition to the log of a teacher's own salary in each year, four other variables are included. First, to capture opportunity costs outside of teaching, I include the log of annual county-level per-capita earnings, available from the Regional Economic Information System of the Bureau of Economic Analysis.[16] To better approximate the opportunity costs for teachers in particular, I restrict this measure to average earnings for service industries only. The second wage variable is the log-salary earned by teachers with a Master's degree and ten years of experience in the district. Theory suggests that in making their mobility decisions, teachers consider not only their current wages but their *expected* wages. In teaching, more so than in many other professions, the trajectory of future wages is well-known to all workers, because district salary schedules set out salaries for all education and experience levels. However, no other studies of teacher mobility have attempted to account for these expectations. The MA + 10 benchmark of the salary schedule gives teachers some indication of what they can expect to earn if they stay in the district and thus serves as a proxy for a teacher's expectations of future earnings.[17,18] Furthermore, work by Lankford and Wyckoff (1997) shows that the majority of teacher salary increases over the last few decades have gone to experienced teachers at the top of the salary schedule. It is assumed that such increases do little to improve the quality of the teaching force because they matter little to those considering entering the profession or to teachers at the beginning of their careers (or at least, they are assumed to matter considerably less than increases in beginning salaries). While this assumption seems plausible, very little empirical work has addressed this issue. It is worthwhile to learn more about the actual impact of experienced teacher salaries on retention of beginning teachers.

Finally, two measure of a teacher's relative wage within the teaching profession are also included in the model. Many studies of teacher mobility have considered the wage differential between teaching and other professions (see, for example, Baugh & Stone, 1982, or Rickman & Parker, 1990). However, teachers who intend to stay in the profession are likely to be just as interested in the wage differential between their current district and other districts. Theobald and Gritz (1996) attempt to account for this by including the average salary that a teacher would earn in all other districts in the state. However, because of the high transaction costs associated with moving to a new community, teachers who transfer are likely to first consider districts within commuting distance of their original position. I therefore construct relative wage variables for a smaller geographic region. For certain administrative purposes, Wisconsin is divided into 12 cooperative educational service agencies (CESAs).[19] Between 30% and 40% of all inter-district transfers are within the same CESA; that increases to 75% when adjacent CESAs are included. Therefore, I calculate a teacher's relative salary as the ratio of his or her own salary to the average salary earned by teachers with the same level of education and experience within each teacher's CESA

(*footnote continued*)
men and women, with interaction terms for each variable with gender. Although not all of the interaction terms are statistically different from zero, many are individually statistically significant and I can reject the null hypothesis that the interaction terms, as a group, are equal to zero. This supports the basic intuition that it is appropriate to estimate separate models for men and women.

[14]Instructional spending includes spending on teacher salaries, materials, and teacher support such as training and curriculum development.

[15]The results do not change if wages and spending are deflated with a more regional CPI for the Midwest.

[16]Available at http://www.bea.doc.gov/bea/regional/reis/

[17]A more complete measure of expected wages would involve assumptions about discount rates, expectations about future employment, etc. However, it seems reasonable to assume that the salary benchmark captures much of the relevant information without the additional complications.

[18]An alternative measure of future wages could be the maximum salary paid in the district. However, because there can be differences across districts in the amount of time it takes to reach that maximum, I use the more standardized MA + 10 benchmark. Using the schedule maximum does not change the results reported in the next section.

[19]Each CESA covers five to six counties, and range from 18 districts to 75 districts.

and adjacent CESAs. Because salaries in other districts are only likely to matter if a teacher actually has the opportunity to move, the average wages in these other districts are also weighted by vacancies in the teacher's subject of specialty. I compute a similar relative CESA wage ratio measure for the MA + 10 benchmark.[20]

6. Results

Tables 4 and 5 report the results of the hazard estimation for women and men. Each of the tables shows the hazard ratios, calculated as $\exp(\beta)$, where β is the estimated coefficient from Eq. (2). In most cases, the hazard ratio is easily interpreted as the relative shift in the hazard rate that is associated with a one-unit change in the variable. For example, in column 1 of Table 4, the hazard ratio for a female teacher who teaches special education is 1.065, indicating that her probability of leaving is 6.5% higher than a teacher in the omitted category. Similarly, a one percentage point increase in the percent of low-income students will decrease attrition by less than 1% (hazard ratio = 0.998) and a $100 increase in per-pupil spending will increase attrition by 5.6% (hazard ratio = 1.056). In general, a hazard ratio greater than one implies an increased probability of attrition while a ratio less than one implies a decreased probability. For the salary variables, which are measured in logs, the hazard ratios are not as easily interpretable. For these variables, the coefficient itself, β, may be preferred as it represents the elasticity of the hazard rate with respect to a percentage increase in the wage. These coefficients are reported as well. All models also include cohort and year effects.

7. Binary-choice models

For comparison with the models commonly found in the literature, Table 4 first presents the binary-choice models. Columns 1–4 report the probability that a teacher leaves the Wisconsin public school system so transfers are grouped with stayers. In columns 5–8, the dependent variable is whether or not a teacher leaves her or his particular district so transfers are grouped with exits. The results are quite similar for these two models and generally mirror the results found in other attrition studies. For example, female teachers are less likely to leave if they teach at the elementary level or began teaching at an older age, but they are more likely to leave if they have an advanced degree or teach in larger districts. Teaching special education also increases attrition in the second specification. Race is a factor in that non-white women are more likely to leave in general, but this effect is dampened if they teach larger proportions of non-white students. Women appear *less* likely to leave Milwaukee, however, given Milwaukee's size, this could be simply offsetting higher attrition associated with higher enrollment. Higher instructional spending can reduce female attrition while higher per-pupil spending increases attrition; higher non-instructional spending could reflect reduced resources for teachers, or inefficiency in administration, either of which would increase a teacher's desire to leave. Finally, higher salary levels, both for beginning and experienced teachers, are associated with lower attrition; however, higher salaries *relative* to surrounding districts appear to increase attrition out of the profession.

Among men, there are fewer results that are statistically significant, however, the salary results are the same. Race appears to play a larger role for men, with white male teachers significantly more likely to leave as the proportion of non-white students increases. In contrast to women, men who begin teaching when they are older are *more* likely to leave (in the first specification).

It is also interesting to point out a few of the common results in the literature that are *not* supported by the Wisconsin data. Teaching math or science does not have a statistically significant effect on the attrition rate, nor does teaching high school, or being in a district with larger numbers of low-income students. Among men, district size and spending also have no effect.[21]

8. Competing risk model

Since these models could mask differences between teachers who are transferring between districts and those who are leaving the profession altogether, Table 5 reports the results from the competing risk model where transfers and exits are separated. It is clear that, in these data, the behavior of exiting teachers dominates the results in the binary models. When examined separately, the hazard ratios for exits are extremely similar to the binary models and all of the results discussed above still hold. However, the competing risk model uncovers several noteworthy differences between exits and transfers.

[20] Since it represents a future wage, the MA10 relative benchmark used in the estimates presented in the next section is not weighted by vacancies. However, the results do not change if a weighted measure is used instead.

[21] As mentioned in the previous section, the sample sizes for men are much smaller than for women and the models are therefore estimated with less precision. This should be kept in mind in reviewing the results.

Table 4
Single-risk (binary attrition choice) hazard model estimates

	Stay/leave profession				Stay/leave district			
	Women		Men		Women		Men	
	Hazard ratio	β	Hazard ratio	β	Hazard ratio	β	Hazard ratio	β
Wages								
Teacher salary (log)	0.318***	−1.144***	0.066***	−2.725***	0.396***	−0.926***	0.165***	−1.804***
	[5.99]	[5.99]	[5.58]	[5.58]	[3.59]	[3.59]	[3.37]	[3.37]
Relative wage ratio	1.012***		1.027***		1.004		1.011	
	[3.00]		[3.40]		[0.95]		[1.48]	
MA + 10 benchmark	0.021***	−3.846***	0.016**	−4.130**	0.015***	−4.229***	0.016***	−4.113***
	[3.71]	[3.71]	[2.03]	[2.03]	[4.88]	[4.88]	[2.82]	[2.82]
Relative MA + 10 ratio	1.030***		1.02		1.032***		1.021	
	[2.86]		[0.99]		[3.59]		[1.49]	
Avg county earnings (log)	1	0	1.151	0.141	1.059	0.058	1.198	0.181
	[0.00]	[0.00]	[0.38]	[0.38]	[0.34]	[0.34]	[0.68]	[0.68]
Teacher characteristics								
Race (1 = non-white)	2.174***		2.814**		1.895***		2.186***	
	[3.89]		[2.93]		[3.43]		[2.89]	
Advanced degree	1.269***		1.348		1.181**		1.298*	
	[2.59]		[1.71]		[1.97]		[1.89]	
Entry age (1 = enter after age 30)	0.633***		1.286**		0.633***		1.077	
	[7.10]		[2.24]		[8.27]		[0.88]	
Math (1 = teaches math or science)	1.001		0.86		1.097		0.982	
	[0.01]		[1.27]		[1.37]		[0.22]	
Special ed	1.065		1.098		1.219***		1.164	
	[1.12]		[0.67]		[4.19]		[1.46]	
Elementary	0.828***		0.823		0.802***		0.747***	
	[3.50]		[1.46]		[4.79]		[2.81]	
High school	0.912		1.14		1.009		1.145*	
	[1.31]		[1.28]		[0.15]		[1.80]	
District characteristics								
Milwaukee	0.130***		0.311		0.341**		2.7	
	[3.74]		[0.85]		[2.12]		[0.84]	
Rural	0.999		1.165		1.063		1.055	
	[0.02]		[1.20]		[1.12]		[0.59]	
Cost of living index	1.007		0.999		0.999		0.992	
	[0.83]		[0.08]		[0.07]		[0.56]	
Unemployment rate	1		1.004		1.001		1.044	
	[0.01]		[0.07]		[0.06]		[1.15]	
Total spending ($100)	1.056***		1.039		1.050***		1.013	
	[4.47]		[1.83]		[4.86]		[0.83]	
Instructional spending ($100)	0.935***		0.944		0.942***		0.963	
	[3.50]		[1.65]		[3.79]		[1.45]	
Student characteristics								
% Poor students	0.998		0.99		0.997		0.991	
	[0.47]		[1.90]		[1.09]		[1.77]	
% Non-white students	1		1.014**		1.001		1.015***	
	[0.03]		[2.56]		[0.28]		[3.17]	
Non-white teacher × non-white students	0.985***		0.987**		0.985***		0.987***	
	[4.34]		[2.15]		[4.71]		[2.64]	

Table 4 (*continued*)

	Stay/leave profession				Stay/leave district			
	Women		Men		Women		Men	
	Hazard ratio	β	Hazard ratio	β	Hazard ratio	β	Hazard ratio	β
District enrollment (100)	1.003*** [4.35]		1.002 [0.98]		1.002*** [3.00]		0.999 [0.81]	

Absolute value of robust *z*-statistics in parentheses.
**Significant at 5%; ***Significant at 1%.

8.1. Wage effects

Of primary policy interest is the effect of wages on teacher mobility. The competing risk model makes it clear that wages influence transfers and exits in different ways since, for both men and women, increasing salary levels reduces exits but has no statistically significant effect on transfers. However, female transfers do respond to the *relative* level of wages.[22] This suggests that if policymakers were to increase the level of wages across the state, it could help decrease the number of beginning teachers who leave the profession, but have little impact on transfers.[23] To reduce female transfers, salary increases need to be targeted to specific districts, so that wages are competitive with surrounding districts. This makes intuitive sense—if an individual intends to stay in the teaching profession, she is likely to care less about her salary relative to outside options and more about her salary relative to other teaching positions. But increasing the relative wage is also correlated with higher *exit* attrition (for both men and women). This result is similar to that found by Theobald and Gritz (1996) and could perhaps be explained in the following way: A teacher has decided to leave a district where salaries are relatively high, and cannot find another teaching position that pays a comparable salary. She therefore chooses to leave teaching entirely. That is, higher relative salaries may not necessarily increase the probability that a teacher will leave, so much as the probability that she will exit given that she wants to leave anyway. The competing-risk model cannot clearly differentiate these decisions. Another possible explanation is that the higher relative salary reflects a compensating differential for district characteristics that are not fully captured in the model but that lead teachers to want to leave. How the offsetting effects of higher salary *levels* versus higher *relative* wages will balance out for various districts will depend on whether they are more likely to lose teachers through transfers or exits and the ratio of men and women.

Higher salaries for more experienced teachers also reduces attrition, for both exits and female transfers.[24] But higher *relative* salaries for more experienced teachers increases female attrition, for both exits and transfers. Again, it may be that higher relative salaries reflect compensating differentials for factors that are not included in the model.

8.2. District and teacher characteristics

Among female teachers, teaching math and science or special education increases the attrition rate for transfers but has no statistically significant effect on exits. At first glance, this seems at odds with the conventional wisdom that math and science teachers have more opportunities (or could earn higher wages) outside of teaching and that this is one cause of the shortages in these fields. However, if we assume that individuals with math and science skills are less likely to become teachers in the first place, then those that *do* become teachers will be in high demand in the profession overall. They are thus more likely to transfer because they are likely to have more opportunities to make advantageous moves. Given that they are more likely than other teachers to find a job that is a good fit, they may then be less likely to leave the

[22]Higher relative wages also decrease male transfers, however, the coefficient for men is only statistically significant at the 10% level. I therefore focus on the women.

[23]It is important to point out that a decrease in exit rates due to higher salaries would likely have a secondary effect on transfer rates since there would be fewer vacancies for transferring teachers to fill. The partial equilibrium framework of this model only tells us that it is unlikely that salary has any *direct* impact on transfer rates, *ceteris paribus*. All policy conclusions discussed in the remainder of the paper should be considered within this partial equilibrium framework.

[24]Again, the effect for male transfers is negative but only statistically significant at the ten-percent level.

Table 5
Competing risk hazard model estimates

	Transfers				Exits			
	Women		Men		Women		Men	
	Hazard ratio	β	Hazard ratio	β	Hazard ratio	β	Hazard ratio	β
Wages								
Teacher salary (log)	1.037	0.036	1.09	0.086	0.328***	−1.113***	0.074***	−2.610***
	[0.07]	[0.07]	[0.08]	[0.08]	[5.65]	[5.65]	[5.21]	[5.21]
Relative wage ratio	0.973***		0.977		1.011***			
	[3.15]		[1.66]		[2.64]		[3.13]	
MA + 10 benchmark	0.010***	−4.586***	0.015	−4.193	0.016***	−4.119***	0.014**	−4.304**
	[2.62]	[2.62]	[1.86]	[1.86]	[3.95]	[3.95]	[2.09]	[2.09]
Relative MA + 10 ratio	1.036**		1.027		1.032***		1.022	
	[2.00]		[1.25]		[3.04]		[1.08]	
Avg county earnings (log)	1.229	0.206	1.298	0.261	1.012	0.012	1.145	0.135
	[0.59]	[0.59]	[0.59]	[0.59]	[0.06]	[0.06]	[0.37]	[0.37]
Teacher characteristics								
Race (1 = non-white)	0.805		1.48		2.094***		2.831***	
	[0.25]		[0.70]		[3.66]		[2.99]	
Advanced degree	0.867		1.126		1.269***		1.314	
	[0.68]		[0.51]		[2.58]		[1.56]	
Entry age (1 = enter after age 30)	0.640***		0.785		0.625***		1.284**	
	[3.73]		[1.70]		[7.31]		[2.24]	
Math (1 = teaches math or science)	1.334**		1.135		1.022		0.868	
	[2.06]		[0.96]		[0.27]		[1.19]	
Special ed	1.692***		1.245		1.095		1.109	
	[5.27]		[1.22]		[1.61]		[0.74]	
Elementary	0.731***		0.633***		0.819***		0.812	
	[3.10]		[2.58]		[3.70]		[1.56]	
High school	1.278**		1.13		0.929		1.158	
	[2.07]		[1.00]		[1.05]		[1.42]	
District characteristics								
Milwaukee	43.736***		109.422**		0.111***		0.298	
	[2.63]		[2.14]		[3.98]		[0.86]	
Rural	1.215		0.911		0.994		1.178	
	[1.78]		[0.67]		[0.08]		[1.28]	
Cost of living index	0.956**		0.973		1.008		1.002	
	[2.45]		[1.05]		[0.93]		[0.09]	
Unemployment rate	1.008		1.083		0.994		1.001	
	[0.16]		[1.33]		[0.23]		[0.02]	
Total spending ($100s)	1.016		0.975		1.061***		1.039	
	[0.68]		[0.96]		[4.82]		[1.79]	
Instructional spending ($10s)	0.98		0.992		0.931***		0.945	
	[0.57]		[0.18]		[3.73]		[1.61]	
Student characteristics								
% Poor students	0.99		0.995		0.998		0.990	
	[1.63]		[0.52]		[0.44]		[1.82]	
% Non-white students	1.008		1.014		0.999		1.015***	
	[1.26]		[1.54]		[0.15]		[2.61]	
Non-white teacher × non-white students	0.978		0.976		0.986***		0.987**	
	[1.46]		[1.81]		[4.19]		[2.21]	
District enrollment (100s)	0.997**		0.995**		1.003***		1.001	
	[2.19]		[2.12]		[4.56]		[0.93]	

Absolute value of robust *z*-statistics in parentheses.
**Significant at 5%; ***Significant at 1%.

profession. The same may be true for special education teachers who face tougher requirements to become a teacher but are likely to have more options once they enter the teaching force. This suggests that *retention* of math and special education teachers may be more of a district-level problem, while the problem for the profession is one of *recruitment*.

The age at which a teacher enters the teaching profession also significantly affects mobility but in different ways for men and women. Older men appear less likely to transfer but *more* likely to exit teaching altogether. This could be explained by the fact that the older a man is when he begins teaching, the more likely that he acquired schooling or job experience outside of teaching before beginning his teaching career. This would make him more attractive for jobs outside teaching, but not necessarily for other jobs within the teaching profession. On the other hand, if a person is committed to teaching, then all else equal, an older teacher is probably more likely to have roots in a community and be less willing to move. In contrast to men, older women are less likely to leave a district either as transfers or exits. This could reflect a difference in the reasons why men and women delay entry into teaching. For men who begin teaching later in life, the delay is likely to be due to either additional schooling or experience in another occupation, either of which would increase his opportunity costs. While these are viable reasons for women as well, women may also delay entry in order to have children, which would have little impact on their outside opportunities. These results suggest that recent efforts to recruit older, 'second career' individuals into teaching (e.g., Troops to Teachers) could be particularly useful for districts where transfer rates are high but districts should also be aware that these teachers may be more likely to leave for non-teaching positions.

The role of education is also different for transfers and exits, with an advanced degree increasing exit attrition among female teachers and having no impact on transfer attrition. An advanced degree also appears to have no effect on the mobility of male teachers. These results conflict with a few studies that have found that more educated teachers are less likely to exit a district or teaching (Baugh & Stone, 1982; Greenberg & McCall, 1974), however, they use cross-sectional samples of teachers that include all levels of experience. Studies that focus on beginning teachers only are more likely to find no effects (Stinebrickner, 1998; Mont & Rees, 1996). This seems consistent with two different forms of human capital. If an advanced degree represents an investment in occupation-specific skills (such as courses in pedagogy or education-related topics), as is more likely the case for more experienced teachers who obtained their degree after becoming teachers, one would expect exit attrition to be lower among more educated individuals. On the other hand, if a degree is not teaching-specific, as is more likely the case for beginning teachers, one would expect that degree to have a greater impact on a teacher's outside opportunities than within the profession.

Race appears to be more important to exiting teachers than to transfers, with higher exit attrition among white men when there are more non-white students in a district. Non-white teachers, both male and female, have higher exit (but not transfer) attrition but they are less likely to leave when they have more non-white students. These results are consistent with Antos and Rosen (1975) who find that white teachers require a compensating salary differential to teach non-white students, but it is unclear why race matters for exits and not transfers. It should be noted that there is a very small number of non-white teachers in Wisconsin, particularly outside of Milwaukee. Thus, it may be that if a non-white teacher desires to leave her district because she feels isolated, she may find few other districts that are likely to be any better and therefore, simply leaves the profession entirely.

The last district characteristics that I will highlight are district size and the indicator for Milwaukee. It was noted that in the binary models, teacher attrition increased with district size. In the competing risk model, exit attrition still increases with enrollment but transfer attrition decreases. This could reflect the fact that in larger districts with many schools, teachers who want a different school assignment are more likely to find a match with a school in the district, rather than needing to move to a different district altogether. At the same time, it appears that exit attrition is lower, and transfer attrition is higher, out of Milwaukee. But because Milwaukee is so much larger than other districts in Wisconsin, it is important to look at the combined effect of enrollment with Milwaukee.

To see the combined effect of the district and student characteristics more clearly, Fig. 2 shows the survivor functions for an average teacher in four representative districts. The survivor function measures the probability

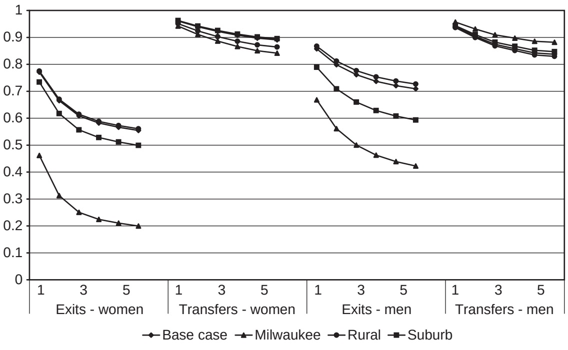

Fig. 2. Simulated survivor functions for Milwaukee, rural, suburban.

that a teacher will still be teaching at each time period (i.e., the probability that she will have 'survived' until time *t*). These simulated survivor functions are calculated using the coefficients in Table 5, with the values of the teacher variables set to those of an average male or female teacher. The base case female teacher is assumed to be a white, elementary-school teacher with a bachelor's degree teaching a non-math subject in a regular education program and who began teaching before age 30. The base case male teacher teaches high school but is otherwise the same as the base case female. The average district is one where the values of the district, student and salary variables are set at the state averages. To calculate the survivor functions for the rural, suburban and Milwaukee districts, the district and student variables take on the average values of those district types while the salary variables are held constant at the state averages.[25]

From the functions in Fig. 2, it is clear that, overall, both men and women exit more quickly than they transfer, and the difference between exit rates and transfer rates is larger for women than for men.[26] All else equal, urban districts like Milwaukee generally lose teachers at the quickest rates. However, male transfer rates out of Milwaukee are slower than most other kinds of districts, and transfer rates in general are much slower than exit rates. This somewhat contradicts the often-heard story that urban districts lose teachers to districts in the more attractive suburbs. Instead, it suggests that high attrition rates out of urban districts (or at least, Milwaukee) may be better explained by teachers simply deciding not to teach.

9. Proportional hazard assumption

As discussed earlier, the Cox proportional hazards model makes the fairly strong assumption that the independent variables have the same proportional effect on the hazard rate over the duration of the spell. Grambsch and Therneau (1994) suggest a way to test the proportional hazard (PH) assumption using the scaled Schoenfeld residuals (see Grambsch & Therneau, 1994; StataCorp, 2003, for details). Using this test, I find that there are several variables that violate the proportional hazard assumption for at least one of the models. Specifically, Entry Age violates the PH assumption in all four models (female exits, female transfers, male exits and male transfers), % Poor Students and Average Country Earnings violate the PH assumption for female exits, % Non-white Students and Special Education violate the assumption for male exits, and Math/Science violates the assumption for male transfers.

If a variable is found to violate the proportional hazard assumption, one of two adjustments can be made. For dichotomous variables, the sample can be stratified into two groups and the baseline hazard allowed to vary across groups.[27] For example, female teachers who begin teaching after the age of thirty have a lower exit attrition rate in every period than teachers who begin teaching before age thirty, but that difference is larger in earlier periods (that is, the hazard over time is flatter for older teachers). Separate baseline hazards for these two groups will reflect this difference.

For continuous variables that violate the proportional hazard assumption, we can interact the variable with the duration period, so the marginal effect is allowed to be different in each period. In some cases, the effect was only significantly different in one or two periods. For example, the residual tests suggested that Average County Earnings violates the PH assumption for female exits. When this variable was interacted with indicators for each period, the coefficients in the first two periods were negative while the coefficients in periods three through six were positive. For the sake of parsimony, in cases where the effect of a variable was clearly different in particular periods, I retained only the interactions with the periods that are statistically significantly different.[28]

Table 6 reports the results from the competing risk models once these adjustments have been made. Only a few of the results discussed above are significantly changed but it is interesting to note how the effect of certain characteristics varies over the duration of a beginning teaching spell. Teaching math or science, which had no effect on male transfers in the previous models, appears to significantly increase transfer attrition at the end of the first year of teaching only. This is consistent with the idea that math and science teachers have more opportunities within the profession but then perhaps stay put once they find a good fit. Teaching special education also affects attrition differently over a teaching spell for men, with male special education teachers more likely to exit teaching in later years. This could reflect teachers 'burning out' from the higher demands associated with teaching special education.

[25]For the simulations, only variables that are statistically significant at the 5% level or higher, for a given subsample, are allowed to vary. For example, district enrollment and the Milwaukee dummy are not statistically significant for male exits so the values of those variables do not vary across the district types in the simulations for male exits.

[26]Also note that although women are less likely to transfer than men, there are also three times as many women in the sample.

[27]The coefficients on the other independent variables are still assumed to be the same for both groups.

[28]I also then re-tested the PH assumption to verify that, once this adjustment was made, the assumption held for all variables.

Table 6
Competing risk hazard model estimates, adjusted for proportional hazard assumption

	Transfers				Exits			
	Women		Men		Women		Men	
	Hazard ratio	β	Hazard ratio	β	Hazard ratio	β	Hazard ratio	β
Wages								
Teacher salary (log)	1.047	0.046	1.454	0.374	0.355***	−1.036***	0.087***	−2.439***
	[0.09]	[0.09]	[0.35]	[0.35]	[6.49]	[6.49]	[4.90]	[4.90]
Relative wage ratio	0.973***		0.974		1.010**		1.024***	
	[3.12]		[1.86]		[2.53]		[2.96]	
MA + 10 benchmark	0.042	−3.172	0.081	−2.517	0.069**	−2.669**	0.066	−2.721
	[1.81]	[1.81]	[1.12]	[1.12]	[2.53]	[2.53]	[1.32]	[1.32]
Relative MA + 10 ratio	1.023		1.013		1.019		1.007	
	[1.29]		[0.60]		[1.74]		[0.36]	
Avg county earnings (log)	1.27	0.239	1.363	0.31	1.57	0.451	1.175	0.161
	[0.69]	[0.69]	[0.70]	[0.70]	[1.53]	[1.53]	[0.44]	[0.44]
Avg county earnings × first 2 years					0.580	−0.544		
					[1.90]	[1.90]		
Teacher characteristics								
Race (1 = non-white)	0.819		1.448		2.149***		2.874***	
	[0.23]		[0.65]		[3.75]		[3.10]	
Advanced degree	0.878		1.073		1.260**		1.297	
	[0.61]		[0.31]		[2.55]		[1.50]	
Entry age (1 = enter after age 30)	0.637***		0.788					
	[3.78]		[1.68]					
Math (1 = teaches math or science)	1.342**		0.875		1.025		0.868	
	[2.11]		[0.73]		[0.30]		[1.21]	
Math × period 1			1.664**					
			[2.10]					
Special ed	1.705***		1.238		1.098		1.039	
	[5.37]		[1.19]		[1.66]		[0.26]	
Special ed × period 5 or 6							4.661***	
							[2.88]	
Elementary	0.735***		0.634***		0.824***		0.818	
	[3.04]		[2.58]		[3.59]		[1.51]	
High school	1.286**		1.137		0.93		1.168	
	[2.13]		[1.05]		[1.04]		[1.51]	
District characteristics								
Milwaukee	64.651***		154.979**		0.145***		0.379	
	[2.83]		[2.26]		[3.38]		[0.67]	
Rural	1.213		0.92		0.993		1.178	
	[1.78]		[0.60]		[0.11]		[1.29]	
Cost of living index	0.953**		0.971		1.006		1.001	
	[2.56]		[1.12]		[0.72]		[0.04]	
Unemployment rate	1.013		1.082		0.995		1.007	
	[0.28]		[1.31]		[0.19]		[0.13]	
Total spending ($100s)	1.015		0.976		1.060***		1.04	
	[0.64]		[0.91]		[4.74]		[1.82]	
Instructional spending ($100s)	0.982		0.989		0.932***		0.943	
	[0.53]		[0.25]		[3.65]		[1.67]	
Student characteristics								
% Poor students	0.992		0.998		0.999		0.992	
	[1.33]		[0.17]		[0.23]		[1.36]	
% Poor students × first 2 years					(1.00)			
					[0.90]			

Table 6 (*continued*)

	Transfers				Exits			
	Women		Men		Women		Men	
	Hazard ratio	β	Hazard ratio	β	Hazard ratio	β	Hazard ratio	β
% Non-white students	1.006 [1.01]		1.011 [1.15]		0.998 [0.56]			
% Non-white students × period 1							1.014** [2.47]	
% Non-white students × period 2							1.011 [1.61]	
% Non-white students × period 3							1.009 [1.09]	
% Non-white students × period 4							1.020** [2.39]	
% Non-white students * period 5							1 [0.02]	
% Non-white students × period 6							1.008 [0.45]	
Non-white teacher × non-white students	0.978 [1.47]		0.976 [1.78]		0.985*** [4.31]		0.987** [2.27]	
District enrollment (100s)	0.996** [2.44]		0.994** [2.24]		1.003*** [3.91]		1.001 [0.70]	

Absolute value of robust *z*-statistics in parentheses.
**Signficant at 5%; ***Significant at 1%.

The percent of low-income students violated the PH assumption for female exits and interaction with duration indicators revealed that the effect of more low-income students was positive in the first 2 years and negative in the last 4 (though it was not statistically significant in any period). Average county earnings also has a different effect in the first 2 years of a teaching spell for women: higher earnings generally increase attrition but have no effect during the first 2 years. Given that the first 2 years are generally probationary (and teachers are given 'tenure' in or after their third year), it is not all that surprising that teachers in these years exhibit different behavior. In the case of male exits and the percent of non-white students, there is no clear pattern over time. The effect is only statistically significant in years 1 and 4 but the proportional hazard assumption was still rejected for the other years and I therefore retained the interaction terms for all six periods.

Although the salary variables themselves do not violate the PH assumption,[29] there was a notable change in the effect of experienced teacher salaries once the other adjustments were made. In the previous models, the MA + 10 benchmark had a large negative effect on exit and female transfer attrition. With the adjustments made for the PH assumption, this variable now has no effect on men at all, while the magnitude of the effect for women is smaller and is only significant for female exits. The somewhat unexpected result from the previous models that higher relative salaries for more experienced teachers increase female attrition, also goes away in this specification. However, it is still puzzling that the MA + 10 benchmark variables have no impact on the mobility decisions of men. One contributing factor may be that men are much more likely, overall, to move into administrative positions at some point in their careers (Brewer, 1996) and therefore may put less weight on future wages in teaching.

10. Policy simulations

The wage results suggest that teachers *are* responsive to changes in salary but the impact of such changes may depend whether they are targeted to a specific district

[29]Although the residual test did not reject the proportional hazard assumption for any of the teacher salary variables, I also interacted each of the salary variables with duration as a further check. In most cases, the coefficients on each of the interaction terms were extremely close in magnitude and not statistically different from each other. This gives further reassurance that the PH assumption is justified for these variables. Results available from the author upon request. It should be noted that in some of the models for male exits and transfers, the small sample size made it very difficult to estimate the salary effects with much precision.

and how they are distributed between beginning and experienced teachers. To illustrate the impact of various wage policies, I use the results of the competing-risk estimation (adjusted for the PH assumption) to simulate the change in the survivor functions for female exits and transfers out of Milwaukee. It is important to point out that although the survivor functions in Fig. 2 were calculated holding wages constant at the levels of the average district, Milwaukee generally offers higher wages than the average district, and higher wages than adjacent districts. On average, Milwaukee's beginning salaries, and relative wages, are roughly one standard deviation higher than in the base case district (ranging from \$3331 more for second-year teachers to \$5038 more for sixth-year teachers), and MA + 10 salaries are slightly under one standard deviation higher (\$2940). The third column in Table 7 shows that when the survivor functions are re-calculated using Milwaukee's actual (higher) wages, the exit rate slows somewhat, and the transfer rate slows enough that Milwaukee's transfer rate is actually lower than in the baseline district.

The rest of Table 7 shows the changes in the survivor functions when \$5000 (roughly 20%, or just over one standard deviation, of current beginning salaries, and roughly fifteen percent, or one and a one half standard deviation, of MA + 10 salaries) is allocated in various ways, on top of current salary levels.[30] Female exits are most responsive when salaries are increased across the state; when raises are targeted to Milwaukee, the increase in relative salary entirely offsets the effect of the increase in the absolute level. Because transfer rates for women are so low, the improvement in transfer rates that comes from higher relative salaries does little to affect overall attrition so changes in overall attrition are clearly dominated by exits.

Increasing salaries for experienced teachers actually has a larger impact on female exits than increasing beginning salaries (either relative or absolute). Although this may seem counter-intuitive, it would be consistent with a model in which teachers consider their entire stream of expected wages. With current wages held constant, higher salaries for more experienced teachers means higher wages over one's entire career (that is, the 'slope' of the salary schedule is steeper). But with experienced salaries held constant, a higher current salary means smaller increases for additional experience (that is, the 'slope' of the salary schedule is flatter). It may therefore not be surprising that the former would be a stronger inducement for teachers to stay than the latter. These results are particularly interesting in light of the work mentioned earlier that has examined increases

[30] Note that since relative beginning salary is the only salary variable that is statistically significant for female transfers, the only simulations that shows a change in the survivor function for transfers are those that affect the relative salary.

Table 7
Survivor functions for Milwaukee: simulations with \$5000 added to salaries

Duration of teaching spell	Base case	Milwaukee-average salary	Milwaukee-actual salary	Raise for all beginning teachers	Raise for beginning teachers in Milwaukee	Raise for all experienced teachers	Raise for experienced teachers in Milwaukee	Raise for all teachers in the state	Raise for all teachers in Milwaukee
Exits									
1	80.01	56.99	64.21	70.34	63.93	74.41	74.41	78.79	74.21
3	59.01	27.46	35.85	43.73	35.21	50.02	50.02	56.81	49.44
5	54.59	23.13	31.20	38.87	30.49	45.32	45.32	52.26	44.65
Transfers									
1	96.73	95.49	97.01	97.01	98.25	97.01	97.01	97.01	98.25
3	92.27	89.44	92.93	92.93	95.84	92.93	92.93	92.93	95.84
5	89.68	85.99	90.54	90.54	94.40	90.54	90.54	90.54	94.40
Total									
1	76.74	52.48	61.22	67.35	62.18	71.42	71.42	75.80	72.46
3	51.28	16.91	28.79	36.66	31.05	42.95	42.95	49.74	45.28
5	44.27	9.12	21.74	29.41	24.88	35.87	35.87	42.80	39.04

in salaries for veteran teachers over the last few decades. Such increases may contribute to retention of less experienced teachers as well, thus at least partially mitigating the argument that raises for veteran teachers do not improve the quality of the teaching force, e.g., Lankford and Wyckoff (1997), though it is important to note that these results do not necessarily contradict Lankford and Wykoff because those authors find that many New York districts increased salaries for veteran teachers at the expense of new teachers (i.e., veteran salaries increased while new teachers actually saw real salaries decrease).

10.1. Limitations of the model

Although this simulation highlights that urban districts like Milwaukee require fairly large salary increases to achieve attrition rates comparable to other districts, it is important to point out the limitations of this exercise. First, the partial equilibrium nature of the analysis does not fully reflect the overall effects of policies. For example, salary increases that primarily reduce exit attrition are likely to eventually reduce transfer attrition as well since there will be fewer vacancies for transferring teachers to fill. Similarly, while the focus here is on retention, higher salaries would also surely affect recruitment, again affecting transfers by increasing competition for available positions. Second, since it is somewhat unclear exactly *why* higher relative salaries are correlated with higher exit rates, it is possible that targeted salary increases would not have as strong an offsetting effect as the simulations predict. If, as suggested earlier, higher relative salaries reflect compensating differentials for unpleasant district characteristics, increasing district salaries may still reduce attrition.

10.2. Omitted teacher quality

A final caveat about the results is that the administrative data are lacking in measures of teacher quality and this omission could lead to biased estimates. If it is assumed that unobserved teacher quality is correlated with outside opportunities that are not explicitly captured in the data, the overall probability of transferring or exiting should be higher for higher-quality teachers. To the extent that higher teacher quality is also correlated with any of the independent variables, the coefficients on those variables will be biased. That is, if high-quality teachers are more likely to start out in certain types of districts, the probability of leaving those districts will appear higher. Of particular concern here is that there is some evidence that better teachers are more likely to begin their careers in higher-salary and urban districts (see Ballou & Podgursky, 1997; Figlio, 1997). The omission of measures of teacher quality could therefore lead to upward bias in the effect of salaries and urban environment on leaving. That is, higher salaries or urban environment would appear to be more highly correlated with leaving than is actually the case. This may explain why higher relative salaries increase exit attrition. It would also suggest that attrition out of Milwaukee is over-stated. The coefficients on these variables should therefore only be considered an outer bound of their relationship to exits or transfers.

11. Conclusions and future work

For districts facing teacher shortages, there are two challenges: attracting teachers into the district and retaining them once they are there. This paper has focused on the latter issue and in particular, whether salary increases can be an effective tool for retaining teachers. Increasing teacher wages is a common proposal among educators but there has been little research of how *much* wages need to be increased and how such raises might be structured to be most effective. This paper provides insights on both these points.

Previous studies of teacher mobility treat attrition as a binary choice where transfers are categorized as either stayers (in the profession) or exits (from a district). This ignores the possibility that transfer attrition may be influenced by different factors than exit attrition. By using a competing risks duration model to estimate separate hazard rates for transfers and exits among new teachers, it becomes clear that transfer attrition, at least for women, is more responsive to changes in the relative wage than the absolute level while exit attrition is sensitive to both. Thus, increasing salaries for beginning teachers can help reduce high attrition rates out of districts that lose many teachers to other districts (such as rural districts) but the strength of the response may depend on whether district wages increase relative to surrounding districts. In addition, since math and science teachers appear to have higher transfer rates, districts that are having a hard time holding onto teachers in these fields may want to ensure that their salaries are competitive with surrounding districts.

The results of this study also suggest that new female teachers consider future wages in at least their exit decisions. While the magnitude of the effects here are unlikely to warrant policymakers specifically increasing salaries for veteran teachers, these results do suggest that perhaps observed increases in wages of experienced teachers over the last few decades may have an overlooked benefit of increased retention among newer teachers, as long as they are not at the expense of salaries for beginning teachers. On the other hand, it is also important to point out that the focus here has been solely on retention of teachers already in the teaching force. The question of recruitment, how salary changes affect the decision to *become* a teacher is a separate, though related issue. Increasing beginning salaries may well have the additional benefit of attracting teachers, while increasing salaries at the top of the salary schedule does not. More work is needed to examine the cost-effectiveness of salary increases at different points along the salary schedule.

Finally, while there is abundant evidence that increasing salaries can help retain teachers, the political reality is that the funding for such increases is limited. Simulations in this study suggest that it could take wage increases of more than fifteen to twenty percent to reduce attrition out of urban districts to levels similar to an average district. It is therefore important to consider whether the benefits of retaining experienced teachers are large enough to justify such a cost. Intuition suggests that districts that lose experienced teachers are less likely to be attracting experienced teachers, and are therefore replacing outgoing teachers with new, inexperienced individuals. While previous research on education production suggests that inexperienced teachers are less effective than more experienced teachers, one must consider whether the magnitude of these effects are large enough to make it cost-effective to retain teachers through higher salaries.

In addition, given that large salary increases are likely to be politically difficult to achieve regardless of the benefits, researchers and policymakers should continue to search for other, lower-cost ways to retain teachers. Future work on teacher attrition should explore the effectiveness of alternative policies such as improving teaching conditions, mentoring programs, etc. Whatever the policy tools, policymakers should bear in mind that there may be differences in their impact on exit and transfer attrition.

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