Three Essays on Teacher Labor Markets

Lynn Patten Priestley Mahler
Sewanee, Tennessee

Bachelor of Science, Davidson College, 2003
Master of Arts, Duke University, 2008

A Dissertation presented to the Graduate Faculty
of the University of Virginia in Candidacy for the Degree of
Doctor of Philosophy

Department of Economics

University of Virginia
May, 2014

For my parents,

from whom I learned to be thoughtful.

Contents

Abstract

Teachers are an important piece of the education production function. How teachers vary in both their effectiveness and in their distribution across schools has large ramifications on student outcomes. These three chapters uncover how specific policies have affected teacher labor markets by altering characteristics of the group of teachers in the workforce and the allocation of teachers to different types of schools.

In the first chapter I explore how public school teachers respond to the incentives embedded in North Carolina's retirement system. Like most public-sector retirement plans, North Carolina's teacher pension implicitly encourages teachers to continue working until they are eligible for their pension benefits, and then leave soon afterward. Given that salaries are generally fixed by the state, I find that pension benefit eligibility subsumes most of the variation in pension wealth, making these eligibility thresholds the major facet driving retirement behavior. I find that teacher retirements are quite responsive to pension incentives; furthermore, these incentives generally prevail over non-pecuniary benefits of continued teaching such as working conditions and teacher effectiveness.

The second chapter is an extension of the first. I investigate the effects of a return-to-work policy that allowed North Carolina retired teachers to receive pension benefits along with a full-time salary. Using a hazard model I find that this policy had the unintended effect of increasing retirement rates by 16 percent for those eligible to receive their pension. Additionally, pension-eligible teachers who have not retired have exit rates twice as high as returning retirees. I find that this return-to-work policy was beneficial on two fronts: attracting higher quality teachers back to the profession and filling vacancies in high-poverty schools.

The third chapter describes the ways in which New York City teacher labor markets changed after sweeping changes were made to education policies. In particular, uncertified teachers, who made up over half of the entering workforce, were eliminated entirely and a new alternative certification pathway was created called the New York

City Teaching Fellows. We describe how the certification and school placement of Teaching Fellows changed from initially supplying childhood-certified teachers in high-poverty elementary schools to supplying teachers of hard-to-staff subjects (math, science, English as a second language, and special education) across a wider variety of school levels and student populations. Our analysis suggests that this alternative pathway to teaching was able to meet the changing demands of the New York City school system more quickly than traditional certification pathways.

Taken as a whole, these essays describe how changing incentives for teacher recruitment and retention has the potential to bring about large effects on the teacher workforce and the distribution of teachers across schools. These analyses highlight important intended and unintended effects that inform education policies going forward.

Acknowledgments

This research would not have been possible without the generous assistance of many individuals and entities.

I wish to thank the North Carolina Research and Data Center, the New York City Department of Education, and the New York State Education Department for the giving me access to the data employed in this research. This research was funded by the Center for Retirement Research at Boston College; the Institute of Education Sciences, U.S. Department of Education, through Grant R305B090002 to the University of Virginia; the Bankard Fund for Political Economy at the University of Virginia; the NOYCE Foundation; and the National Center for the Analysis of Longitudinal Data in Education Research, supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A060018 to the Urban Institute.

Many professors and students played a substantial role in shaping this work and my experience at UVa. In particular these include my advisors Sarah Turner, Leora Friedberg and Jim Wyckoff, and my friends Charlie Murry, Catherine Alford, Erin Dunlop Velez and Kelli Bird.

Most notably, I have been blessed with the unconditional support of my spirited husband Joe and two loving dogs, the tenacious Molly and sweet Eta.

Chapter 1

Retaining a High Quality Teaching Workforce: The Effects of Pension Design

1.1 Introduction

Over the next decade, more than half of all public school teachers will become eligible for retirement (National Commission on Teaching and America's Future, 2009). Attrition of these experienced persons could have negative consequences on student learning and further exacerbate the disproportionate demand for high-quality teachers in disadvantaged schools. This potential crisis is driven by the aging Baby Boom Generation that makes up a large portion of the teaching workforce, but it is amplified by the public pension systems that provide incentives for teachers as young as 50 years old to retire. My research concerns how these pension incentives affect the retention of effective teachers who have important impacts on student learning or staffing in hard-to-staff schools.

Teacher pension funds fall short of their liabilities by an estimated $1 trillion, causing many states to consider cost-saving changes including restructuring their plans (Pew Center on the States, 2010). Public school teachers in almost every state are eligible for defined-benefit pension plans, which are quite different from the defined-contribution plans (e.g., a 401(k)) offered in most private sector jobs. Defined-benefit plans provide teachers with a fixed annuity paid regularly over their retirement, and teachers must reach certain age-experience thresholds to begin receiving payments. In contrast, a defined-contribution plan puts money aside in an account that does not depend on age or experience and can be accessed by the individual after retirement. The present structure of defined-benefit plans provides incentives to "pull" mid-career individuals toward continuing teaching, while "pushing" later-career teachers out of the profession. These

---

The research reported here was supported by the Center for Retirement Research at Boston College; Institute of Education Sciences, U.S. Department of Education, through Grant R305B090002 to the University of Virginia; and the Bankard Fund for Political Economy at the University of Virginia.

incentives may affect the behavior of teachers differentially due to differences in alternative career options or enjoyment of teaching, which make retirement from the teaching profession a more or less attractive choice. These differential impacts by individual characteristics might impact certain school types more than others (e.g., teachers may be less satisfied at a hard-to-staff school, making teaching less enjoyable) or affect education quality (e.g., higher quality teachers may have more lucrative alternative career opportunities). Therefore, I ask:

- How responsive are teachers to the "pull" and "push" of pension incentives?
- Do teachers with different characteristics (qualifications, effectiveness) have different responses to pension incentives?
- Do teachers in different school environments (student racial/ethnic composition, student poverty, grade level, urbanicity) have different responses to pension incentives?

The answers to these questions inform the debate on pension reform. For example, if highly effective teachers are the only ones responsive to the pension "push" then the school system should consider ways to dampen the incentives to exit. On the other hand, if less effective teachers are the ones being "pushed" out, then this incentive is likely improving the quality of instruction and should be kept in place.

I exploit variation driven by pension rules to explore my research questions. In North Carolina, eligibility for full pension benefits occurs at set age-experience combinations: age 60 with 25 years experience, age 65 with 5 years, or any age with 30 years. Consider two individuals who are 60 years old, but one has 24 years of experience and one has 25 (so one began teaching at age 35 and the other at age 36). The first teacher crosses the age-60/exp-25 threshold earlier and can exit this year and receive benefits immediately, while the other teacher has to wait an additional year. Assuming the exit behavior of individuals with 24 and 25 years of experience is comparable in the absence of pensions (so those who start teaching at age 35 versus age 36 are similar), then the difference in the exit behavior of these two individuals approximates the effect of the pension system.[1] All of my specifications include controls for current pension wealth, age and earnings in order to account for the possibility that these variables may affect retirement propensity directly as well as pension receipt eligibility. After controlling for these direct effects, my coefficients of interest are identified off of differences in an individual's behavior from those with similar characteristics due to sharp changes in pension receipt eligibility.

To explore my research questions, I use a unique set of detailed data on every North Carolina teacher and student over 14 years, as described in Section 1.3. I can follow teachers over time as they retire and explore their responses to the North Carolina retirement plan. These data have several critical features which are often absent in other studies of retirement. First, I observe important characteristics of their work place necessary to decipher whether teacher exit behavior differs by school characteristics, such as student demographics. Second, I link 4th- and 5th-grade teachers with their students who took End-Of-Grade (EOG) achievement tests. This allows me to evaluate a teacher's quality in terms of her prior teaching performance, measured using teacher value-added. I use these value-added measurements to study how exit behavior varies with teacher effectiveness.

My results show that teachers are quite responsive to pension incentives: when the average teacher reaches eligibility for her benefits, the probability she exits is around 17 percentage points higher than the probability of exit just two years earlier. High- and low-quality teachers have a higher probability of exit than those of medium quality upon reaching eligibility. These differences by quality could be driven by the exhausting effort that an individual has to put forth to be a high-quality teacher, or by the relative lack of job satisfaction that a low-quality teacher enjoys. It is important to note that these results by quality may not be applicable to the workforce for whom I cannot measure value-added (teachers of other grades or non-tested subjects), as teachers for whom I am missing value-added have a higher propensity to leave than value-added teachers regardless of pension eligibility. Teachers also respond differently to pension incentives based on some attributes of their school. Teachers in urban schools and schools with a

[1] More precisely, in order to determine that differences in their exit behavior are driven by pensions, I assume that the natural differences in the propensity of 24- and 25-year teachers to exit are accounted for by a smooth function of experience.

high percentage of black students are less responsive than those in other schools. Being less responsive means these teachers are less "pulled" to stay prior to pension eligibility, but the ones who do stay feel less of a pension "push" once they are eligible. Perhaps the teachers who are less attached to their jobs have more alternative opportunities in an urban setting, making them more likely to exit in general as they lead up to pension eligibility; however, those who continue teaching until pension eligibility are a selective group who are actually more dedicated to their jobs and less likely to exit. There are no differences in pension responses by percentage of free/reduced price lunch students (a measure of student poverty) in one's school.

It is important to note that my results pertain only to those who persist in teaching long enough to reach at least age 40 and be a member of my sample (meaning they have non-missing values for key variables), so my analysis does not apply to young teachers who may leave teaching after just a few years. Furthermore, even for those in my sample, the effect of becoming eligible for retirement benefits is only identified by those who choose to stay in teaching until that point; however, prior to eligibility for one's pension the average annual attrition rate for teachers in my sample is around five percent, so selective attrition is limited.

In Section 1.2 I describe the literature on modeling pension incentives and provide evidence that, despite receiving similar salaries, teachers with different quality or working conditions vary in terms of their persistence in the workforce. This evidence suggests that teachers' responses to pension incentives may also vary along these dimensions. I explain the North Carolina pension plan and my data in Section 1.3 and describe how the pension plan affects teachers' incentives. To understand why teachers might respond differently to these incentives, I develop a model of teacher behavior in Section 1.4 where individuals have different values for teaching and exiting. Teachers' values differ because they have different non-pecuniary benefits from teaching, such as a helpful principal or a simple enjoyment of the profession. My inclusion of individual characteristics is a significant innovation in modeling retirement behavior, and especially important when studying teachers because they are paid according to a rigid salary schedule – implying that observed differences in retirement may be driven by non-pecuniary factors.

In Section 1.5 I present my estimation strategy to examine variation in teacher exit behavior in response to the pension eligibility rules. These rules create the “pull” and “push” described earlier, allowing me to estimate the causal effect of pension incentives on teacher retention. In Section 1.6 I describe my results. In Section 1.7 I explain some policy implications of this research.

1.2 My Contributions and a Review of the Literature

A few studies examine teacher pensions (Costrell and Podgurksy, 2009; Friedberg and Turner, 2010), with five focusing on differential responses among teachers (Furguson, Strauss, and Vogt, 2006; Friedberg and Turner, 2011; Costrell and McGee, 2010; Koedel, Podgursky, and Shi, 2013; McGee, working paper). In the most closely related study, McGee (working paper) analyzes Arkansas teacher responses by their teaching effectiveness. I use a different methodology that isolates an additional source of the variation in retirement incentives within the North Carolina pension plan: years until eligible for immediate pension benefit receipt. McGee (working paper) is hampered by potentially important data limitations due to measuring teaching quality at the grade-level (grouping several teachers together). I have measures of teacher quality at the teacher-level, which substantially reduces the measurement error associated with grade-level data. I also have a 14-year panel of data, which allows me to observe an individual’s work history and separate the effects of pension incentives from the effects of an increase in the value of leisure over an individual’s lifetime.

My study lies more broadly at the intersection of two areas of research: behavioral responses to retirement incentives and teacher retention. Economists have established a number of ways to assess the value of future retirement income to an individual today (e.g., Stock and Wise, 1990; Samwick, 1998). I study a single pension system where individuals are paid using a salary schedule based on years of experience and education. I exploit variation driven by the pension rules that affect one’s eligibility for pension receipt, which drives a large part of the growth in pension wealth over time.

There is a large body of literature on teacher retention, often studying teachers early in their careers. Many papers study the effect of current compensation on teacher turnover using variation in pay scales across districts, which may be endogenous, or salaries in alternative occupations, which are difficult to accurately measure (e.g. Podgursky et al., 2004; Hanushek et al. 2004). I use variation in benefit eligibility thresholds (that affect pension accruals), which are primarily driven by exogenous factors such as a teacher's age and years of experience.

Another branch of literature focuses specifically on the quality of retained teachers. These studies show that teacher retention varies by teachers' general knowledge test scores and the competitiveness of the college attended, finding that those with better credentials are more likely to exit (Boyd et al., 2005; Lankford et al., 2002). Researchers have also developed the value-added measure of quality, which is the average growth in achievement that a teacher's students experience during the school year (Rivkin et al., 2005). Many studies compare the value-added measures of exiting early-career teachers to those who stay, finding that those with higher value-added are more likely to stay (e.g. Boyd et al., 2007; Goldhaber et al., 2011). I study the behavior of mid- and later-career teachers with respect to their qualifications, and measure their value-added over multiple years to get a more informed measurement of a teacher's effectiveness.[2]

Researchers have additionally studied the sorting of different types of teachers across schools, concluding that schools with more disadvantaged students are likely to have high teacher turnover and generally less effective teachers (Clotfelter et al., 2006; Boyd et al., 2007). I study whether teachers in hard-to-staff schools are also more responsive to pension incentives.

As stated above, many of my contributions are a product of a careful insight into the pension plan in North Carolina as well as an exceptionally detailed and encompassing data set. I describe the specifics of the pension plan and data in the following section.

1.3 North Carolina Pension Plan and Data

North Carolina teacher pension plan. Teachers in North Carolina, and most other states, are eligible for a defined-benefit pension plan that provides an annuity paid regularly after they retire from teaching. This annuity equals 1.82% of the average salary of their last four years, multiplied by the years they have taught in North Carolina public

---

[2] Rothstein (2008) notes the bias introduced in value-added measures due to the non-random assignment of students and teachers. Koedel and Betts (2011) show that measuring value-added with many years of data, as I do, reduces this bias.

schools. This annuity comprises a large portion of a teacher's total compensation; for instance, a 30-year teacher receives over half of her highest salary for each year following retirement. Teachers are entitled to full pension benefits when they reach certain age-experience thresholds: full benefit eligibility at age 60 with experience 25, age 65 with experience 5, or any age with experience 30.[3] I explore exit behavior as a function of pension incentives, which are measured as years passed these thresholds. If exit behavior is the same regardless of how close or far away one is from eligibility, then the pension incentives are apparently not strong. On the other hand, if exit behavior displays a different pattern before and after eligibility (e.g., low exit rates prior to eligibility, high exit rates afterward) then pension incentives may be playing a large role in teacher exit behavior.

Any promise of wealth or income after retirement is likely to affect teacher exit behavior. In order to isolate the push and pull effects of defined-benefit pensions from these income effects, I control for pension wealth in all of my specifications. I calculate pension wealth by collapsing the stream of annuity payments one will receive into one number: the pension's present discounted value. The pension wealth of individual i who exits teaching in year t and receives annuity $annuity_{it}$ is:

$$(1.1) PensionWealth_{it} = \sum_{s=t}^{T} \beta^{s-t} \pi_{s|t} annuity_{it}.$$

This calculation discounts payments received later (because they are less valuable than those received sooner) by multiplying by a discount rate β, which I assume to be 0.95. Pension wealth is also a function how long one lives, so the annuity one expects to receive in year s is multiplied by the probability $\pi_{s|t}$ that one is alive in the later period to receive that payment (conditional on being alive in period t). I calculate $\pi_{s|t}$ using life tables by gender and race (white, black, Hispanic, and other) from the National Center for Health Statistics for the year 2006 (Arias 2010a, 2010b).

Figure 1.1 shows pension wealth as a function of exit age for a hypothetical North Carolina teacher who starts teaching at age 21. Figure 1.2 shows how much pension

[3] Teachers can retire short of these thresholds and receive a reduced benefit. Reduced benefit eligibility: age 50/60 with 25/5 years of teaching. Benefits are reduced by 3-5 % per year short of full retirement threshold, depending on age at retirement. Note, a teacher may retire before reaching an age-threshold, but not receive benefits until her age and experience are past the threshold. E.g., a 58-year-old could retire after her 25th year and receive reduced benefits immediately and thereafter, or wait two years and get full benefits upon turning 60.

wealth accrues at each age. This defined-benefit plan provides incentives to continue teaching up until age 52, when she has 30 years of experience and can begin to receive her annuity immediately upon exiting teaching. Up until age 52 pension wealth increases for a number of reasons. First, as is true throughout her career, an additional year of work and any associated increase in salary significantly raise the annuity amount. Second, during this period in particular, pension wealth increases because she is closer to receiving her benefits – one more year of work implies (at least) one fewer year she has to wait to get her annuity. The accrual rate is at its highest when she is 49 years old, at which point she would receive an additional $56K worth of pension wealth for teaching just one more year. Once she reaches age 52 she is able to receive her annuity immediately upon exiting teaching, after which the accrual rate drops from $38K to $14K. This additional pension wealth may "pull" her to continue teaching. If she continues to work passed 52 the annuity amount would still increase but her total pension wealth nonetheless declines because each additional year of teaching imposes an implicit cost – it is one fewer year that she could be receiving benefits. After age 65, this cost exceeds the additional annuity amount, possibly "pushing" her out of teaching. I measure the effects of pensions by exploring the relationship between exit behavior and the years until or since one is eligible for pension receipt, which proxy for this pension accrual pattern.

Data. I address my research questions using data from administrative records of all North Carolina public school students and teachers over the 1994-95 through 2008-09 school years, maintained by the North Carolina Education Research Data Center. These records follow individuals over time and link students and teachers in classrooms of schools. I observe students' 3rd- through 8th-End-of-Grade (EOG) math and reading test scores (although, for reasons explained below, I only use the 3rd- through 5th-grade scores for my teacher effectiveness measure), race, sex, exceptionality status, limited English proficiency status, and free/reduced price lunch eligibility (a measure of student poverty). I observe teachers' undergraduate and graduate degree institutions, graduation date, salary, race, sex, teaching assignment, and years of experience.[4] I do not observe the teacher's age, but assume they are 21 when they graduate from college. This attenuates the effect that I estimate of becoming eligible for pension benefits, as teachers who graduate when they are older are eligible for benefits earlier than I label them as such (i.e., there are some individuals who are actually eligible for benefits who I label as not eligible).

In light of pension eligibility and data requirements, I exclude some individuals from the sample, such as those who have non-teaching positions or missing values for important variables, as described in Table 1.1.[5] I exclude individuals who are under 40 years old because teachers younger than 40 generally have a very low accrual rate (but this begins to change around age 40) and are often choosing whether to leave or stay in teaching for reasons unrelated to their pensions. The resulting sample size is 61,767 individuals. The sample of teachers that I am able to link with EOG math and reading scores is the subset of 5,329 of these teachers who teach 4th- or 5th-grade during the 1998-99 and 2007-08 school years. I choose this subset due to two data limitations. First, student EOG scores are associated with the teacher who proctored the exam. In elementary school grades (3 through 5), the proctor is likely to be the student's instructor for math and reading, because students are generally with one teacher most of the day. In 6th through 8th grades, the proctor may not be the student's instructor for math or reading. In these middle school grades a teacher may instruct multiple classes of students. North Carolina administers EOG tests to all students within the school at the same time, making it impossible for all of a teacher's students to be proctored by her. (It is likely that students are proctored by their "homeroom" teacher.) I follow Xu et al. (2008) and compare the student composition (class size, number of white students, number of male students) of the tested class with that of the class that the proctor instructs (data from a separate source). If the characteristics of tested classroom are similar to the instructor's classroom, then I deem the proctor to also be the instructor. Second, in order to calculate

[4] Other variables that influence retirement (marital status, health status, household assets) are not available in these data. I do not expect that these variables are correlated with pension eligibility, pension accrual or pension wealth.

[5] I include those who are ever full-time teachers with greater than five years of experience (making them eligible for the defined-benefit pension plan) if their date of college graduation and other demographic variables are given, and work in a single school with non-zero salary during each year in the data.

a teacher's value-added I need her students' prior test scores and demographic characteristics. The prior test scores of 3rd-grade students are unavailable (because there is no test prior to 3rd-grade), so I exclude 3rd-grade teachers from my value-added analysis. The available student demographic data varies from year to year, and only the 1998-99 through 2007-08 school years contain the student information that I include in my value-added specification. Table 1.2 shows descriptive statistics for teachers in the beginning, middle and end of the time period I study for the full sample as well as the sample for whom I have value-added. Consistent with the large cohort of Baby Boomers moving toward retirement, the average teacher age, experience, pension wealth, and teaching salary are increasing over time. Approximately half of teachers in the full sample are in elementary schools, with the remaining half split between middle and high school. Teachers in the value-added sample are primarily in elementary schools because these are individuals who have taught 4th- or 5th-grade. Most teachers attended competitive or least competitive colleges, and the vast majority are white females.

I define teachers as exiting if they are not observed as a full-time employee in the North Carolina data for two consecutive years. Figures 1.3 and 1.4 show the proportion of individuals who exit by age and years of experience. Many of the discrete jumps in the exit rate coincide with teachers becoming eligible for retirement benefits. The most pronounced is the jump at 30 years of experience, when all teachers (regardless of age) are eligible for full benefits immediately upon exiting teaching.

I classify schools as elementary (PK-1 through 1-8), middle (4-7 through 5-9), and high (7-12 through 12) according to the lowest and highest grade levels of the school in the Common Core Data each year. I split schools into quartiles (over all schools within that year) of percent free/reduced price lunch and percent black students according to the Common Core Data. If the data on student characteristics are missing, I impute the quartile from the closest non-missing year for that school. I associate teachers with the competitiveness of the institution from which they received their undergraduate degree, where competitiveness is measured according to the Barron's rankings from the year closest to their graduation date (1984, 1986, 1988, 1990, or 1992). "Less competitive" is a Barron's rating of noncompetitive or less competitive; "competitive" is a rating of competitive; and "more competitive" is a rating of very competitive, or more competitive.

1.4 Theoretical Model

My theoretical model differs from the canonical models that have been used to study retirement because I include non-pecuniary benefits from work. Teachers are paid according to a rigid salary schedule, so these non-monetary factors are an important extension to explain differences in retirement behavior that cannot be explain by differences in compensation. These non-pecuniary factors may involve utility received from enjoying the teaching profession or from school characteristics. I outline the following model to guide my estimation strategy.

Model. Each period a teacher makes the choice to exit (d_{it}=1) and never return to teaching, or to continue teaching (d_{it}=0) and face the same decision the following period. As shown in (1.2), her per-period consumption depends on both her choice to leave or exit, and her eligibility for pension benefit receipt. In every period that she teaches, she receives income w_{it}^{τ}. Her income upon exiting depends on her eligibility for pension benefit receipt $Elig(\cdot)$, which depends on her current age age_{it} and teaching experience exp_{it}. All income is used for consumption c_{it} each period.[6]

She makes the decision to teach or exit this year in order to maximize the discounted sum of expected lifetime utility (1.3) subject to the budget constraint (1.2), where d_{is}^{*} is the optimal teaching/exit decision in period $s > t$, and z_{it} is a vector of state variables (z_{it}^{c}, z_{it}^{l}, z_{it}^{τ}) related to consumption z_{it}^{c}, leisure z_{it}^{l} and teaching z_{it}^{τ}. The expectation in (1.3) is taken with respect to future state values.

(1.2) $c_{it} = (1 - d_{it}) \cdot w_{it}^{\tau} + d_{it} \cdot annuity_{it} \cdot 1\{t \geq Elig(age_{it}, exp_{it})\}$

(1.3) $V_t(z_{it}) = E\left[\sum_{s=t}^{T} \beta^{s-t} \pi_{s|t} u(d_{is}^{*}, z_{is})\, | z_{it}\right]$

Individuals receive utility from consumption, leisure, and teaching. Utility is linear in consumption (1.4). Utility from leisure is only gained if an individual exits, and is quadratic in age (1.5).[7] Utility from teaching (1.6) is a linear function of a teacher's taste for teaching θ_{i0}, her exogenously defined quality e_{i}^{τ},and vector of school characteristics $\boldsymbol{School}_{it}$ (demographics, location, etc.).[8]

---

[6] Given linear utility, individuals have no incentive to smooth consumption.
[7] When utility is linear in consumption an individual's valuation of future pension benefits is proportional to pension wealth.
[8] Including a quadratic in experience to allow for the utility of teaching to vary by tenure does not qualitatively change my results.

(1.4) $u^c(d_{it}, z_{it}^c) = \gamma_0 + \gamma_1 c_{it}$

(1.5) $u^l(z_{it}^l) = \alpha_0 + \alpha_1 age_{it} - \alpha_2 age_{it}^2$

(1.6) $u^\tau(z_{it}^\tau) = \theta_{i0} + \theta_1 e_i^\tau + \boldsymbol{School}_{it}\eta$

An individual's utility u in period t (1.7) is an additive function of utility from consumption u^c, leisure u^l (if she has exited), and non-pecuniary utility from teaching u^τ (if she teaches). Before making any choices, each individual receives a shock ζ_{it} to this period's value of working and the value of exiting (e.g. a person's health deteriorates or her spouse gets a job in a new city). This will generate some sudden, unplanned retirements.

(1.7) $u(d_{it}, z_{it}) = u^c(d_{it}, z_{it}^c) + d_{it} \cdot u^l(z_{it}^l) + (1 - d_{it}) \cdot u^\tau(z_{it}^\tau) + \zeta_{it}(d_{it})$

I define the choice-specific conditional value functions (1.8) and (1.9) as the current period utility net of the choice-specific shock ζ_{it} plus the discounted expected value of future utility.

(1.8) $v_t(d_{it} = 1, z_{it}) = u^c(1, z_{it}^c) + u^l(z_{it}^l) + \beta E[V_{t+1}(z_{it+1})|d_{it} = 1, z_{it}]$

(1.9) $v_t(d_{it} = 0, z_{it}) = u^c(0, z_{it}^c) + u^\tau(z_{it}^\tau) + \beta E[V_{t+1}(z_{it+1})|d_{it} = 0, z_{it}]$

Teachers continue to teach if the total value (including ζ_{it}) of teaching exceeds that of exiting. Table 1.3 summarizes the utility components in period t and future periods conditional on today's decision and whether the individual is eligible for pension receipt.

The value of exiting (1.8) depends on whether she is eligible to receive her pension benefits. If she exits when she is not eligible, the current period utility, and utility in all periods leading up to eligibility, includes only the value of leisure in that period because she receives no salary, no annuity, and no non-pecuniary teaching benefits during these periods. If she exits when she is eligible, then the current period utility is the value of receiving her annuity and leisure. Once a teacher exits, regardless of whether she is eligible for benefits when at that time, she has no other decisions to make for the rest of her lifetime. There may be uncertainty with respect to shocks ζ_{it} to her utility, but she knows when she will start receiving her annuity.

There are two important distinctions between utility from exiting and continuing. The first is that the current period utility for someone who continues teaching is the value of teaching income, and an extra term – the utility of non-pecuniary benefits she receives from teaching $u^{\tau}(z_{it}^{\tau})$. The second distinction is the value of utility in future periods. In contrast with someone who exits this period, one who continues to teach has the option to choose between teaching and exiting again next period. Her expected future value of utility is a function of future teaching salaries and school characteristics for the expected remainder of her teaching career; as well as pension income, non-teaching income, and the length of her life once she exits. This future value will vary depending on how long she intends to continue teaching, which is related to the relative value of teaching and exiting in all future periods.

Impact of pensions. Pensions affect an individual's retirement decision through the budget constraint. I focus on two ways that pensions affect behavior, creating a wealth effect and an 'eligibility' effect.

A given accrual in pension wealth (or any other retirement wealth) from one year to the next generates a wealth effect for teachers eligible for any type of retirement benefits. Two mechanisms influence year-to-year changes in pension wealth. First, the pension annuity amount increases over time as a teacher adds more years of service and her salary increases. Second, as individuals age, they move closer to the eligibility dates for annuity payments, which increases the current value of their future retirement income. Pension wealth growth over time is not specific to defined-benefit plans – defined-contribution plans accrue wealth as more money is added to the retirement account and the money grows due to investment. In both plans, these increases in lifetime wealth may cause a teacher to consume more of all normal goods, including leisure, increasing her likelihood of retirement. In order to accurately measure the response to defined-benefit pension incentives it is important to separately account for this wealth effect, which would be present in any retirement plan.

In the context of my model, the wealth effect is due to changes in the value of exiting this period due to variation in the current value of pension wealth. Equation (1.10) defines the current value of pension wealth PW_t. Co-variation between exit behavior and PW_tmeasures the wealth effect.

(1.10) $PW_{it} = \sum_{s=t}^{T} \beta^{s-t} \pi_{s|t} annuity_{it} \cdot 1\{t \geq Elig(age_{is}, exp_{is})\}$.

One key benefit of teaching until eligible for immediate pension receipt is a larger stream of income over her remaining lifetime. I term a teacher's response to this incentive the ‘eligibility’ effect. The eligibility effect is a substitution effect in that the leisure of retirement is very costly in the years leading up to eligibility (because she gives up a large amount of rapidly growing pension wealth by exiting early). If she teaches until eligibility, retirement is suddenly cheaper – she has to give up less pension wealth because it is growing less rapidly (see Figure 1.1 after age 52). This effect would not be present in the defined-contribution plan where pension wealth growth is relatively constant regardless of one’s age or experience (although sometimes with a penalty if the individual is too young). Importantly, in addition to being a marker that distinguishes a time of sharp versus smooth pension accrual in a defined-benefit plan, the time of eligibility is itself a salient feature of defined-benefit pensions, making it a variable that individuals are likely to respond to.

In the context of my model, prior to eligibility, the possibility of having an larger stream of income over one’s life (by teaching until eligibility) makes continuing to teach this period more valuable than it otherwise would. Post eligibility, the relative value between teaching and exiting is diminished because one can exit and does not have to give up much pension wealth growth. These shifts in the values of teaching versus exiting over one’s lifetime create the eligibility effect. I examine the differences in exit behavior in years prior to, at, and post eligibility to quantify this effect.[9]

Teacher responses to pension incentives. The relative value of continuing to teach depends on how long one intends to continue teaching. For example, someone who does not intend to stay until eligibility should not be affected by the utility gains from staying until eligibility. My model posits that this attachment to teaching varies with teachers’ attributes, causing individuals with different characteristics to respond differently to retirement incentives. Teachers may have different tastes for their work that give their non-pecuniary benefits from teaching, either through the enjoyment of teaching, satisfaction from being an effective teacher, or having a fondness for a particular school environment. Teachers with high non-pecuniary benefits would be less influenced by the

[9] There are additional substitution effects due to the magnitude of pension accrual that one can gain by continuing to teach, but, given that I only study one pension system, there is not enough variation in these measures to identify meaningful effects separate from the wealth and eligibility effects. Inflation, which is not accounted for in my model, also makes teaching until eligibility a profitable idea. If a teacher leaves prior to eligibility her eventual annuity is not adjusted for inflation that might occur between her retirement and the time she begins receiving benefits.

value of pension accruals as they relate to her retirement decision. For example, consider two teachers with the same salary and years until they are eligible to retire, but one has high non-pecuniary benefits because she likes her school environment and the other does not. As they age and the value of teaching approaches the value of exiting, the teacher with high non-pecuniary benefits has a higher value of teaching because she values the non-pecuniary benefits that she can continue to receive over her future career. This makes her less sensitive to both the "pull" and the "push" of pensions than the other teacher. To capture differences in responsiveness to pension incentives, I study the relationship between exit behavior and years until eligibility for teachers with different observable non-pecuniary benefits.

This model motivates an empirical investigation to describe the magnitude of teachers' responsiveness to pensions, and whether their responses vary with teacher or school characteristics.

1.5 Estimation Strategy

In this section I describe the specifications and identifying assumptions I use to model teacher exit behavior and teacher quality.

Exit behavior. My model suggests the following specification to determine how teachers respond to pension incentives. I model the probability that teacher i in year t exits teaching ($d_{it} = 1$) as a probit:

$$(1.11)\quad Prob(d_{it} = 1) = \Phi(\delta_0 + \delta_1 w_{it}^{\tau} + \delta_2 age_{it} + \delta_3 age_{it}^2 + \delta_4 PW_{it} + \boldsymbol{YrsElig}_{it}\boldsymbol{\lambda} + \boldsymbol{X}_{it}\boldsymbol{\beta}.$$

I control for the teacher's total compensation w_{it}^{τ} and a quadratic in age (to capture the utility of leisure from retiring). δ_3 represents the wealth effect of pensions, the co-variation between current pension wealth PW_{it} and exit behavior. $\boldsymbol{YrsElig}$ is a vector of indicator variables $YrsElig_{Elig-t}$, which are equal to one if an individual is $Elig - t$ many years away from eligibility. $Elig - t$ is less than zero when she is not yet eligible, equal to zero when eligible, and greater than zero once eligible. The coefficients on these indicator variables $\boldsymbol{\lambda}$ represent the eligibility effect of pensions. In order to determine if individuals vary in their responsiveness to pensions, I interact $\boldsymbol{YrsElig}$ with a teacher's individual or school characteristic (interaction not shown in equation (1.11)), such as her quality (described below) or her school's demographic composition. I am able to identify coefficients on a quadratic function of age in order to isolate exit behavior related to pensions from that related to age because I have teachers of different ages at each value of $\boldsymbol{YrsElig}$. The last term, $\boldsymbol{X}_{it}$, contains characteristics about the teacher including the teacher's race, sex, and an indicator for the school year (to capture any system-wide changes in the attractiveness of teaching). I cluster standard errors at the individual level to account for error correlation within an individual over time.

Equation (1.11) is a simplification of equations (1.2) through (1.10), modeling the differences in the value of teaching and exiting in a given period while approximating the expectation of future utility values with the years since one is eligible for immediate annuity receipt and using current wages and pension wealth to stand in for the whole future time path of wages and pension wealth. These approximations are necessary because the inclusion of all these variables would make estimation intractable due to collinearity. The reason these approximations are reasonable is because all teachers in my sample have so much in common. For instance, due to the rigid salary structure, everyone with the same wage expects the same wage increases. More interestingly, teachers with the same value of have very similar expectations of how pension wealth will increase in the future. To see this, I choose three hypothetical teachers based on the age-experience distribution of teachers in my sample. Approximately half of teachers start teaching at 21 or 22. Teacher A represents this group – she started teaching right out of college when she was 21. Approximately one third of the sample started teaching between the ages of 22 and 29, with more starting earlier rather than later. Teachers B and C represent this group. Teacher B started when she was 25, and Teacher C started when she was 29. Due to their different start ages, they have different pension wealth distributions and vary in the year in which they are eligible for pension receipt. The left panel of Figure 1.5 shows these pension wealth distributions indexed by age. The right panel shows them indexed by $\boldsymbol{YrsElig}$, showing a great deal of similarity between these teachers' projected pension wealth growth. My empirical specification takes into consideration these similarities across teachers in order to simplify the model to a more tractable empirical specification.

Teacher quality. I measure teacher quality $Quality_i$ as a time-invariant trait characterized by the competitiveness of college from which the teacher graduated (the definition of which is discussed in Section 1.3) or a measure of her teaching effectiveness termed value-added.[10] I estimate value-added using the following specification for teachers of grades 4 and 5, for whom I have students' prior year EOG achievement test scores, important student demographics, and confidence that students are accurately matched with their instructor.

$$(1.12)\quad Achievement_{jit} = Quality_i + \boldsymbol{Y}_{jt}\boldsymbol{\rho} + \nu_{jit}$$

The dependent variable is the normalized (mean zero, standard deviation one) test score $Achievement_{jit}$ of student j of teacher i in year t. I regress this on a vector of student, class, and school attributes $\boldsymbol{Y}$, which includes student j's test score from the previous year, demographic and achievement measures for other students in j's classroom and school, and grade and year fixed effects.[11] I do not include any measure of the teacher's experience in this specification. It is well established by the literature (Rockoff, 2004; Boyd et al., 2008) that teachers' value-added increase as they gain experience, especially in the first few years of teaching. Teachers in my sample are in their fifth or higher year of teaching so it is likely that these teachers have little variation in quality due to increases in experience. Additionally, the most policy relevant comparison is to compare the pension responsiveness of all teachers to one another as opposed to controlling for experience and only being able to compare a teacher to her same-experienced peers.

The value-added measure of a teacher's quality $Quality_i$ is the average growth in teacher i's students, compared to the growth of other teachers' students, after netting out the average effects of other observable factors. To address concerns about bias in value-added measures, I follow Koedel and Betts (2011) and estimate a teacher's value-added using the test scores of her students over multiple years. I use empirical Bayes shrinkage (Wisconsin Center for Education Research, 2010) to account for measurement error in the value-added estimates. To address the possible endogeneity of an individual's value-added and her exit behavior, I drop the students in the teacher's class during her final year of teaching from the value-added estimation. Because there are separate math and reading tests, I compute three different measures of teacher value-added: math value-added, reading value-added, and average value-added (the average of reading and math).

[10] I can test the assumption that teacher quality is time-invariant by measuring value-added at the teacher-year level and study trends in these measures over time.
[11] I intend to test different specifications to calculate teacher value-added.

Table 1.4 shows my specification for teacher value-added, which I estimate for 4th- and 5th-grade teachers in my sample who teach 10 or more students in a given year. Recall that value-added is measured at the teacher (not the teacher-year) level. On average there are 76 test scores per teacher, but this ranges from 10 to 227. The standard deviation of math and reading value-added is 0.19 and 0.11. The correlation between these two measures is 0.66. These results are consistent with other researcher's value-added estimates using the same North Carolina data (and other states as well) (e.g., Clotfelter et al., 2007). I split teachers into terciles based on their math, reading, and the average of their math and reading value-added to study differences in retirement patterns.[12]

1.6 Results

Table 1.5 has coefficients from the probit described in equation (1.11) as well as the corresponding linear probability model (LPM). The predictions of these two models are qualitatively the same, but the coefficients of the LPM are more readily interpretable.[13] The omitted category for the $\boldsymbol{YrsElig}$ vector is someone who is 10 years away from eligibility, the farthest possible in my sample. The LPM coefficients on $\boldsymbol{YrsElig}$ are statistically significant and display a pattern consistent with the intuition behind the "eligibility" effect of pensions – the coefficients are negative and increasingly negative prior to eligibility, with a sharp jump up at eligibility, and a consistently higher value afterward. Nine years away from eligibility (YrsElig equals -9), an individual does not have much more of an incentive to stay than someone who is 10 years away from eligibility. However, as one approaches eligibility the benefits of continuing to teach are larger because one has fewer years to wait for her benefits, as seen by the increasing magnitude of the coefficients on $\boldsymbol{YrsElig}$. By the time a teacher is two years away from

[12] The results are robust to using average quality quintiles (instead of terciles).

[13] Usually one reports the marginal effects corresponding to the probit model, but neither the average of the marginal effects, nor the marginal effects at the average are appropriate to describe the effect of the YrsElig indicator variables. This is due to fact that many variables (age, salary, and YrsElig) move together over time. For example, in calculating the average of the marginal effects, it would be inappropriate to include the marginal effect of reaching eligibility for a 40-year-old observed individual because this individual would never be eligible. Similarly, this specification cannot be generalized into the marginal effect for someone who is always the average age (49), because some marginal effects (e.g., the effect of being 5 years past eligibility) do not affect 49-year-olds.

eligibility, she has a five percentage point lower probability of exiting than she did when she was 10 years out. As she moves from two years away to being eligible, her probability of exit increases by 17 percentage points (from -0.05 to 0.12). (The slight jump up at one year from eligibility is likely due to measurement error in experience or age.) After eligibility teachers have a five to 10 percentage point higher likelihood of exiting than they do when they are 10 years from eligibility. These parameter estimates indicate teachers' substantial responsiveness to the time structure of defined-benefit pensions.

Other coefficients in this specification are in line with theoretical predictions and are statistically significant. A \$100K increase in the value of pension wealth today (PW_{it}) leads to a 4.5 percentage point increase in the probability of exiting. This is indicative of the wealth effect described earlier. Higher values of teaching salary increase the value of continuing to teach and, thus, decrease the likelihood of exiting by 7.2 percentage points for every \$10K.

It is difficult to tell the effects of pensions through these coefficients because many variable values are changing at once. An individual is aging and her pension wealth and salary are changing as $\boldsymbol{YrsElig}$ changes. To visualize the effects of pensions, I use my model to predict the exit probability for hypothetical teachers. I choose three hypothetical teachers based on the age-experience distribution of teachers in my sample. Teacher A began teaching right out of college at age 21, similar to approximately half of my sample. Approximately a third of my sample started teaching between age 22 and 29. This third is represented by Teacher B, who started when she was 25, and Teacher C, who started when she was 29. I assume that these teachers are always paid according to the 2000-01 salary schedule, and that they are white females, representative of the majority of teachers. As discussed in Section 1.5, Figure 1.5 shows the three teachers' pension wealth distributions by age and $\boldsymbol{YrsElig}$, demonstrating how similar pension wealth growth is across these teachers who have very different start ages. Figure 1.6 shows the predicted probability of exit (using the probit model in Table 1.5) by $\boldsymbol{YrsElig}$ for each of these teachers.

Figure 1.6 visually displays the pattern of the coefficients described in Table 1.5, with a low exit probability when far from eligibility, rising sharply around eligibility, and staying markedly higher afterward. Note that Teacher C (the oldest one) always has a higher probability of exiting, and Teacher A (the youngest) has the lowest, in line with the idea that leisure may be more valuable as teacher's age. These differences are especially strong after eligibility, showing that the oldest teacher may feel more of a "push" than the younger ones.

The clearest way to determine whether different types of teachers respond differently to pension incentives is to simply compare responses to this pension plan for teachers with different attributes. To do this I predict exit probabilities for Teacher A (who started teaching right out of college like half of all teachers in my sample) assuming she has different attributes (different quality, different school level setting, etc.). I then look to see if the predicted probabilities based on these different attributes are statistically different from one another. I predict these probabilities using the probit specification in equation (1.11) with an additional interaction between the variable of interest (effectiveness, school urbanicity, etc.) and $\boldsymbol{YrsElig}$, along with a level effect.[14]

Figures 1.7 through 1.9 show how exit probabilities differ based on teacher quality and qualifications. Figure 1.7 shows that, in the sample for which I can calculate value-added, there are few differences in their exit behaviors. The only meaningful and statistically significant difference occurs right at eligibility – teachers of medium quality have a smaller jump in exit probability than those of high or low quality. It could be that high quality teachers exert a lot of effort in order to be high quality, and they are quite responsive to the relief that retirement might bring. Low quality teachers, on the other hand, may have less of an attachment to teaching and view retirement eligibility as a good time to leave the profession. It is unclear whether these results by quality can be extrapolated to the workforce in general. Figure 1.8 shows that the exit probability for the 90 percent of teachers for whom I cannot calculate value-added (because of the grade, subject or year they are teaching) is always significantly higher than the teachers for whom I do have value-added. This could be due to selection into teaching assignments that are under high accountability pressures in tested grades and subjects. Perhaps the teachers who persist in grades 4 and 5 are also particularly committed to the profession in general.

[14] The probit and LPM coefficients for these specifications are in Tables 1.6 through 1.11.

Figure 1.9 shows the exit probability for teachers who attended competitive and more competitive colleges. For the sake of visual clarity, those who attended less competitive colleges are not included in this graph, but they behave qualitatively similar to those who attended competitive but not more competitive colleges. Teachers from more competitive colleges have a slightly smaller jump at eligibility (0.26 versus 0.31). About 10 percent of teachers in my sample attended these more competitive institutions. It could be that they gave up more attractive careers in order to stay in teaching, making them more likely to persist in the profession regardless of pension incentives.

Figures 1.10 through 1.13 show how exit behavior differs by school characteristics. Figure 1.10 shows that exit behavior is generally no different among elementary, middle, and high school teachers. Figure 1.11 shows that teachers in urban settings are slightly more likely to exit the profession when they are far from eligibility, but when they become eligible, they have a slightly lower likelihood of exiting than rural (and lower than town/suburban teachers who behave similarly to rural teachers but are not shown). There is a similar effect for teachers in schools with the highest percentage of black students (Figure 1.12), but no difference between the highest and lowest quartile of percent free lunch students (Figure 1.13). Thus, there is some evidence that teachers who select into different working conditions have different exit behaviors – in particular, teachers at urban schools and those with a high percentage of black students are actually more likely to persist in the profession conditional on having stayed until eligibility.

1.7 Summary and Policy Implications

The impending retirement of the Baby Boom Generation has considerable implications for school staffing and student learning. States are concerned with the financial burden that this mass retirement could impose and are considering comprehensive changes to public pension systems. These debates around cost-saving reform overlook the effects that pension incentives have on school staffing. My study investigates these effects to see if teachers with different characteristics or school environments have different responses to pension incentives. I develop a conceptual model of teacher retirement behavior and employ a unique data set to estimate the causal effect of pensions on teachers' exit decisions.

I find that teachers are quite responsive to the eligibility cutoffs – a teacher who is eligible for immediate pension benefits has a 17 percentage point higher probability of exiting than one who is two years away from eligibility. Given that the average rate of attrition for those prior to eligibility is less than five percent, a 17 percentage point jump is quite sizable (an increase of 300 percent). There is some evidence that teachers respond differently to pension incentives. Those with high and low value-added are five percentage points more likely to exit at eligibility than those with medium value-added. However, these results may not apply to teachers for whose quality I cannot measure. Teachers who attended competitive and less competitive colleges are also around five percentage points more likely to exit teaching at eligibility than those who attended more competitive colleges. I find that teacher responses to pensions do not vary much by school environment, but that teachers in urban schools and those with a high proportion of black students are slightly less responsive to pension incentives.

This research is a necessary first step in considering the effects of pension reform in order to implement a retirement system that encourages the retention of high quality teachers in all types of schools. It is clear that teachers are generally quite responsive to pension incentives and likely to change their behavior if there are changes to the structure of retirement income. For the set of teachers for whom I can measure effectiveness, both the high and low quality teachers are more responsive to pension incentives. However, whether this means they are highly responsive to the "pull" (which keeps them in teaching until eligibility) or more responsive to the "push" (which kicks them out at eligibility) is important for the design of new pension systems. Given that the teachers in my study are all subject to the same pension system, it is difficult to determine what the behavior of these teachers would be in the absence of pensions, but simulations with alternative pension systems could provide clues as to how teachers might respond to pension reform.

Table 1.1: Sample Selection

	N	Percent
Full-time individuals, age 40 or more, eligible for pension	95,906	100%
Not in sample because:		
Ever not a teacher	20,056	20.9%
Unknown/unreasonable salary or hours worked	2,215	2.3%
Unreasonable/inconsistent values of experience	2,421	2.5%
Unreasonable/unknown value of age	5,723	6.0%
Unknown sex or race/ethnicity	3,724	3.9%
In sample:	61,767	64.4%
In sample with teacher value-added:	5,329	8.6%

Table 1.2: Descriptive Statistics for Full Sample and Value-Added Sample

		Full sample			Value-Added sample		
Year		1994-95	2000-01	2006-07	1994-95	2000-01	2006-07
N		30,610	32,424	30,711	2,484	3,818	3,283
Age (in fall)	mean	46.91	48.64	49.68	45.30	48.57	50.30
	s.d.	5.15	5.13	6.00	3.98	4.99	5.84
	min	40	40	40	40	40	40
	max	70	70	70	62	65	69
Experience (in fall)	mean	20.60	21.54	21.14	19.20	21.66	21.77
	s.d.	6.21	6.68	7.39	5.26	6.63	7.37
	min	4	4	4	4	4	4
	max	40	40	40	35	40	40
Current Pension Wealth / $100K	mean	1.77	2.20	2.12	1.37	2.22	2.28
	s.d.	1.33	1.47	1.52	1.01	1.48	1.53
	min	0.07	0.07	0.08	0.09	0.08	0.10
	max	6.32	6.73	7.09	5.14	5.86	6.62
Teaching Salary / $10K	mean	4.82	5.39	5.13	4.68	5.38	5.16
	s.d.	0.62	0.65	0.67	0.54	0.62	0.63
	min	2.40	2.50	2.49	2.57	3.10	3.06
	max	7.57	9.24	8.67	6.44	7.57	7.89
% Black students in school	mean	30.33	30.98	27.41	28.64	31.25	26.09
	s.d.	22.10	23.26	22.39	22.53	24.71	22.47
% Free lunch students in school	mean	28.78	31.39	35.57	33.85	37.76	39.03
	s.d.	17.41	19.36	18.36	16.85	20.14	19.70
Rural School		0.24	0.38	0.45	0.29	0.41	0.45
Town/Suburban School		0.41	0.33	0.30	0.41	0.33	0.30
Urban School		0.34	0.28	0.24	0.30	0.26	0.24
Elementary School		0.50	0.49	0.48	0.93	0.94	0.92
Middle School		0.21	0.21	0.21	0.06	0.05	0.07
High School		0.28	0.27	0.28	0.00	0.00	0.00
More Competitive College		0.09	0.09	0.12	0.06	0.07	0.09
Competitive College		0.51	0.52	0.51	0.51	0.50	0.49
Least Competitive College		0.41	0.39	0.38	0.43	0.42	0.41
Female		0.84	0.84	0.82	0.95	0.95	0.94
White		0.83	0.84	0.85	0.83	0.82	0.84
Black		0.16	0.15	0.13	0.16	0.17	0.15

Table 1.3. Current and Future Utility by Today's Decision

Period t decision	Period t utility	Utility in period $s > t,\ s < Elig_{it}$	Utility in period $s > t, s \geq Elig_{it}$
Exit & $t < Elig_{it}$	$u^l(age_{it})$	$u^l(age_{is})$	$u^c(annuity_{it}) + u^l(age_{is})$
Exit & $t \geq Elig_{it}$	$u^c(annuity_{it}) + u^l(age_{it})$	n/a	$u^c(annuity_{it}) + u^l(age_{is})$
Teach	$u^c(w_{it}^{\tau}) + u^{\tau}(z_{it}^{\tau})$	$V_s(z_{is})$	$V_s(z_{is})$

Table 1.4. Teacher Value-Added Specification
Dependent variable=standardized (mean 0, s.d. 1 in grade and year) EOG test score

	math		reading	
Previous score (standardized by grade and year)	0.741	**	0.690	**
	(0.001)		(0.001)	
Female	-0.011	**	0.015	**
	(0.002)		(0.002)	
Black	-0.102	**	-0.134	**
	(0.002)		(0.003)	
Hispanic	0.015	**	-0.004	
	(0.005)		(0.005)	
Other race	0.011	**	-0.028	**
	(0.004)		(0.004)	
Limited English proficiency status	-0.032	**	-0.109	**
	(0.007)		(0.008)	
Eligible for free/reduced price lunch	-0.072	**	-0.090	**
	(0.002)		(0.002)	
Student variables (switching schools, repeating a grade, age in 3rd grade)	X		X	
Year indicators	X		X	
Grade 4 indicator	X		X	
Student exceptionality status (gifted, speech or language disability, physical disability, emotional disability, mental disability, learning disability, or other disability indicators)	X		X	
Class-level variables (membership, lagged achievement, % non-white, % female, % LEP, % free lunch)	X		X	
School-level variables (% black, % Hisp, % free lunch)	X		X	
N	409,903		407,377	
R-squared	0.76		0.69	

Notes: Standard errors shown in parentheses. ** signify significance at the 1% level.

Table 1.5. Probit and LPM Results for Full Sample using Equation (1.11)
Dependent variable = 1 if exit, = 0 if continue

	Probit		LPM	
Years Eligible (-10 omitted)				
-9	-0.062	**	-0.004	*
	(0.022)		(0.002)	
-8	-0.174	**	-0.011	**
	(0.023)		(0.002)	
-7	-0.276	**	-0.019	**
	(0.025)		(0.002)	
-6	-0.354	**	-0.027	**
	(0.026)		(0.003)	
-5	-0.389	**	-0.031	**
	(0.029)		(0.004)	
-4	-0.510	**	-0.044	**
	(0.033)		(0.005)	
-3	-0.587	**	-0.052	**
	(0.038)		(0.006)	
-2	-0.585	**	-0.050	**
	(0.044)		(0.007)	
-1	-0.274	**	0.020	*
	(0.049)		(0.008)	
0 (eligible)	-0.032		0.120	**
	(0.055)		(0.009)	
1	-0.167	**	0.100	**
	(0.059)		(0.010)	
2	-0.326	**	0.072	**
	(0.063)		(0.011)	
3	-0.403	**	0.067	**
	(0.066)		(0.012)	
4	-0.505	**	0.055	**
	(0.070)		(0.013)	
5	-0.467	**	0.087	**
	(0.074)		(0.014)	
6	-0.565	**	0.074	**
	(0.079)		(0.015)	

(continued on next page)

Table 1.5 (continued)

Pension wealth today / $100,000	0.472 (0.018)	**	0.049 (0.003)	**
Teaching Salary / $10,000	-0.568 (0.013)	**	-0.072 (0.002)	**
Female	-0.166 (0.009)	**	-0.017 (0.001)	**
Black	0.077 (0.009)	**	0.006 (0.001)	**
Other Race	0.056 (0.030)		0.006 (0.004)	
Age	-0.218 (0.014)	**	-0.038 (0.002)	**
Age^2	0.003 (0.000)	**	0.000 (0.000)	**
Constant	5.077 (0.375)	**	1.204 (0.055)	**
Year indicators	Yes		Yes	
Observations	414,203		414,203	
R-squared	n/a		0.10	

Notes: Standard errors shown in parentheses. *, ** signify significance at the 5%, 1% level. Monetary values are in 2009 dollars. Years Eligible are indicator variables showing how many years one has until she is eligible for retirement (if Years Eligible < 0), or how many years one has been eligible (if Years Eligible ≥ 0). The specification include additional values of Years Eligible (-20 through -11, and 6 through 10) but these coefficients are not shown.

Table 1.6. Probit and LPM Results for Full Sample, Interactions with Teacher Quality
Dependent variable = 1 if exit, = 0 if continue

	Probit		LPM	
Years Eligible (-10 omitted)				
-9	-0.065	**	-0.004	*
	(0.023)		(0.002)	
-8	-0.184	**	-0.012	**
	(0.024)		(0.002)	
-7	-0.273	**	-0.019	**
	(0.025)		(0.002)	
-6	-0.355	**	-0.027	**
	(0.027)		(0.003)	
-5	-0.389	**	-0.031	**
	(0.030)		(0.004)	
-4	-0.519	**	-0.045	**
	(0.034)		(0.005)	
-3	-0.582	**	-0.051	**
	(0.039)		(0.006)	
-2	-0.587	**	-0.049	**
	(0.044)		(0.007)	
-1	-0.275	**	0.022	**
	(0.049)		(0.008)	
0 (eligible)	-0.036		0.122	**
	(0.055)		(0.009)	
1	-0.168	**	0.103	**
	(0.059)		(0.010)	
2	-0.322	**	0.075	**
	(0.063)		(0.011)	
3	-0.394	**	0.072	**
	(0.067)		(0.012)	
4	-0.507	**	0.056	**
	(0.071)		(0.013)	
5	-0.456	**	0.093	**
	(0.075)		(0.014)	
6	-0.571	**	0.074	**
	(0.079)		(0.015)	
Low Quality	-0.524	**	-0.026	**
	(0.128)		(0.004)	
Medium Quality	-0.527	**	-0.025	**
	(0.135)		(0.004)	
High Quality	-0.282	**	-0.016	**
	(0.104)		(0.004)	

(continued on next page)

Table 1.6 (continued)

Low Quality X Years Eligible		
-9	0.187 (0.166)	0.007 (0.005)
-8	0.397 * (0.157)	0.018 ** (0.006)
-7	0.204 (0.166)	0.008 (0.005)
-6	0.371 * (0.155)	0.016 ** (0.006)
-5	0.39 ** (0.151)	0.015 * (0.007)
-4	0.404 ** (0.151)	0.016 * (0.007)
-3	0.137 (0.158)	-0.004 (0.006)
-2	0.245 (0.151)	-0.006 (0.008)
-1	0.298 * (0.142)	-0.019 (0.012)
0 (eligible)	0.428 ** (0.140)	-0.001 (0.018)
1	0.449 ** (0.144)	0.007 (0.021)
2	0.254 (0.152)	-0.050 * (0.022)
3	0.25 (0.158)	-0.049 (0.025)
4	0.338 * (0.166)	-0.026 (0.030)
5	0.281 (0.179)	-0.053 (0.038)
6	0.202 (0.204)	-0.072 (0.045)

(continued on next page)

Table 1.6 (continued)

Med Quality X Years Eligible				
-9	0.19		0.006	
	(0.176)		(0.006)	
-8	0.032		0.003	
	(0.192)		(0.005)	
-7	0.03		0.003	
	(0.192)		(0.005)	
-6	0.182		0.007	
	(0.176)		(0.006)	
-5	0.008		-0.004	
	(0.181)		(0.005)	
-4	0.289		0.008	
	(0.165)		(0.007)	
-3	0.139		-0.004	
	(0.167)		(0.007)	
-2	0.311	*	-0.000	
	(0.158)		(0.009)	
-1	0.356	*	-0.012	
	(0.151)		(0.014)	
0 (eligible)	0.265		-0.050	**
	(0.150)		(0.018)	
1	0.321	*	-0.032	
	(0.154)		(0.022)	
2	0.362	*	-0.019	
	(0.161)		(0.025)	
3	0.304		-0.041	
	(0.171)		(0.029)	
4	0.319		-0.034	
	(0.181)		(0.034)	
5	0.258		-0.053	
	(0.193)		(0.042)	
6	0.439	*	-0.000	
	(0.219)		(0.057)	

(continued on next page)

Table 1.6 (continued)

High Quality X Years Eligible				
-9	-0.095 (0.153		-0.003 (0.006)	
-8	0.168 (0.137)		0.010 (0.007)	
-7	-0.176 (0.161)		-0.003 (0.006)	
-6	-0.26 (0.164)		-0.007 (0.005)	
-5	-0.04 (0.140)		-0.005 (0.006)	
-4	0.116 (0.133)		0.003 (0.007)	
-3	-0.011 (0.135)		-0.009 (0.007)	
-2	0.109 (0.127)		-0.005 (0.009)	
-1	0.054 (0.121)		-0.033 (0.012)	**
0 (eligible)	0.164 (0.118)		-0.021 (0.018)	
1	0.039 (0.124)		-0.056 (0.019)	**
2	0.095 (0.129)		-0.035 (0.022)	
3	0.032 (0.140)		-0.057 (0.026)	*
4	0.306 (0.147)	*	0.025 (0.034)	
5	0.045 (0.169)		-0.059 (0.040)	
6	0.539 (0.180)	**	0.116 (0.056)	*

(continued on next page)

Table 1.6 (continued)

Pension wealth today / $100,000	0.469 (0.018)	**	0.050 (0.003)	**
Teaching Salary / $10,000	-0.57 (0.013)	**	-0.073 (0.002)	**
Female	-0.144 (0.009)	**	-0.014 (0.001)	**
Black	0.075 (0.009)	**	0.006 (0.001)	**
Other Race	0.054 (0.030)		0.005 (0.004)	
Age	-0.214 (0.014)	**	-0.038 (0.002)	**
Age^2	0.002 (0.000)	**	0.000 (0.000)	**
Constant	4.997 (0.379)	**	1.205 (0.055)	**
Year indicators	Yes		Yes	
Observations	412,771		414,203	
R-squared	n/a		0.11	

Notes: See Table 1.5 notes. Omitted quality group is those for whom I cannot calculate value-added.

Table 1.7. Probit and LPM Results for Full Sample, Interactions with College Competitiveness
Dependent variable = 1 if exit, = 0 if continue

	Probit	LPM
Years Eligible (-10 omitted)		
-9	-0.143 * (0.066)	-0.011 (0.006)
-8	-0.206 ** (0.066)	-0.016 ** (0.006)
-7	-0.348 ** (0.068)	-0.028 ** (0.006)
-6	-0.445 ** (0.069)	-0.038 ** (0.007)
-5	-0.54 ** (0.069)	-0.046 ** (0.007)
-4	-0.627 ** (0.071)	-0.056 ** (0.008)
-3	-0.605 ** (0.071)	-0.051 ** (0.009)
-2	-0.671 ** (0.074)	-0.053 ** (0.010)
-1	-0.506 ** (0.076)	-0.007 (0.013)
0 (eligible)	-0.315 ** (0.080)	0.073 ** (0.016)
1	-0.483 ** (0.086)	0.046 ** (0.017)
2	-0.63 ** (0.093)	0.023 (0.019)
3	-0.57 ** (0.100)	0.057 * (0.023)
4	-0.753 ** (0.109)	0.023 (0.025)
5	-0.717 ** (0.118)	0.06 (0.031)
6	-0.724 ** (0.134)	0.085 * (0.038)
Competitive College	-0.209 ** (0.051)	-0.019 ** (0.005)
Less Competitive College	-0.180 ** (0.053)	-0.018 ** (0.005)

(continued on next page)

Table 1.7 (continued)

Competitive College X Years Eligible		
-9	0.101 (0.073)	0.009 (0.006)
-8	0.043 (0.073)	0.006 (0.006)
-7	0.087 (0.075)	0.01 (0.006)
-6	0.09 (0.074)	0.011 (0.006)
-5	0.159 * (0.073)	0.015 * (0.007)
-4	0.139 (0.072)	0.013 (0.007)
-3	0.027 (0.069)	-0.002 (0.008)
-2	0.106 (0.069)	0.004 (0.008)
-1	0.287 ** (0.066)	0.037 ** (0.011)
0 (eligible)	0.332 ** (0.066)	0.061 ** (0.014)
1	0.352 ** (0.070)	0.065 ** (0.015)
2	0.321 ** (0.077)	0.054 ** (0.018)
3	0.177 * (0.083)	0.015 (0.022)
4	0.231 * (0.093)	0.029 (0.025)
5	0.229 * (0.102)	0.025 (0.030)
6	0.125 (0.120)	-0.018 (0.039)

(continued on next page)

Table 1.7 (continued)

Less Competitive College X Years Eligible		
-9	0.087 (0.075)	0.008 (0.006)
-8	0.037 (0.075)	0.006 (0.007)
-7	0.089 (0.077)	0.011 (0.006)
-6	0.123 (0.076)	0.014 * (0.007)
-5	0.182 * (0.075)	0.019 ** (0.007)
-4	0.106 (0.074)	0.012 (0.007)
-3	-0.016 (0.072)	-0.004 (0.008)
-2	0.05 (0.071)	0 (0.008)
-1	0.188 ** (0.068)	0.019 (0.011)
0 (eligible)	0.246 ** (0.067)	0.036 ** (0.014)
1	0.297 ** (0.072)	0.052 ** (0.016)
2	0.293 ** (0.078)	0.048 ** (0.018)
3	0.132 (0.084)	0.001 (0.022)
4	0.262 ** (0.094)	0.039 (0.025)
5	0.254 * (0.103)	0.031 (0.030)
6	0.136 (0.120)	-0.014 (0.039)

(continued on next page)

Table 1.7 (continued)

Pension wealth today / $100,000	0.488 (0.018)	**	0.051 (0.003)	**
Teaching Salary / $10,000	-0.58 (0.013)	**	-0.073 (0.002)	**
Female	-0.169 (0.009)	**	-0.017 (0.001)	**
Black	0.081 (0.010)	**	0.007 (0.001)	**
Other Race	0.067 (0.032)	*	0.009 (0.004)	*
Age	-0.235 (0.015)	**	-0.04 (0.002)	**
Age^2	0.003 (0.000)	**	0 (0.000)	**
Constant	5.704 (0.394)	**	1.276 (0.057)	**
Year indicators	Yes		Yes	
Observations	401,723		401,723	
R-squared	n/a		0.11	

Notes: See Table 1.5 notes. Omitted category for college competitiveness is more competitive.

Table 1.8. Probit and LPM Results for Full Sample, Interactions with School Level (Elementary, Middle, High)
Dependent variable = 1 if exit, = 0 if continue

	Probit		LPM	
Years Eligible (-10 omitted)				
-9	-0.058 (0.035)		-0.003 (0.002)	
-8	-0.136 (0.035)	**	-0.007 (0.002)	**
-7	-0.276 (0.037)	**	-0.017 (0.003)	**
-6	-0.325 (0.038)	**	-0.023 (0.003)	**
-5	-0.373 (0.039)	**	-0.028 (0.004)	**
-4	-0.468 (0.043)	**	-0.038 (0.005)	**
-3	-0.565 (0.047)	**	-0.047 (0.006)	**
-2	-0.529 (0.052)	**	-0.041 (0.008)	**
-1	-0.247 (0.056)	**	0.021 (0.009)	*
0 (eligible)	0.065 (0.062)		0.141 (0.011)	**
1	-0.07 (0.067)		0.122 (0.012)	**
2	-0.225 (0.071)	**	0.094 (0.013)	**
3	-0.317 (0.075)	**	0.085 (0.014)	**
4	-0.372 (0.080)	**	0.088 (0.015)	**
5	-0.324 (0.085)	**	0.126 (0.017)	**
6	-0.423 (0.092)	**	0.112 (0.020)	**
Middle School	0.086 (0.041)	*	0.007 (0.003)	*
High School	0.060 (0.039)		0.006 (0.003)	*

(continued on next page)

Table 1.8 (continued)

Middle School X Years Eligible				
-9	0.007		0.000	
	(0.058)		(0.004)	
-8	-0.072		-0.006	
	(0.059)		(0.004)	
-7	-0.042		-0.004	
	(0.060)		(0.004)	
-6	-0.023		-0.001	
	(0.058)		(0.004)	
-5	0.006		0.001	
	(0.056)		(0.004)	
-4	-0.013		0.001	
	(0.056)		(0.005)	
-3	-0.013		0.001	
	(0.055)		(0.005)	
-2	-0.081		-0.005	
	(0.054)		(0.005)	
-1	-0.039		0.006	
	(0.050)		(0.007)	
0 (eligible)	-0.102	*	-0.012	
	(0.050)		(0.010)	
1	-0.096		-0.011	
	(0.053)		(0.011)	
2	-0.101		-0.013	
	(0.057)		(0.013)	
3	-0.043		0.006	
	(0.062)		(0.015)	
4	-0.2	**	-0.045	*
	(0.069)		(0.017)	
5	-0.202	**	-0.05	*
	(0.076)		(0.022)	
6	-0.187	*	-0.043	
	(0.088)		(0.027)	

(continued on next page)

Table 1.8 (continued)

High School X Years Eligible		
-9	-0.02 (0.055)	-0.002 (0.004)
-8	-0.056 (0.055)	-0.004 (0.004)
-7	0.035 (0.055)	0.002 (0.004)
-6	-0.055 (0.055)	-0.004 (0.004)
-5	-0.002 (0.053)	0 (0.004)
-4	-0.069 (0.053)	-0.005 (0.004)
-3	-0.005 (0.051)	0.001 (0.004)
-2	-0.046 (0.049)	-0.003 (0.005)
-1	0.054 (0.046)	0.021 ** (0.007)
0 (eligible)	-0.102 * (0.046)	-0.022 ** (0.008)
1	-0.117 * (0.048)	-0.028 ** (0.010)
2	-0.097 (0.052)	-0.021 (0.011)
3	-0.087 (0.056)	-0.018 (0.013)
4	-0.109 (0.060)	-0.024 (0.015)
5	-0.141 * (0.066)	-0.038 * (0.019)
6	-0.168 * (0.077)	-0.046 * (0.023)

(continued on next page)

Table 1.8 (continued)

Pension wealth today / $100,000	0.47 ** (0.019)	0.047 ** (0.003)
Teaching Salary / $10,000	-0.588 ** (0.014)	-0.073 ** (0.002)
Female	-0.152 ** (0.010)	-0.014 ** (0.001)
Black	0.067 ** (0.010)	0.004 ** (0.001)
Other Race	0.067 * (0.031)	0.007 (0.004)
Age	-0.208 ** (0.015)	-0.036 ** (0.002)
Age^2	0.002 ** (0.000)	0 ** (0.000)
Constant	4.888 ** (0.399)	1.145 ** (0.058)
Year indicators	Yes	Yes
Observations	381,639	381,639
R-squared	n/a	0.11

Notes: See Table 1.5 notes. Omitted category for school level is elementary.

Table 1.9. Probit and LPM Results for Full Sample, Interactions with Urbanicity (Rural, Town/Suburb, City)
Dependent variable = 1 if exit, = 0 if continue

	Probit		LPM	
Years Eligible (-10 omitted)				
-9	-0.034		-0.001	
	(0.039)		(0.003)	
-8	-0.153	**	-0.009	**
	(0.040)		(0.003)	
-7	-0.221	**	-0.014	**
	(0.040)		(0.003)	
-6	-0.343	**	-0.024	**
	(0.042)		(0.003)	
-5	-0.355	**	-0.028	**
	(0.042)		(0.004)	
-4	-0.462	**	-0.039	**
	(0.045)		(0.005)	
-3	-0.520	**	-0.046	**
	(0.049)		(0.006)	
-2	-0.524	**	-0.044	**
	(0.053)		(0.007)	
-1	-0.203	**	0.027	**
	(0.056)		(0.009)	
0 (eligible)	0.033		0.126	**
	(0.062)		(0.011)	
1	-0.083		0.112	**
	(0.066)		(0.012)	
2	-0.243	**	0.084	**
	(0.070)		(0.013)	
3	-0.313	**	0.081	**
	(0.075)		(0.014)	
4	-0.409	**	0.071	**
	(0.080)		(0.016)	
5	-0.416	**	0.089	**
	(0.085)		(0.018)	
6	-0.504	**	0.080	**
	(0.092)		(0.020)	
Rural	0.016		-0.001	
	(0.039)		(0.003)	
City	0.220	**	0.021	**
	(0.039)		(0.003)	

(continued on next page)

Table 1.9 (continued)

Rural X Years Eligible		
-9	-0.021 (0.055)	-0.002 (0.004)
-8	0.006 (0.055)	-0.000 (0.004)
-7	-0.041 (0.055)	-0.003 (0.003)
-6	-0.011 (0.055)	-0.001 (0.004)
-5	0.037 (0.052)	0.003 (0.004)
-4	-0.002 (0.052)	-0.000 (0.004)
-3	-0.074 (0.051)	-0.006 (0.004)
-2	-0.037 (0.049)	-0.003 (0.005)
-1	-0.023 (0.046)	0.000 (0.006)
0 (eligible)	0.026 (0.046)	0.018 * (0.008)
1	-0.009 (0.048)	0.007 (0.010)
2	-0.040 (0.052)	-0.004 (0.011)
3	-0.058 (0.056)	-0.008 (0.013)
4	-0.062 (0.061)	-0.009 (0.015)
5	-0.056 (0.068)	-0.008 (0.019)
6	-0.001 (0.077)	0.011 (0.023)

(continued on next page)

Table 1.9 (continued)

City X Years Eligible		
-9	-0.033 (0.055)	-0.003 (0.004)
-8	-0.039 (0.056)	-0.004 (0.004)
-7	-0.107 (0.056)	-0.010 * (0.004)
-6	-0.004 (0.055)	-0.002 (0.004)
-5	-0.119 * (0.054)	-0.009 * (0.004)
-4	-0.125 * (0.054)	-0.010 * (0.004)
-3	-0.103 * (0.052)	-0.006 (0.005)
-2	-0.117 * (0.051)	-0.006 (0.005)
-1	-0.185 ** (0.048)	-0.018 * (0.007)
0 (eligible)	-0.236 ** (0.047)	-0.037 ** (0.009)
1	-0.259 ** (0.050)	-0.043 ** (0.010)
2	-0.215 ** (0.054)	-0.029 * (0.012)
3	-0.224 ** (0.058)	-0.031 * (0.014)
4	-0.265 ** (0.064)	-0.042 ** (0.016)
5	-0.122 (0.069)	0.005 (0.020)
6	-0.208 ** (0.081)	-0.026 (0.024)

(continued on next page)

Table 1.9 (continued)

Pension wealth today / $100,000	0.490 ** (0.018)	0.051 ** (0.003)
Teaching Salary / $10,000	-0.610 ** (0.013)	-0.077 ** (0.002)
Female	-0.173 ** (0.009)	-0.017 ** (0.001)
Black	0.066 ** (0.009)	0.004 ** (0.001)
Other Race	0.049 (0.031)	0.005 (0.004)
Age	-0.239 ** (0.015)	-0.041 ** (0.002)
Age^2	0.003 ** (0.000)	0.000 ** (0.000)
Constant	5.711 ** (0.385)	1.283 ** (0.056)
Year indicators	Yes	Yes
Observations	405,895	405,895
R-squared	n/a	0.11

Notes: See Table 1.5 notes. Omitted category for urbanicity is town/suburb.

Table 1.10. Probit and LPM Results for Full Sample, Interactions with Quartile of Percentage of Black Students
Dependent variable = 1 if exit, = 0 if continue

	Probit	LPM
Years Eligible (-10 omitted)		
-9	-0.121 * (0.049)	-0.007 * (0.003)
-8	-0.243 ** (0.049)	-0.014 ** (0.003)
-7	-0.317 ** (0.050)	-0.020 ** (0.003)
-6	-0.399 ** (0.050)	-0.027 ** (0.004)
-5	-0.378 ** (0.050)	-0.029 ** (0.005)
-4	-0.480 ** (0.052)	-0.039 ** (0.005)
-3	-0.596 ** (0.055)	-0.051 ** (0.006)
-2	-0.574 ** (0.058)	-0.048 ** (0.008)
-1	-0.238 ** (0.061)	0.022 * (0.009)
0 (eligible)	0.098 (0.066)	0.152 ** (0.011)
1	-0.044 (0.070)	0.130 ** (0.013)
2	-0.209 ** (0.075)	0.099 ** (0.014)
3	-0.327 ** (0.080)	0.082 ** (0.016)
4	-0.423 ** (0.086)	0.071 ** (0.018)
5	-0.371 ** (0.092)	0.108 ** (0.021)
6	-0.425 ** (0.101)	0.113 ** (0.025)
2nd Quartile % Black (25-50th percentile)	0.018 (0.046)	0.005 (0.003)
3rd Quartile % Black (50-75th percentile)	0.087 (0.045)	0.010 ** (0.003)
4th Quartile % Black (75-100th percentile)	0.102 * (0.048)	0.010 ** (0.003)

(continued on next page)

Table 1.10 (continued)

2nd Quartile % Black (25-50th percentile) X Years Eligible		
-9	0.105 (0.065)	0.006 (0.004)
-8	0.104 (0.066)	0.005 (0.004)
-7	-0.009 (0.067)	-0.002 (0.004)
-6	0.080 (0.065)	0.004 (0.004)
-5	-0.027 (0.062)	-0.004 (0.004)
-4	-0.022 (0.062)	-0.003 (0.005)
-3	0.063 (0.060)	0.004 (0.005)
-2	0.047 (0.058)	0.004 (0.005)
-1	0.045 (0.055)	0.008 (0.008)
0 (eligible)	-0.088 (0.054)	-0.033 ** (0.010)
1	-0.035 (0.057)	-0.015 (0.012)
2	-0.068 (0.062)	-0.026 (0.013)
3	-0.016 (0.067)	-0.012 (0.016)
4	-0.067 (0.074)	-0.025 (0.018)
5	-0.074 (0.081)	-0.028 (0.023)
6	-0.078 (0.093)	-0.033 (0.029)

(continued on next page)

Table 1.10 (continued)

3rd Quartile % Black (50-75th percentile) X Years Eligible		
-9	0.046 (0.065)	0.002 (0.004)
-8	0.091 (0.065)	0.004 (0.004)
-7	0.077 (0.065)	0.003 (0.004)
-6	0.022 (0.064)	-0.000 (0.004)
-5	0.023 (0.061)	0.002 (0.005)
-4	-0.050 (0.061)	-0.004 (0.005)
-3	0.035 (0.060)	0.004 (0.005)
-2	0.015 (0.057)	0.004 (0.006)
-1	-0.050 (0.054)	-0.003 (0.007)
0 (eligible)	-0.134 * (0.053)	-0.033 ** (0.010)
1	-0.167 ** (0.057)	-0.043 ** (0.011)
2	-0.151 * (0.061)	-0.037 ** (0.013)
3	-0.097 (0.066)	-0.022 (0.015)
4	-0.075 (0.072)	-0.014 (0.018)
5	-0.069 (0.080)	-0.013 (0.023)
6	-0.174 (0.093)	-0.051 (0.028)

(continued on next page)

Table 1.10 (continued)

4th Quartile % Black (75-100th percentile) X Years Eligible		
-9	0.109 (0.068)	0.007 (0.005)
-8	0.106 (0.068)	0.005 (0.005)
-7	0.114 (0.068)	0.006 (0.005)
-6	0.112 (0.067)	0.007 (0.005)
-5	0.018 (0.064)	0.002 (0.005)
-4	0.027 (0.064)	0.003 (0.005)
-3	0.018 (0.063)	0.003 (0.005)
-2	0.007 (0.061)	0.005 (0.006)
-1	-0.020 (0.057)	0.007 (0.008)
0 (eligible)	-0.166 ** (0.057)	-0.039 ** (0.011)
1	-0.147 * (0.060)	-0.033 ** (0.012)
2	-0.084 (0.064)	-0.012 (0.014)
3	-0.034 (0.069)	0.001 (0.017)
4	-0.047 (0.076)	-0.002 (0.019)
5	-0.085 (0.083)	-0.015 (0.024)
6	0.109 (0.068)	-0.031 (0.029)

(continued on next page)

Table 1.10 (continued)

Pension wealth today / $100,000	0.47 ** (0.018)	0.048 ** (0.003)
Teaching Salary / $10,000	-0.58 ** (0.013)	-0.073 ** (0.002)
Female	-0.166 ** (0.009)	-0.016 ** (0.001)
Black	0.042 ** (0.010)	0.001 (0.001)
Other Race	0.042 (0.031)	0.005 (0.004)
Age	-0.22 ** (0.014)	-0.038 ** (0.002)
Age^2	0.003 ** (0.000)	0.000 ** (0.000)
Constant	5.139 ** (0.382)	1.205 ** (0.056)
Year indicators	Yes	Yes
Observations	405,895	405,895
R-squared	n/a	0.11

Notes: See Table 1.5 notes. Omitted category for % Black quartile is the lowest (0-25th percentile).

Table 1.11. Probit and LPM Results for Full Sample, Interactions with Quartile of Percentage of Students Qualifying for Free/Reduced Price Lunch (FRPL)
Dependent variable = 1 if exit, = 0 if continue

	Probit	LPM
Years Eligible (-10 omitted)		
-9	-0.078 * (0.039)	-0.005 (0.003)
-8	-0.209 ** (0.040)	-0.014 ** (0.003)
-7	-0.305 ** (0.041)	-0.021 ** (0.003)
-6	-0.400 ** (0.042)	-0.030 ** (0.004)
-5	-0.424 ** (0.042)	-0.034 ** (0.004)
-4	-0.577 ** (0.046)	-0.049 ** (0.005)
-3	-0.608 ** (0.049)	-0.054 ** (0.006)
-2	-0.619 ** (0.053)	-0.054 ** (0.008)
-1	-0.300 ** (0.057)	0.013 (0.009)
0 (eligible)	-0.063 (0.062)	0.108 ** (0.011)
1	-0.207 ** (0.067)	0.087 ** (0.012)
2	-0.359 ** (0.071)	0.061 ** (0.013)
3	-0.455 ** (0.076)	0.051 ** (0.014)
4	-0.567 ** (0.081)	0.036 * (0.016)
5	-0.494 ** (0.086)	0.079 ** (0.018)
6	-0.583 ** (0.093)	0.069 ** (0.021)
2nd Quartile FRPL (25-50th percentile)	-0.093 * (0.042)	-0.009 ** (0.003)
3rd Quartile FRPL (50-75th percentile)	0.008 (0.043)	-0.003 (0.003)
4th Quartile FRPL (75-100th percentile)	0.006 (0.047)	-0.002 (0.004)

(continued on next page)

Table 1.11 (continued)

2nd Quartile FRPL (25-50th percentile) X Years Eligible		
-9	0.088 (0.059)	0.007 (0.004)
-8	0.128 * (0.059)	0.010 * (0.004)
-7	0.088 (0.060)	0.006 (0.004)
-6	0.101 (0.059)	0.008 (0.004)
-5	0.103 (0.057)	0.009 * (0.004)
-4	0.138 * (0.057)	0.010 * (0.004)
-3	0.100 (0.055)	0.008 (0.005)
-2	0.097 (0.054)	0.009 (0.005)
-1	0.116 * (0.050)	0.016 * (0.007)
0 (eligible)	0.108 * (0.050)	0.017 (0.009)
1	0.142 ** (0.053)	0.029 ** (0.011)
2	0.147 ** (0.057)	0.029 * (0.012)
3	0.172 ** (0.061)	0.036 * (0.014)
4	0.140 * (0.068)	0.026 (0.017)
5	0.144 * (0.074)	0.027 (0.021)
6	0.066 (0.085)	0.002 (0.025)

(continued on next page)

Table 1.11 (continued)

3^{rd} Quartile % FRPL ($50-75^{th}$ percentile) X Years Eligible		
-9	-0.024 (0.061)	-0.001 (0.004)
-8	-0.019 (0.063)	-0.001 (0.004)
-7	-0.039 (0.063)	-0.001 (0.004)
-6	0.038 (0.061)	0.003 (0.004)
-5	0.025 (0.059)	0.004 (0.005)
-4	0.061 (0.059)	0.006 (0.005)
-3	-0.022 (0.058)	0.000 (0.005)
-2	0.070 (0.055)	0.013 * (0.006)
-1	0.014 (0.052)	0.011 (0.008)
0 (eligible)	0.041 (0.051)	0.025 * (0.010)
1	0.046 (0.054)	0.026 * (0.011)
2	0.022 (0.059)	0.016 (0.013)
3	0.059 (0.063)	0.027 (0.015)
4	0.047 (0.070)	0.024 (0.017)
5	-0.028 (0.076)	0.001 (0.021)
6	0.075 (0.088)	0.036 (0.027)

(continued on next page)

Table 1.11 (continued)

4th Quartile % FRPL (75-100th percentile) X Years Eligible		
-9	0.025 (0.066)	0.002 (0.005)
-8	0.068 (0.066)	0.005 (0.005)
-7	0.087 (0.066)	0.006 (0.005)
-6	0.067 (0.066)	0.004 (0.005)
-5	0.042 (0.064)	0.004 (0.005)
-4	0.108 (0.063)	0.009 (0.005)
-3	0.029 (0.062)	0.004 (0.005)
-2	0.015 (0.060)	0.004 (0.006)
-1	0.009 (0.056)	0.008 (0.008)
0 (eligible)	0.023 (0.056)	0.018 (0.010)
1	0.013 (0.059)	0.013 (0.012)
2	0.006 (0.063)	0.011 (0.014)
3	0.007 (0.068)	0.011 (0.016)
4	0.091 (0.074)	0.035 (0.019)
5	-0.002 (0.081)	0.004 (0.023)
6	-0.028 (0.092)	-0.004 (0.027)

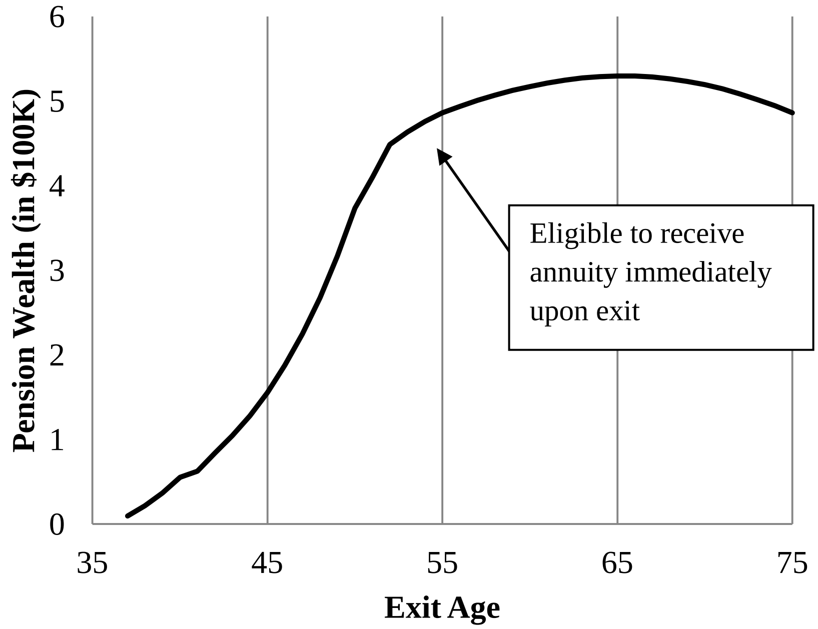
(continued on next page)

Table 1.11 (continued)

Pension wealth today / $100,000	0.473 ** (0.018)	0.049 ** (0.003)
Teaching Salary / $10,000	-0.574 ** (0.013)	-0.073 ** (0.002)
Female	-0.170 ** (0.009)	-0.017 ** (0.001)
Black	0.068 ** (0.010)	0.005 ** (0.001)
Other Race	0.044 (0.031)	0.005 (0.004)
Age	-0.219 ** (0.014)	-0.038 ** (0.002)
Age^2	0.003 ** (0.000)	0.000 ** (0.000)
Constant	5.147 ** (0.383)	1.214 ** (0.056)
Year indicators	Yes	Yes
Observations	405,266	405,266
R-squared	n/a	0.11

Notes: See Table 1.5 notes. Omitted category for % FRPL quartile is the lowest ($0\text{-}25^{th}$ percentile).

Figure 1.1. Pension Wealth by Exit Age

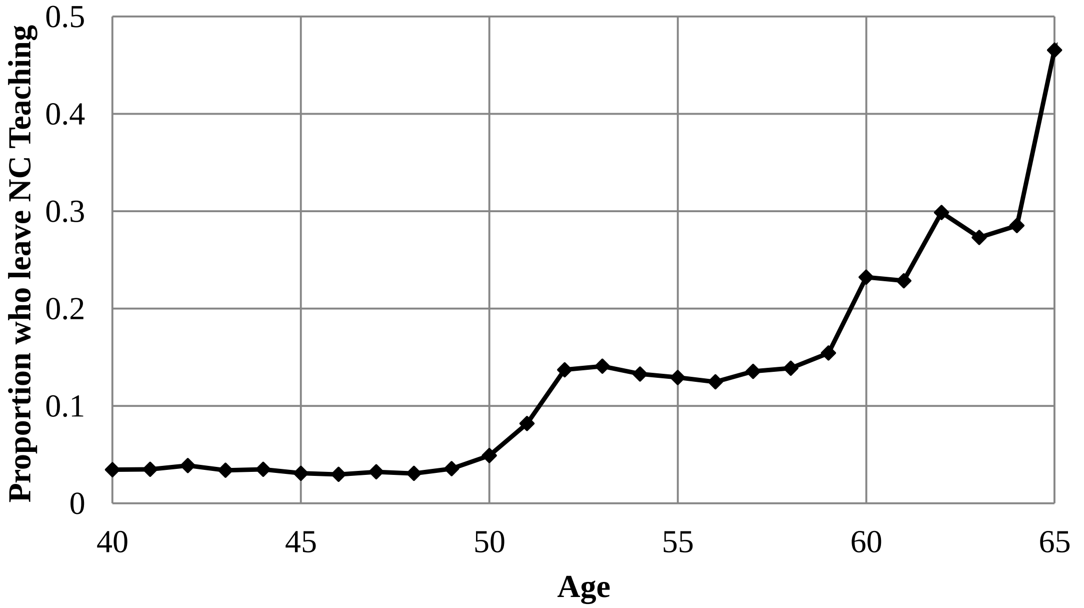


Notes: Pension wealth for a hypothetical teacher who starts teaching at age 21 and faces 2000-01 North Carolina salary schedule during entire career.

Figure 1.2. Change in Pension Wealth for Each Additional Year of Teaching by Exit Age

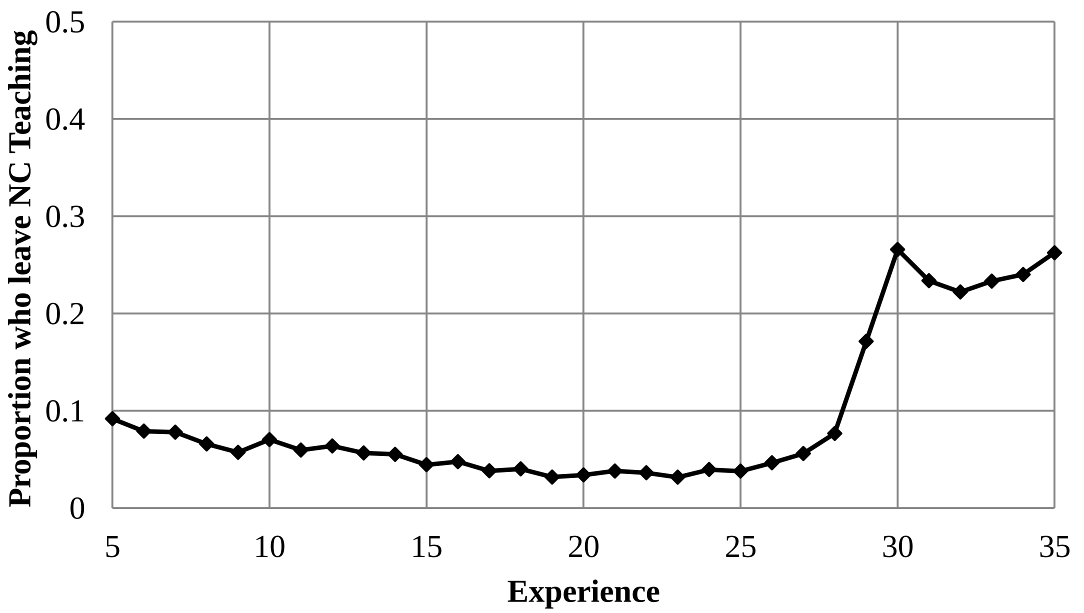
Notes: Same hypothetical teacher as Figure 1.1.

Figure 1.3. Exit Rates by Age: Marginal Percentage Leaving North Carolina Teaching



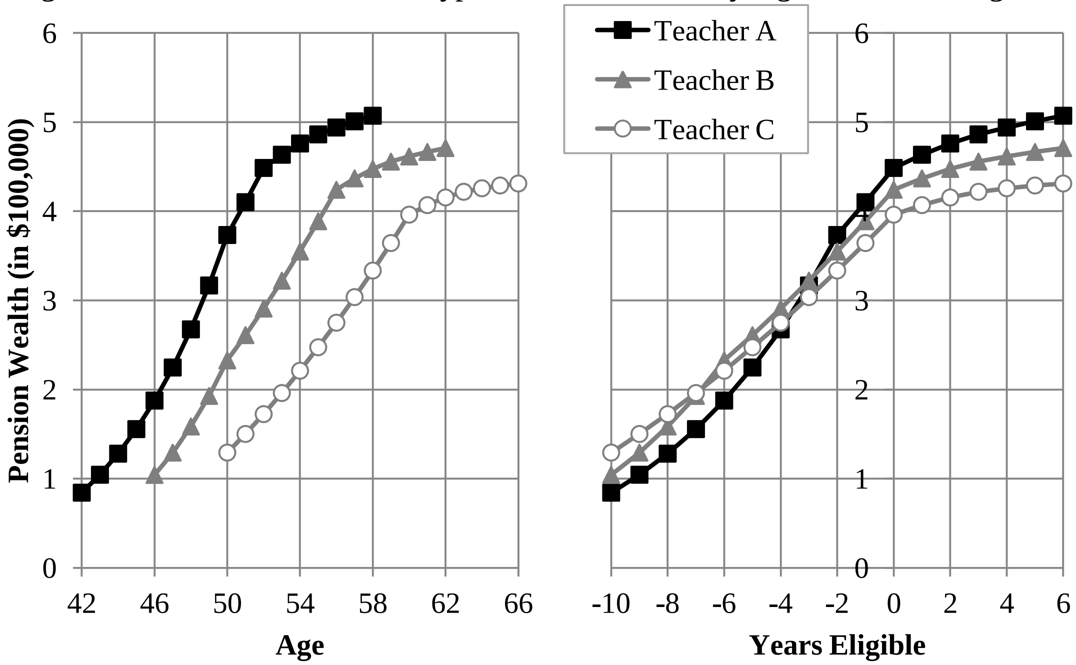
Note: Raw exit hazard for all individuals in full sample.

Figure 1.4. Exit Rates by Years of Experience: Marginal Percentage Leaving North Carolina Teaching



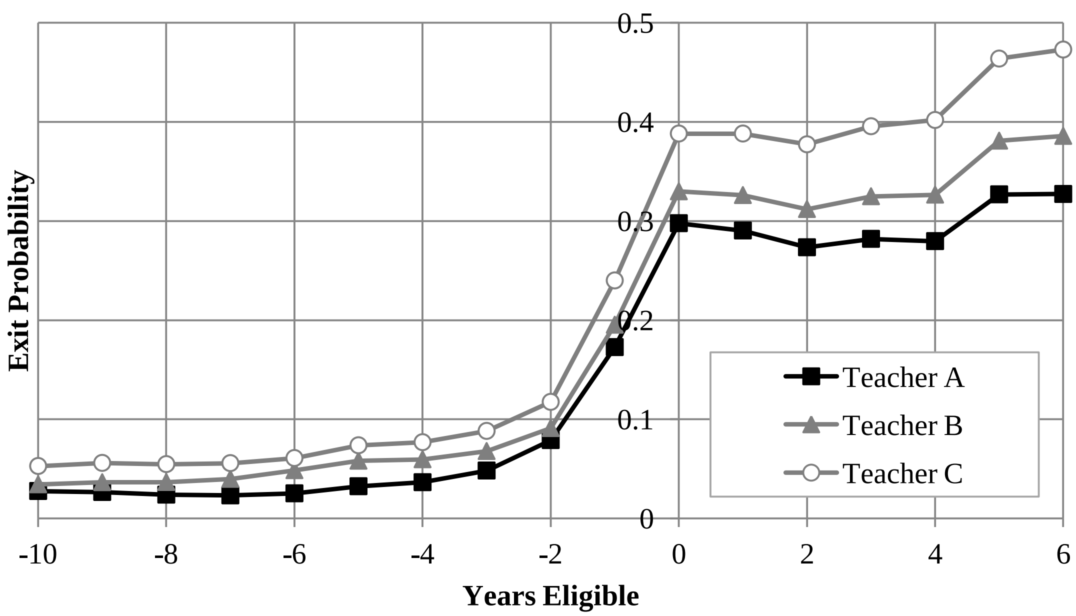
Note: Raw exit hazard for all individuals in full sample.

Figure 1.5. Pension Wealth for Hypothetical Teachers by Age and Years Eligible



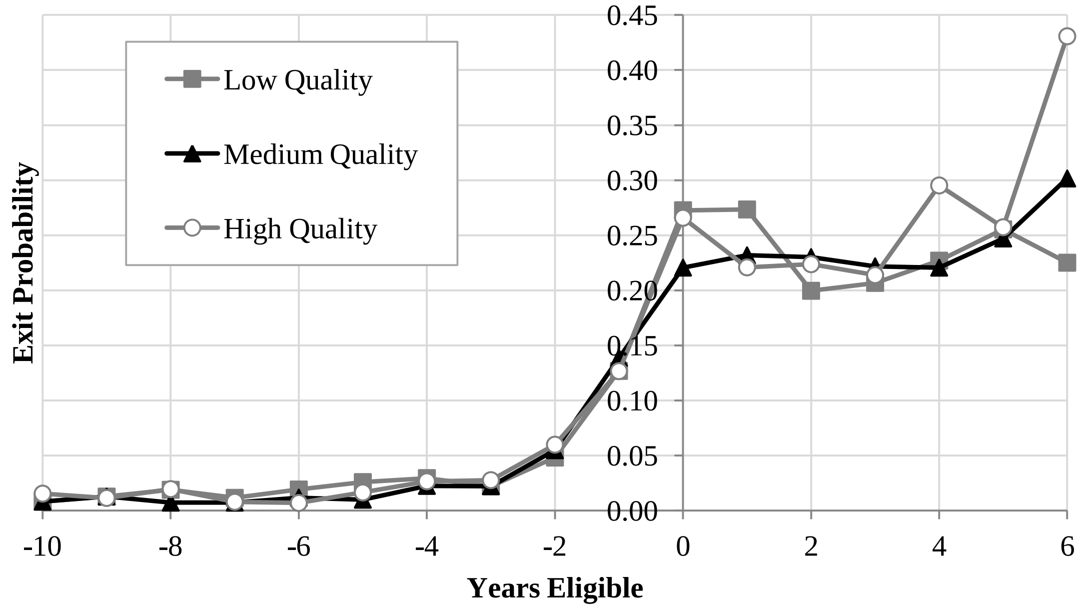
Notes: Teachers A, B, and C are hypothetical white females who started teaching at age 21, 25, and 29. I assume they are always paid according to the 2000-01 salary scale. Years Eligible corresponds to how many years an individual has until (if <0) or since (if ≥0) pension receipt eligibility.

Figure 1.6. Predicted Exit Probability for Hypothetical Teachers



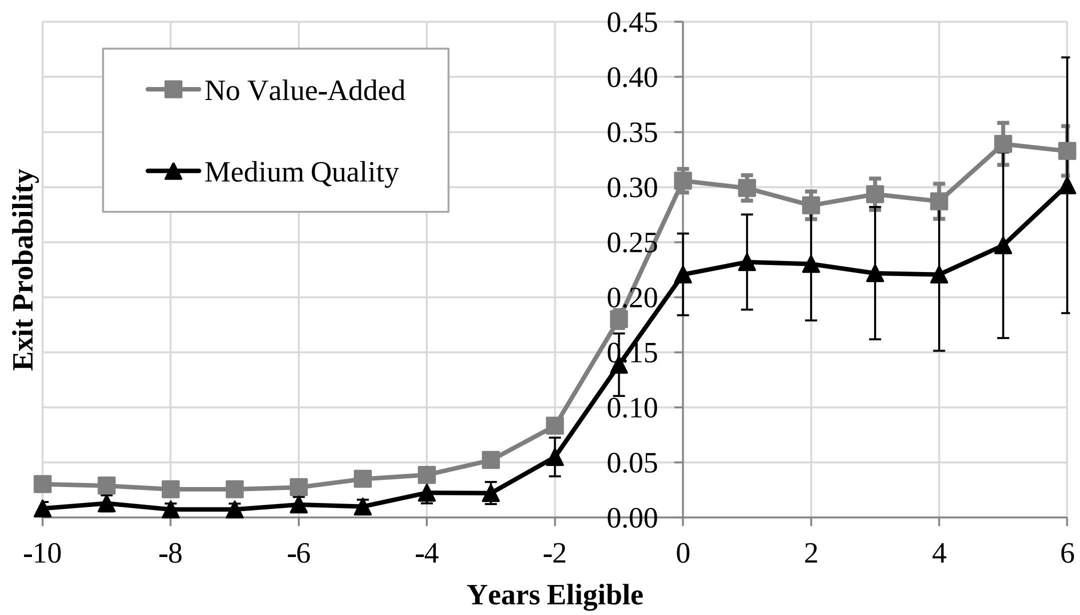
Notes: See Figure 1.5 for notes for definition of Teachers. Predicted probabilities calculated using probit specification in Table 1.5. For each value of Years Eligible, the exit probabilities across teachers are statistically different at the 1% level.

Figure 1.7. Predicted Exit Probability for Teacher A by Value-Added Quality



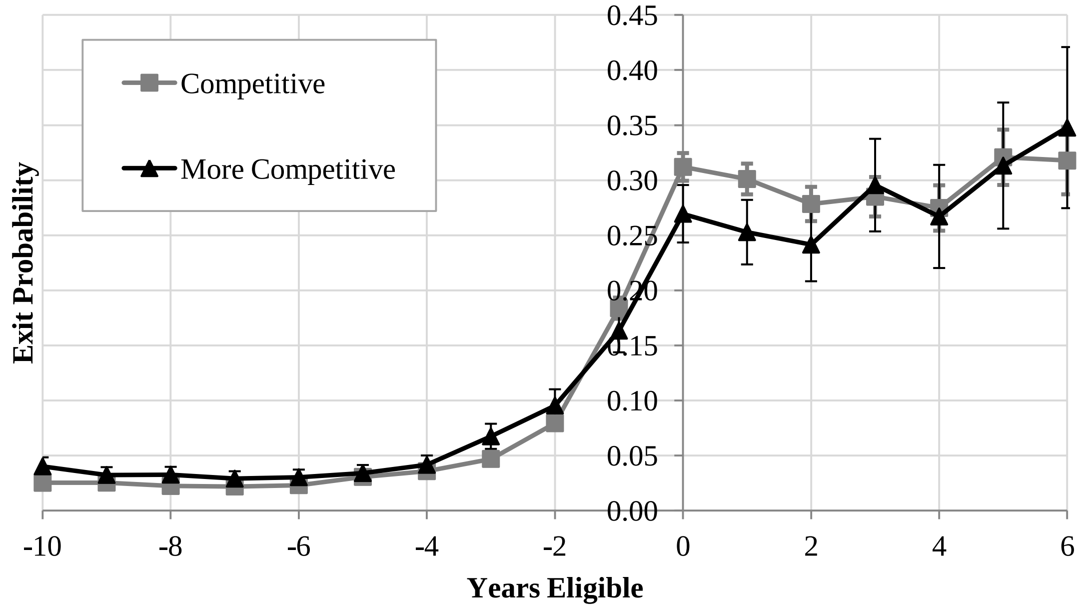
Notes: Predicted exit probability for Teacher A (see Figure 1.5 notes) using probit specification in Table 1.6 with interaction between quality and YrsElig. The difference between high/low quality vs. medium quality at YrsElig equals 0 is statistically significant at the 5% level.

Figure 1.8. Predicted Exit Probability for Teacher A With and Without Value-Added



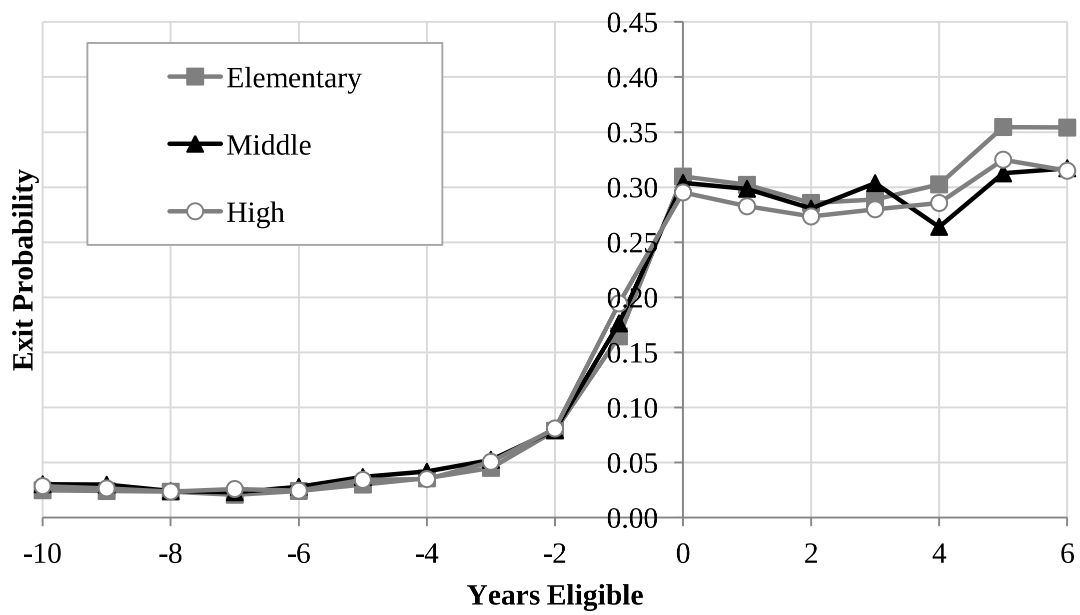
Notes: Predicted exit probability for Teacher A (see Figure 1.5 notes) using probit specification in Table 1.6 with interaction between quality and YrsElig. No Value-Added includes teachers for whom I cannot estimate value-added due to the grade or subject level they teach. Error bars show 95% confidence regions.

Figure 1.9. Predicted Exit Probability for Teacher A by College Competitiveness



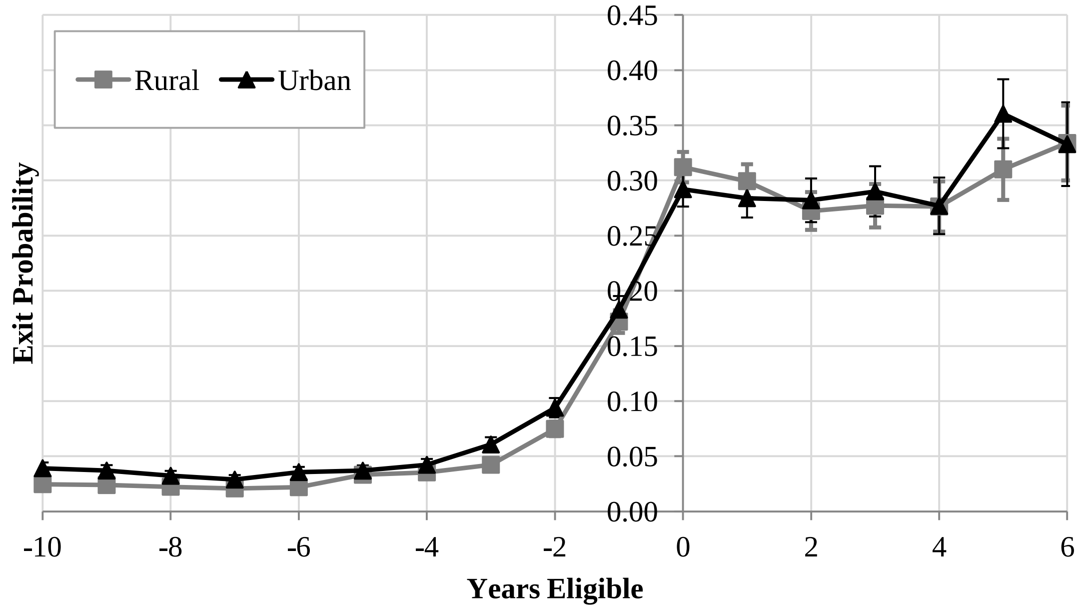
Notes: Predicted exit probability for Teacher A (see Figure 1.5 notes) using probit specification in Table 1.7 with interaction between college competitiveness and YrsElig. Teachers who attended less competitive colleges behave similarly to those who attended competitive colleges. Error bars show 95% confidence regions.

Figure 1.10. Predicted Exit Probability for Teacher A by School Level



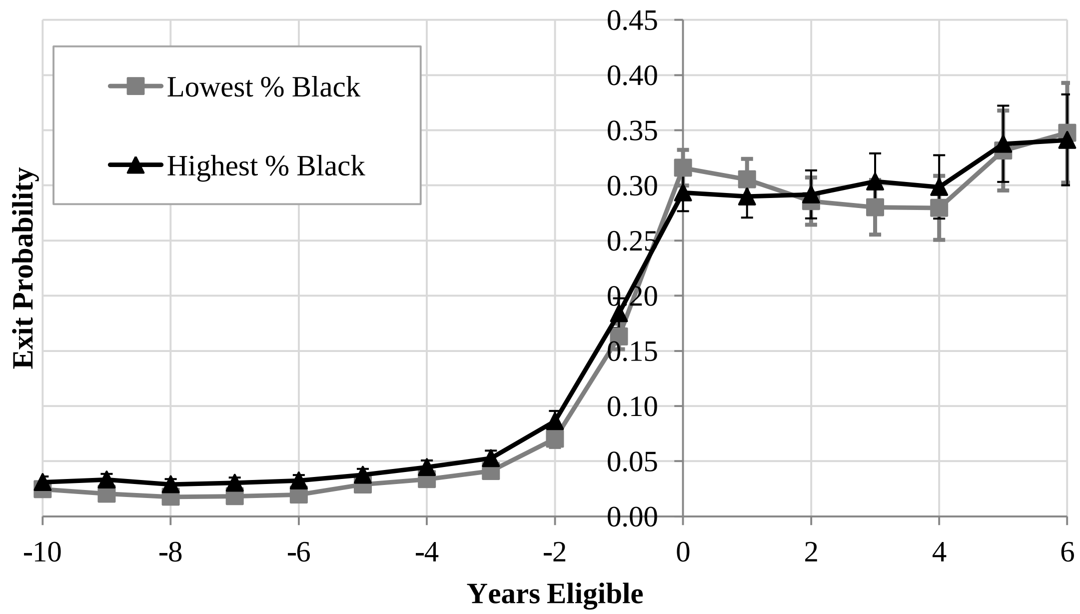
Notes: Predicted exit probability for Teacher A (see Figure 1.5 notes) using probit specification in Table 1.8 with interaction between school level and YrsElig. There are no statistically significant differences by school level.

Figure 1.11. Predicted Exit Probability for Teacher A by Urbanicity



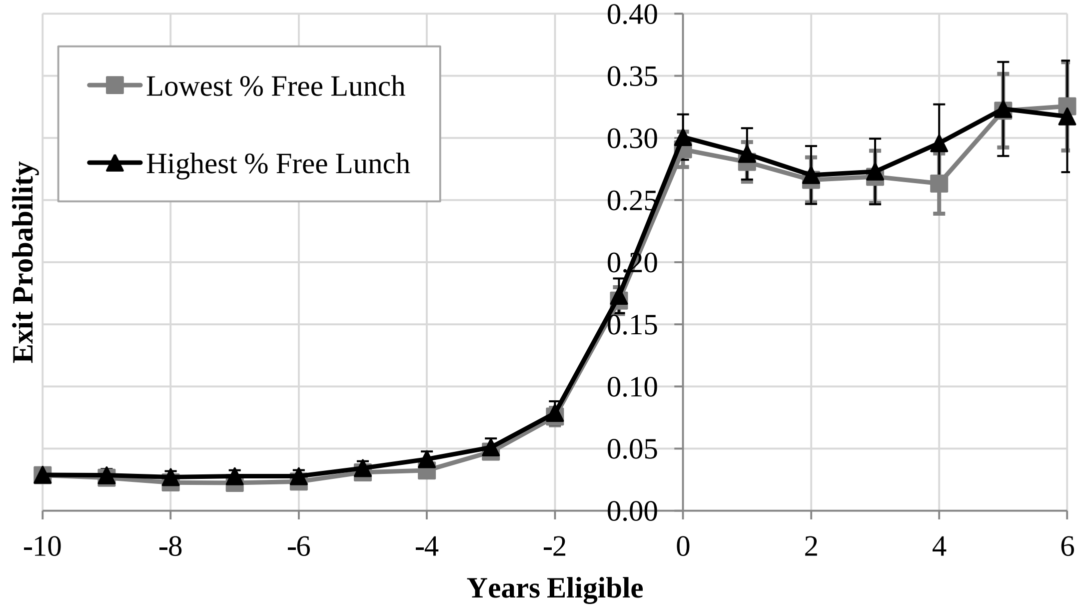
Notes: Predicted exit probability for Teacher A (see Figure 1.5 notes) using probit specification in Table 1.9 with interaction between urbanicity and YrsElig. Teachers who work in schools in towns or suburbs behave similarly those in rural schools. Error bars show 95% confidence regions.

Figure 1.12. Predicted Exit Probability for Teacher A by Quartile Percent Black Students



Notes: Predicted exit probability for Teacher A (see Figure 1.5 notes) using probit specification in Table 1.10 with interaction between quartiles marked by the school's percentage of black students and YrsElig. Error bars show 95% confidence regions.

Figure 1.13. Predicted Exit Probability for Teacher A by Quartile Percent Free Lunch Students



Notes: Predicted exit probability for Teacher A (see Figure 1.5 notes) using probit specification in Table 1.11 with interaction between quartiles marked by the school's percentage of students qualifying for free/reduced prince lunch and YrsElig. Error bars show 95% confidence regions.

Chapter 2

Lifting the Salary Cap: The Effects of a Return-to-Work Policy on Teacher Retirement, Retention, and Quality

2.1 Introduction

Between 1999 and 2009, a third of North Carolina's teaching workforce reached retirement eligibility (Figure 2.1). From the perspective of policy makers in the 1990's, this posed a potential problem. The retirement of the Baby Boomers might leave the state in short supply of teachers, as the Baby Boom cohort was one and a half times the size of the following cohorts, while student enrollment was projected to grow by 3.5 percent (Gerald and Hussar, 2003). Additionally, with the most experienced teachers retiring, education quality might decline with their departure.

The fact that Baby Boomers were fast approaching retirement eligibility was only problematic to the extent that teachers actually retired upon becoming eligible to receive a pension. As in most states, North Carolina offers teachers a defined-benefit (DB) pension plan. This plan offers an annual annuity – often more than half of her full-time salary – to an eligible teacher from the time she retires until she dies (in addition to Social Security, once she is eligible). Teachers are eligible to begin receiving their annuity when they reach certain age-experience thresholds, making most teachers eligible by their mid-50's. The structure of this pension systems creates large incentives to stay in teaching until eligible (the "pension pull"), and then to leave once eligible (the "pension push"), suggesting that the Baby Boomers were indeed likely to exit when they became eligible for benefits.

Policy makers in North Carolina initiated a Return-to-Work (RTW) policy in 1999 to coax retired teachers back into the workforce by paying them both their retirement annuity and their full-time salary at the same time. This policy was intended to

The research reported here was supported by the Center for Retirement Research at Boston College; Institute of Education Sciences, U.S. Department of Education, through Grant R305B090002 to the University of Virginia; and the Bankard Fund for Political Economy at the University of Virginia.

alleviate a potential teacher shortage along with concerns about losing experienced teachers. Without the policy retired teachers could still be employed by North Carolina public schools, but would have to forfeit their annuity if they made more than a set amount (the "salary cap", approximately half of their full-time salary). The RTW policy lifted the salary cap so that teachers who had been retired for (at least) a short period of time could earn any salary from North Carolina public schools while still receiving their annuity.

Initially this policy was restricted to teachers returning to substitute or interim jobs in low-performing schools, but after 2000 retirees could return to permanent jobs in any school. Teachers had to leave North Carolina public schools for six months to one year (depending on the policy in place at the time) and then could return if a school wished to hire them. In response, retired teachers did return to work: from 2007-2009 between four and five percent of the teaching workforce was "retired" returnees.

I study how the RTW policy affected teacher retention North Carolina public schools using administrative data on teachers and students from 1995 to 2011. I look at the effects on two spells of employment: the "first spell" when employed as a full-time *non-retired* teacher and the "second spell" when employed as a full-time *retired* teacher. For example, an individual can stop working full-time in 2004, ending her first spell, and begin claiming her annuity. In 2006, with the RTW policy in place, she can return to full-time teaching and begin her second spell, perhaps continuing to work until the policy expired in 2009.[1]

I investigate the effect of this policy on first spells by comparing the retirement behavior of individuals before versus during the RTW policy, under the hypothesis that RTW would result in individuals ending their first spell earlier in order to return to work and receive both their annuity and salary. I use a proportional hazard model, which captures the effect of covariates (including whether or not the RTW policy was in place) on the probability that an individual ends her first employment spell. This policy is likely to affect individuals differently based on their eligibility for pension annuity receipt: those who could not begin receiving their annuity would be less likely to retire and return

[1] In 2009 the salary cap was reinstated for all employees. Returning retirees who were receiving a full-time salary and their annuity had to revert to part-time work (earning less than the salary cap) in order to keep receiving their annuity, or continue working full-time and stop annuity payments.

than those who could. Therefore, I formulate the baseline hazard to represent the retirement propensity as a function of how many years one has been eligible (or how many years until one is eligible) for pension receipt. I include year effects to control for broad trends in the attractiveness of retirement (because of the business cycle, perhaps) and factors that may make teaching more or less attractive across all levels of retirement eligibility in a given year (e.g., the implementation of No Child Left Behind in 2003).

I find that those who have just become eligible to receive their pension are 16 percent more likely to retire when the RTW policy is in place, compared to those who become eligible before RTW. The number of teachers who work at least one year passed pension eligibility is 23 percent (8 percentage points) smaller during RTW. This effect would likely have been even larger if it were not for considerable uncertainty surrounding the future of the policy. The law was set to expire five times between 1999 and 2009, often just extended for one year at a time. There are only a few years when a full-time teacher would know that the she could retire, take the mandatory six-month/one-year break in employment, and return to work under this policy.

I additionally look at second-spell exits. A teacher in her second spell is receiving her pension annuity while working, whereas a teacher in her first spell may be forgoing her annuity in order to continue to work. First-spell teachers may respond to the "pension push" to retire, while second spell teachers do not face this incentive. Thus, the behavior of second-spell teachers shows how teachers might act in the absence of DB pension incentives – a pertinent piece of evidence for the current DB pension reform debate. Similar to the specification for first spells, I compare the behavior of individuals who have the same pension eligibility, but instead of looking before and after the policy, I compare the retention of first-spell versus second-spell individuals (in both pre-policy and policy periods) using a multiple-failure hazard model. I find that the probability of ending a first spell is twice that of ending a second spell. In fact, many returning retirees taught for four or five years after returning.

While the policy induced retired teachers to return to work, it is important to understand the characteristics of the teachers and the schools to which they returned. I find that the returning retirees have value-added (a measure of teacher quality based on gains in the teacher's students' achievement test scores) that is two percent of a standard deviation in student test scores higher than retired teachers who did not return. Given that the achievement of students of an average teacher grows about 0.25 standard deviations, an increase of 0.02 is equivalent to eight percent more learning (Hill et al., 2008). Moreover, returning retirees' quality is four percent of a standard deviation (students learn 16 percent more) higher than novice teachers with four or fewer years of experience. This comparison is relevant because many schools during this time period may have been deciding between hiring a novice versus a returning retiree. The schools where returning retirees retire from are generally of higher poverty levels and have a higher proportion of black students than typical retirees. I observe that over half of the returning retirees return to the same school they retired from, but many return to schools of higher poverty levels than they retired from, meaning this policy may have helped fill positions in hard-to-staff schools.

In Section 2.2 I describe the North Carolina Pension plan and, in Section 2.3, a review of the related literature. In Sections 2.4 and 2.5 I describe the details of the RTW policy, and the data and sample I use for my analysis. In Section 2.6 I lay out my empirical specification for both the proportional hazard models and my value-added specification, and explain my results in Section 2.7. Finally, in Section 2.8 I conclude and put forth some policy implications of this analysis.

2.1 Defined-Benefit Pension Plans

North Carolina teachers, along with most other public school teachers, are eligible for a defined-benefit (DB) pension plan that offers an annuity to an eligible teacher from the time she retires until she dies. In North Carolina the annuity equals 1.82 percent of the average salary earned by a teacher in her last four years, multiplied by the years of service she has in North Carolina public schools.[2] For a thirty-year teacher, the annuity is over half of her average salary. Teachers are vested in the system after five years of service, which means they can later receive an annuity once they pass certain age-

[2] Years of service is correlated with the years of experience a teacher has, but could be more if the teacher has transferred service from work in other public sector positions. Teachers have the option of trading unused sick days and personal days for additional years of service as well. I use the years of experience (according to the salary step that an employee is paid) to approximate years of service.

experience thresholds.[3] Teachers reach full-benefit eligibility at age 60 with experience of 25 years, age 65 with experience 5, or any age with experience 30. Vested teachers can retire short of these thresholds and receive a reduced benefit (reduced by 3-5 percent per year short of full retirement threshold) at age 50 with experience 25, or age 60 with experience 5.

The value of one's stream of annuity payments is called pension wealth. Specifically, the pension wealth of individual i who exits teaching in year t and receives annuity $annuity_{it}$ is the present discounted value:

(2.1) $PensionWealth_{it} = \sum_{s=t}^{T} \beta^{s-t} \pi_{s|t} annuity_{it}.$

Payments received later in life are less valuable than those received sooner, as shown by the discount rate β, which I assume to be 0.95. Because the annuity is only received when a person is living, the value of an annuity in period s is discounted by the probability $\pi_{s|t}$ that one is alive in the later period to receive that payment (conditional on being alive in period t).[4]

As seen in Figure 2.2, pension wealth grows quickly – increasing as much as 56K in one year – until age 52, when a teacher is eligible to receive her full annuity immediately upon exit. Costrell and Podgursky (2009) and Friedberg and Turner (2010) describe how DB pensions "pull" teachers to stay mid-career, as their annuity grows with more experience and higher average salary. During times when a teacher is ineligible to receive pension benefits for many years, exiting is not an attractive option, as she would be without salary or annuity (from the North Carolina public school system) until she crosses an eligibility threshold; furthermore, she would be giving up large gains in pension wealth and her annuity would not be inflation-adjusted during the interim. Upon reaching eligibility, Figure 2.2 shows that pension wealth begins to level off right after eligibility, and eventually declines. In actuality, even though pension wealth continues to increase for a few years after eligibility, these gains are not worth waiting for once they are actuarially adjusted to take into account the additional time one must wait to receive

[3] Teachers who leave the system prior to becoming vested are given a refund of their retirement contributions. Vested teachers can also receive a refund of their contributions (plus interest) in lieu of an annuity, but this would be valued at considerably less the value of the annuity in the future.

[4] I calculate $\pi_{s|t}$ using life tables by gender and race (white, black, Hispanic, and other) from the National Center for Health Statistics for the year 2006 (Arias 2010a, 2010b).

them. Thus, the “pension push” results from the fact that forgoing one’s annuity – money one would never get back – is a larger cost than the small increase in the annuity that would result from continuing to work.

Figure 2.3 shows the survival and hazard functions by age and years of experience for first employment spells. The survival function by age shows, for example, that around 70 percent of those who were teaching at age 40 are still teaching at age 50. The hazard for experience shows that 25 percent of those who have 30 years of experience promptly end their first spell. Many of the discrete jumps in the exit hazard coincide with teachers becoming eligible for retirement benefits. Figure 2.4 shows the survival function and hazard by pension eligibility, the number of years since one is eligible for immediate annuity receipt upon retirement. There is a pronounced jump when one becomes eligible for annuity receipt (when pension eligibility equals zero).

It would be useful to control for the effects of pension wealth and pension accumulations across individuals in my analysis of the RTW policy, as these factors describe the magnitude of the pension “pull” and “push”. I show in Mahler (Chapter 1 of this dissertation) that, because individuals in my sample are paid according to very similar salary scales and the same pension system, most of the variation in pension wealth across North Carolina teachers is driven by the eligibility thresholds. Thus, I assert that everyone with the same pension eligibility has very similar incentives to stay or retire. Furthermore, controlling flexibly for an individual’s pension eligibility, age, years of experience, monthly salary, and time working subsumes 98 percent of the variation in pension wealth. Thus, while pension wealth itself is not in my empirical specification, I do control for the vast majority of factors that would cause one individual to have a different level of pension wealth than another.

2.2 Literature Review

My study adds to two strains of literature. The first explores the relationship between pension incentives and retirement, including teacher retirement, and studies changes in retirement incentives. The second concerns the measurement of teacher quality and the mobility of high- versus low-quality teachers.

Pension incentives and retirement. Coile and Gruber (2000, 2007) and Friedberg and Webb (2005), define pension incentives based on the way that pension wealth changes as one continues work, showing that these incentives have substantial effects on retirement behavior. Coile and Gruber developed a measure of pension incentives termed “peak value” to describe the additional pension wealth one would gain (or lose) by continuing to work. Peak value was a departure from structural estimation of the effect of DB plans on retirement (Stock and Wise, 1990; Samwick, 1998). My study is different from these papers employing the peak value method because all individuals in my sample are on the same pension system and similar salary schedules, as opposed to across many different industries. In this paper I follow my previous work (Chapter 1 of this dissertation) and set my baseline hazard to absorb the pension incentives, so my results are based on variation within each pension eligibility category. This allows me to test if the policy caused individuals to behave differently when faced with the same pension incentives, and how the policy changed pension incentives for the retirees who returned to work.

A rapidly growing body of literature studies teacher pensions and retirement. Costrell and McGee (2010) describe how teachers respond to pension incentives in Arkansas. Fitzpatrick (2013) exploits a policy change in Illinois and finds that teachers value their pension benefits at a level well below their cost, calling into question the efficiency of highly back loaded compensation. A number of papers look further at teacher quality (or student achievement) and teacher retirement. Mahler (Chapter 1 of this dissertation) shows few differences in teacher retirement patterns by teacher quality (value-added), in agreement with Koedel, Podgursky, and Shi (2013). Fitzpatrick and Lovenheim (forthcoming) shows that an early retirement incentive resulted in a small positive effect on student achievement. These and other studies consider teacher labor markets only through the supply-side – focused on how teachers make decisions about whether or not to work – but my study exploits a unique policy change that affected teacher labor markets through both demand and supply. On the supply-side, the RTW policy removed the pension “push” for some teachers, allowing them to receive both their salary and pension benefits. On the demand-side, RTW gave schools the choice whether or not to hire a returning retiree. My finding that higher quality retirees returned to teaching is in contrast with the previous literature; but this is likely driven by schools choosing those individuals as opposed to high-quality teachers being more interested in returning.

North Carolina was not the first to try to dampen the pension “push”. Forty states have or have had policies in place for state employees to return to work after retirement (National Association of State Retirement Administrators, 2012). For example, Costrell and McGee (2010) describe a Deferred Retirement Option Plan (DROP) program for Arkansas teachers, but the program is in place during the entirety of their study and is treated as a complication to the retirement system rather than the focus of their paper. Alva et al. (2010) report that 33 public sector pension plans in 2010 offered DROP plans, which allow individuals to continue working for a set period of time while their pension benefits accrue in an interest-bearing account. Eventually, workers retire and gain access to the account where pension annuities were deposited. Alva et al. investigate the effects of one DROP program that covered Philadelphia City employees. They find that the implementation of the DROP program is associated with 2-15 months of additional work, but that individuals opt into the DROP program 2.1 years earlier than they would have otherwise retired.

There are four important differences in my analysis of the North Carolina RTW program, compared to the Philadelphia DROP program. First, I use a hazard model, instead of a probit, to describe the propensity to retire. A hazard model takes into account the absorbing nature of retirement (individuals conventionally do not return) and produces consistent estimates of standard errors associated with retirement hazards, whereas a probit does not. Second, the North Carolina RTW policy allowed individuals to receive their pension benefits contemporaneously with their full-time salary, instead of payments in an account that they can have access to once retired. Given evidence of teacher’s valuation of retirement compensation from Fitpatrick (2013), the value of receiving money now through RTW may be much more salient than the benefits of the DROP program. Third, Alva et al. have limited data to describe the nature of selection into the DROP program, particularly of how employees select in based on their quality. I have measurements of some teachers’ quality as measured by the test score gains of their students. Fourth, the RTW policy forced retirees to stop teaching for six months to a year, whereas DROP programs allowed continuous employment.

Teacher mobility and quality. This study adds to a large body of literature on teacher retention, and builds on studies using value-added measures of teacher quality. My research focuses on teacher behavior as it relates to a different type of pecuniary variation than has traditionally been studied: retirement compensation. I leverage the RTW policy to see how returning retirees sort among non-pecuniary aspects of schools, such as working conditions. I use value-added measures to describe teacher quality in late-career transitions (as opposed to early-career transitions, as is generally the focus), including the positive selection of retirees returning to work under RTW.

Research shows that teachers respond to both pecuniary and non-pecuniary aspects of their jobs (e.g., Brewer, 1996; Stinebrickner 1998, 2001, 2002; Hanushek et al., 2004; Lankford et al., 2002; Clotfelter et al., 2006; Boyd et al., 2007). Many papers study the effect of current compensation on teacher turnover using variation in pay scales across districts, which may be endogenous, or salaries in alternative occupations, which are difficult to accurately measure (e.g. Podgursky et al., 2004; Hanushek et al. 2004). I use variation in benefit-eligibility thresholds in order to gauge a teacher's pecuniary trade-offs between teaching and retiring. These thresholds are driven by exogenous factors such as a teacher's age and years of experience. Additionally, I leverage the change in retirement earnings created by the RTW policy, which made retirement potentially more lucrative than it was before.

With respect to non-pecuniary job aspects, research has documented the sorting of different types of teachers across schools, concluding that schools with more disadvantaged students are likely to have high teacher turnover along with more inexperienced and less effective teachers (Clotfelter et al., 2006; Boyd et al., 2007). I find that retired teachers are more likely to return to high-poverty schools, potentially helping students in schools that have a hard time attracting and keeping high-quality teachers. While this selection may be driven by schools' demand for retirees, RTW is an example of an incentive structure that successfully brought teachers to hard-to-staff schools.[5]

---

[5] Some selection of retirees to high-poverty schools could be due to the policy requirements restricting retirees to only returning to high-needs schools in the first two years of the program (explained in the

Another branch of literature focuses specifically on the qualifications and quality of retained teachers. These studies show that teacher retention varies by teachers' general knowledge test scores and the competitiveness of the college attended, finding that those with better credentials are more likely to exit (Boyd et al., 2005; Lankford et al., 2002). Researchers have employed value-added measures of quality to assess teacher retention and generally find that more effective teachers are more likely to remain, especially early in their careers (Rivken et al., 2005; Boyd et al., 2007). A teacher's value-added is estimated using the average growth in her students' achievement during the school year after controlling for a variety of student and class covariates. Some researchers have raised concerns about the use of value-added measures to accurately evaluate an individual teacher's effectiveness due to non-random assignment of students to teachers (Rothstein, 2009). I estimate value-added employing a teacher's students over multiple years, which Koedel and Betts (2011) show reduces this possible bias. Furthermore, Chetty et al. (2011) find no bias in traditional value-added estimates when compared to those estimated including the previously unobserved parent characteristics (that have the potential to create bias). Chetty et al. shows that having a teacher with high-value added has significant impacts on children's lives, including a higher likelihood of attending college and earning a higher salary, making it a valuable measure of teacher quality.

A number of studies look at early-career teachers and find that those with higher value-added are more likely to stay than exit (e.g. Boyd et al., 2007; Goldhaber et al., 2011). I find that teachers who return after retirement have higher value-added than those who did not return. Additionally, returning retirees have higher quality than novice teachers, which is in agreement with literature that shows novice teachers increasing quality in their first five years, and leveling off afterward (Rockoff, 2004).

While much of the research on teacher attrition looks at early-career teachers, I focus on mid- and late-career exits. Early-career teachers may be induced to leave simply because they do not like the profession, they do not receive tenure, or for other personal reasons (such as starting a family). Mid- and late-career exits are different from these along important dimensions. First, mid- and late-career individuals face different

---

following section). However, fewer than 50 retirees returned during those policy years, in contrast to over 200 the following year. Thus, policy rules were not a major force driving this selection to schools.

incentives to stay and exit – the pension “pull” and “push” described earlier. Second, many of these individuals are likely leaving teaching and the workforce, as opposed to leaving teaching for another profession. Third, these are all tenured teachers with job security, making their exit driven by personal choice as opposed to an institution formally asking them to leave. Fourth, late-career teachers are a select group of their original teaching cohort, many of whom have exited years before my dataset begins – a complication for my current analysis. Studies that focus on teachers from the beginning of their career can model and observe this selection process, but, given my data constraints, I model teacher behavior conditional on teaching passed age 40.

In the following section I outline the policy environment and structure of the RTW policy, which creates the exogenous variation in incentives to retire and retire that I leverage in my empirical specification.

2.3 Return-to-Work (RTW) Policy

Even without the RTW policy, retired teachers could continue to work in public schools, but there was a cap on how much salary they could get while getting their pension (50 percent of the inflation-adjusted salary they received when they were teaching).[6] The RTW policy lifted the salary cap for individuals under certain conditions that I discuss below, and are described in Table 2.1.

Note that I treat RTW as a uniform policy over its entire duration, even though the policy changed in potentially important ways over these 10 years. While these policy changes potentially allow me to gauge the effects of separate elements of the program, many of the variables changed at once or changed too frequently to explore individually. Moreover, teachers’ expectations of the policy may be changing in unknown ways over the course of this time period, making it difficult to isolate what change prompted their decisions.

The original law laid out the specifics of who could return and what school and position they could return to – many of which were changed in later legislation (see Table

[6] Part-time positions could be more attractive to retirees than other potential employees because retired teachers receive health insurance from the state and Social Security (once eligible).

2.1). The initial law, passed on October 30, 1998, made effective as of January 1, 1999, was very restrictive:

> Any retired teacher could return to a low-performing school in a geographic area where there is a shortage of teachers in her area of certification. She could return to non-permanent employment (substitute or interim) after a one-year break in employment (except for substitute teacher work).[7]

In 2000 many restrictions were lifted and teachers could return to any school (regardless of certification area shortage) and take on permanent employment. The law was slightly more restrictive in that the break in employment must be immediately preceding reemployment. In 2001 the break in employment was decreased to 6 months. In 2004 districts who hired a retiree had to pay 11.7 percent of the individual's salary to the retirement system. In 2007 they made the law more restrictive in order to discourage individuals from retiring with reduced benefits in order to return to work under this policy. As seen in Table 2.2, as the law became less strict more retirees returned to work. In 1999 only 11 retirees were working full-time; in 2009 1,663 retirees were working – over five percent of full-time teachers. During the entire RTW policy period over 9 percent of teachers who retired between 1995 and 2008 returned to work (Table 2.3).

In order for the policy to potentially cause teachers to "retire" and return, they needed to believe they could do so. The original law was set to expire on June 30, 2003, but was extended to 2004, 2005, 2007, and finally expired in 2009. The expiration of the policy is an important consideration to someone thinking about retiring and returning because reemployment is not immediate – teachers must have a six-month to one-year break in employment before they can return. Table 2.4 shows that the impact of this policy on the decision to retire varies by year. Consider a teacher who might retire in 1999 (top row of Table 2.4). In 1999 the RTW policy was set to expire in the spring of 2003. The teacher could retire in 1999, not work in 2000, and could return full-time in 2001, 2002, and 2003. A teacher considering retirement in 2002, however, finds that the policy may expire in the spring of 2003, making it impossible for her to take a year off of

[7] A break in employment was necessary to satisfy the Internal Revenue Service guidelines of what constitutes a retirement.

work and return to work full-time unless the policy is extended again by law. In actuality the policy expired in 2009, but in the moment that most individuals were considering retirement they did not necessarily know the policy would be extended for that long. Thus, the impact from the RTW policy on first-spell exits is likely smaller than it would have been in the absence of the policy's uncertainty.

Regardless of how long individuals *thought* they could work under this policy (if at all), over half of returning retirees were still working in 2009, just before the policy expired (Table 2.5). Of the 489 teachers who retired in 2003 and returned, over 40 percent were still working six years later. Thus, the incentives to return to teaching – earning 150 percent of a teacher's salary – were effective at attracting and keeping individuals in teaching.

The cost of the RTW policy depends on the relative cost of hiring a novice teacher (salary, plus health benefits, and, retirement benefits) versus paying a retiree a salary (who makes a high salary, but is already receiving health and retirement benefits). A novice teacher starts out receiving a salary that is 60 percent of a returning retiree, but, a novice's salary will rise as she continues to work. A novice may also be less effective in her first few years as she gains experience and learns on-the-job. A retiree, on the other hand, is already receiving health and retirement benefits (regardless of whether she returns), but would get a high salary upon returning. Thus, for one year, the difference in cost between a novice and returning retiree would be the difference in their salaries minus the cost of health insurance – making the retiree very expensive. But, the long-term cost of hiring a new member of the teaching workforce would include the present discounted value of all of her salary and benefits over her career. Hiring a retiree could mean putting off hiring a new teacher, making a retiree less expensive than simply the year-to-year tradeoff. One might argue that the appropriate comparison is not the retiree versus the novice, but the retiree before and after the policy. With my data, it is impossible to see how many people return to work after retirement in the absence of the RTW policy, but North Carolina discourages this practice. Without RTW, if a retired teacher returns then she stops receipt of her annuity, and her annuity value does not reflect any additional years of work or increase in salary until she has worked for three post-retirement years. Thus, if a teacher needs to stop working but expects to work full-time in the future, she would likely not retire and return, but simply take a leave of absence. Therefore, the RTW policy does make a previously retired teacher more expensive than she was before (because now the annuity has to be paid while she returns to work), but a previously retired teacher was likely not a viable option before the RTW policy.

2.4 Data

I use data from the administrative records of all North Carolina public school certified employees and students over the 1994-1995 through 2010-11 school years. These data are maintained by the North Carolina Education Research Data Center (NCERDC). These records follow individuals over time and link students and teachers to classrooms in schools. I observe a teacher's years of experience, salary, college graduation year, and basic demographic information, but do not know exactly how many years of service she has in the retirement system or her precise age. I explain below how I use these data to calculate pension eligibility and other important variables used in my empirical specification.

Data on Teachers. In order to calculate pension eligibility, I need each teacher's age and years of service. I do not observe age, but know college graduation date and impute age assuming someone is 21-years-old upon graduation.[8] I do not observe a teacher's total years of service (the total amount of time someone has worked in the public sector, including years transferred or purchased), but use her years of teaching experience, which I am able to observe given their salary step. Although these variables are measured with some error, the substantial jump in the hazard rate at zero pension eligibility shows that my calculations are capturing the major facets of pension incentives (Figure 2.4). Importantly, I observe a salary code that distinguishes returning retired teachers (those exempt from the salary cap) from other teachers. I also observe the teacher's salary, months worked, race and sex, which are included as covariates in my hazard model. I use information on the school where she works, including the

[8] Age 21 is likely an underestimate of the age at which individuals graduate from college, making some people eligible for their pension sooner than I calculate. There is no reason to believe that this measurement error would differentially affect time periods before versus during the policy, which would be a problem for my analysis of RTW.

characteristics of the student body of the school, to describe retirement and returning patterns.

One difficulty with administrative data is that I only observe a snapshot of who is employed each year. If someone is absent from the data in one year it is difficult to distinguish whether she is on a leave of absence or has terminated her employment – an important detail when studying retirement. I define the end of an individual's first spell of employment according to two rules. First, an individual ends her first spell is she has a break in employment for more than three years. Second, I mark an individual as having ended her first spell in the year previous to the first observation linked to the salary code showing that she is exempt from the salary cap. Similar to the first rule, I mark an individual's second spell of teaching as ending if there is a break in employment of more than three years. The definitions described above have the advantage of treating everyone as having three years to come back to work by dropping any observations observed after a three-year break. According to this rule, if individuals take longer than three years to return to work under RTW, their second spell will be discarded. If I limit the break between the first and second spell to be three years, the number of retirees who return is 2,688; and if I allow for breaks longer than three years (just for those who return under RTW) there are 3,258 returning retirees (Table 2.6). I run the analysis with both of these samples and find no substantial differences in my results. I show results for analysis using all those who ever return, regardless of return timing.

A disadvantage of requiring three years of data to see if someone returns is that the last three years of my data set must be excluded from the analysis. In this case, that is actually fitting, as 2009 is the last full year of the policy, when many retirees working in the school system have to exit simply because the policy is ending. I do not want my estimates to reflect the change in behavior due to the policy ending, so I exclude observations from 2009 and later.

To define my sample, I start with full-time teachers who are at least 40-years-old, as this is a group whose behavior is likely to be influenced by pension incentives (as seen in the rapid accrual growth beginning around age 40 in Figure 2.2), and have at least five years of experience, making them vested in the retirement system. As seen in Table 2.6 this initial group consists of 89,676 teachers. Due to missing or unreasonable data, I exclude about a quarter of these individuals, and my final sample is 63,823. 5.1 percent of these individuals return as retirees at some point; and 4.2 percent return within three years of their retirement.

I tabulate the number of returning retirees by retirement year for these two samples in Table 2.3. First, note how the number of retirees increased from around 2,000 in 1995 to around 3,000 from 2003 to 2007, then back down to around 2,400 in later years – showing the relative size of the Baby Boom cohort about which the 1999 policy makers were concerned. Regardless of the timing of the retirees' return, the middle and right columns show that the bulk of the returning individuals retired after 2000, with 2005 retirees being the largest cohort (over 15 percent of them returning to work).

Data on Students. From 1998-99 through 2007-08 I observe students' 3rd- through 8th-End-of-Grade (EOG) math and reading test scores. I calculate value-added for 7,819 4th- or 5th-grade teachers, including around 17 percent of individuals who retire and return. [9] I include observable student and class characteristics in the value-added model in order to control for differences across teachers' teaching assignments (within and across schools). These characteristics include students' race, sex, exceptionality status, limited English proficiency status, and free/reduced price lunch eligibility.

I observe school characteristics such as enrollment, student demographics, and urbanicity using the Common Core Data.[10] In some analyses I split schools into quartiles (over all schools within that year) of percent free/reduced price lunch and percent black students.

2.5 Estimation Strategy

In this section I explain my strategy for estimating the effects of the RTW policy, and describe my teacher quality (value-added) measure. Because I am interested in the

---

[9] I am unable to calculate value-added for middle school teachers. The data link students to the teacher who proctored their exam. For elementary school teachers, the proctor is likely the teacher. For middle school students, the proctor is likely their homeroom teacher, who may not be the student's math or ELA teacher. To check if the proctor is the instructor, I follow Xu et al. (2008) and compare the student composition (class size, number of white students, number of male students) of the tested class with that of the class that the proctor instructs (data from a separate source). I cannot calculate value-added for 3rd-grade teachers because there is no 2nd-grade test to measure test score growth.

[10] If the data on student characteristics are missing, I impute data from the closest non-missing year for that school.

duration of employment, I use hazard models to characterize the impact of RTW on different aspects of these durations. First, I focus on the impact of the RTW on first spells of teaching to see if there is evidence of individuals ending their first spell early during RTW in order to return. Second, I compare second and first spells to decipher the effect of different retirement incentives on behavior. Lastly, I describe my value-added measure of teacher quality.

Estimating RTW Policy Effect on First Spells. I use a Cox proportional hazard model to estimate differences in first-spell exits caused by the RTW policy. Teachers may end their first spells earlier in order to return. The sample for this analysis is the first spell of all individuals, including individuals who retire and return as well as those who do not. This sample is limited to only include observations for people who are at least 40 years old, and who have at least 5 years of teaching experience. In this specification, ending one's first spell is considered an absorbing state (although the RTW policy changed this). Recall that I characterize pension incentives in terms of pension eligibility, the number of years that an individual has until reaching the pension eligibility threshold (counted in negative numbers) or has worked after passing the threshold (counted in positive numbers). For teacher i at pension eligibility p in district d at time t, the instantaneous hazard rate is:

$$(2.2)\quad \lambda_{idpt} = \lambda_0(p)\exp\Bigg(\left\{\sum_p \alpha_{1,p} 1\{PensionElig_{idpt} = p\} \times RTW_t\right\} + \alpha_2 Age_{idpt} + \alpha_3 Age_{idpt}^2 + \alpha_4 Experience_{idpt} + \alpha_5 Experience_{idpt}^2 + \alpha_6 Salary/Month_{idpt} + \alpha_7 MonthsWorked/Year_{idpt} + \alpha_8 Female_{idpt} + \alpha_9 Black_{idpt} + \alpha_{10} OtherRace_{idpt} + \delta_d + \tau_t\Bigg)$$

$\lambda_0(p)$ is a the nonparametric baseline hazard function, which absorbs differences in retirement propensity related to pension eligibility. The retirement pattern related to the "pull" and "push" of pensions will be captured in the baseline hazard. The advantage of a Cox proportional hazard is that I do not need to assume a functional form for the baseline hazard function, allowing the data freedom from conforming to any parametric representation.[11]

The exponential function describes how individuals' covariates result in a proportional shift of the baseline hazard. These coefficients will be estimated off variation in behavior within pension eligibility values. The key covariate in the exponential function is a vector of indicator variables for the individual's pension eligibility value p, which are interacted with an indicator showing that the RTW policy is in place. The baseline hazard controls for the effects of pension eligibility in the absence of RTW, so the $\alpha_{1,p}$ coefficients are identified off of differences in the baseline hazard contemporaneous with the RTW policy for individuals who have the same pension eligibility – these are my coefficients of interest.

If the RTW policy induces some people to retire and return, they are likely to be individuals who can begin receiving a pension (whose pension eligibility is at or above 0). Individuals who cannot receive a pension upon ending their first spell would not benefit from the policy because they would not receive both their pension annuity and salary at the same time upon returning to work. North Carolina allows individuals to retire and begin claiming their pension before eligibility, but their annuity amount is lower than it would be at normal eligibility. Some teachers who are eligible for this early annuity may opt to retire and return under this policy if having an extra year of annuity payments outweighs the decrease in annuity amount. It is unclear what the effect of RTW might be for those well past eligibility. If they were already past eligibility before the policy came into place, they may be more likely to retire as a result of the policy; however, individuals in the policy period who continue to work despite the policy may

[11] Eliminating the need to choose a functional form for the baseline function is particularly useful given that I am looking for a sharp change in the hazard rate at particular pension eligibility values – an effect that could easily be obscured by forcing baseline hazard to follow a smooth functional form. That being said, there are some advantages of assuming a functional form the for hazard; for instance, including individual-specific random effects to capture latent characteristics (enjoyment of teaching, income of spouse) that might influence whether or not an individual exits teaching. My results are qualitatively similar if I assume a Weibull, loglogistic, exponential, and Gompertz distributions for the baseline hazard. These models are similar to equation (2.2) but include a constant term and indicators for pension eligibility that are not interacted with RTW, in addition to indicators that are not, with pension eligibility less than -10 as the omitted category. These additional indicators allow the RTW effect to be identified off of differences between pre- and post-RTW behavior at a specified level of pension eligibility, as opposed to differences between the baseline hazard evaluated at a value of pension eligibility and post-RTW behavior, which could be driven by the baseline's lack of fit to the data.

have a particularly strong willingness to teach and be more likely to stay than those who have left. The τ indicator variables absorb the average year-to-year differences in the propensity to teach that could be confounded with the RTW policy. For example, these indicator variables would absorb the effect of No Child Left Behind in 2003, which may have made teaching particularly unappealing and cause teachers to end their first spell regardless of their pension eligibility.

I also include smooth quadratic functions of age and experience, which may influence retirement independently of one's pension eligibility. These control for compositional changes across the pre- and during RTW policy periods. It is important to account for differences in pension wealth, defined in equation (2.1), which represents the pecuniary benefits of retiring; however, 98 percent of the variation in pension wealth is due to the covariates in the model (and pension eligibility, in the baseline hazard), so I exclude it from the model. I include monthly salary and number of months worked per year to control for differences in the pecuniary benefits of continuing to teach. Lastly, I control for differences in teacher demographics (race and gender), and in time-constant differences in local labor market conditions across the state by including indicators for each district δ.

Estimating Differences in First versus Second Spells. I use a multiple-failure proportional hazard model to isolate differences between first versus second spell exits. Unlike the hazard specification above, a multiple-failure model does not treat ending one's first spell as an absorbing state – making it fit for use with RTW, which allowed individuals to come back after the completion of their first spell. In this case, ending a first spell is not necessarily absorbing, but ending a second spell is. For example, a returning retiree will end her first spell, return, and later end her second spell. These differences could arise because returning retirees (those in their second spell) do not face the same "push" out of teaching as those in the first spell. Second-spell teachers receive their pension benefits as they teach, while first spell teachers who are pension eligible must give up an annuity in order to continue teaching. I model the timing of when individual i in district d at time t ends an employment spell – either her first or second spell. The instantaneous hazard rate is:

$$(2.3)\ \lambda_{idpt} = \lambda_0(p)\exp\left(\left\{\sum_p \beta_{1,p} 1\{PensionElig_{idpt} = p\} \times SecondSpell_{itdpt}\right\} + \left\{\sum_p \beta_{2,p} 1\{PensionElig_{idpt} = p\} \times RTW_t\right\} + \beta_3 Age_{idpt} + \beta_4 Age^2_{idpt} + \beta_5 Experience_{idpt} + \beta_6 Experience^2_{idpt} + \beta_7\, Salary/Month_{idpt} + \beta_8\, MonthsWorked/Year_{idpt} + \beta_9 Female_{idpt} + \beta_{10} Black_{idpt} + \beta_{11} OtherRace_{idpt} + \delta_d + \tau_t\right)$$

Similar to equation (2.2), the baseline hazard λ_0 absorbs the "pull" and "push" of pensions – the average propensity to retire for individuals with the same value of pension eligibility. $SecondSpell$ is an indicator equal to 1 if an individual is in her second spell of employment – meaning she has "retired" from teaching and returned. For these returning retirees, pension eligibility is equal to what it would have been had they not retired but took a leave of absence. For example, consider an individual who leaves teaching in 1998 when her pension eligibility is 0 (she is just eligible for immediate annuity receipt upon retirement). She returns and begins her second spell in 2000, and her pension eligibility is 1 – this is the first year she has worked since becoming eligible for her pension.

My coefficients of interest are $\beta_{1,p}$ which show differences in teacher exits between individuals in their first and second spell, holding pension eligibility constant. In this way, I assume observations on returning retirees indicate how individuals in their first spell would behave had they retired and returned. Granted, individuals in their first and second spell are very different, simply by the fact that one has retired and the other has not, but I would expect the differences between these groups to bias my results such that individuals in their first spell are even *less* likely to exit than returning retirees in their second spell. Thus, my results are a lower bound for how first-spell individuals would act in response to a similar policy that negates pension incentives and incentivizes continued teaching.

I include all other controls that were in specification (2.2), including the interaction between pension eligibility indicators and the RTW policy (in order to control for changes in first-spell behavior), and district and year indicators.

Estimating Teacher Quality (Value-Added). In order to understand the possible impacts of RTW on student achievement, I need a measure that captures the gains in student achievement associated with each particular teacher. I estimate a teacher's value-added using specification (2.4) for 4th and 5th grade teachers. For these grades, I have students' prior year EOG achievement test scores, important student demographics, and am confident of the match between instructor and students.

(2.4) $Achievement_{jit} = Quality_i + \boldsymbol{\rho Y_{jit}} + \nu_{jit}$

The dependent variable is the normalized (mean zero, standard deviation one) test score $Achievement_{jit}$ of student j of teacher i in stage s in year t. Stage refers to whether a teacher is a novice (years of experience 0 to 4), an established non-retired teacher (experience greater than 4 years but not a returning retiree), or a returning retiree. I regress achievement on a vector of student, class, and school attributes $\boldsymbol{Y}$, which include student j's test score from the previous year, demographic and achievement measures for other students in j's classroom, and grade and year fixed effects. Table 2.7 includes the full list of covariates in the specification, as well as a selection of important coefficients. The value-added measure of a teacher's quality $Quality_{is}$ is the average growth in teacher i's students during stage s, compared to the growth of other teachers' students, after netting out the average effects of other observable factors.

I measure quality at the teacher-stage level to describe whether those who returned are different from other groups. I allow teacher quality to change at different stages in her career, as value-added has been shown to rise for novice teachers, and level off when a teacher becomes established (Rockoff, 2004; Boyd et al., 2008). I do not include teacher experience as a covariate because the differences due to additional years of experience are potentially important to associate with the teacher. For instance, principals may be deciding between hiring a novice versus a retiree teacher and choose the retiree because she has relatively higher quality – not necessarily in comparison with her same-experienced peers, but with respect to the novice.

I use empirical Bayes shrinkage (Wisconsin Center for Education Research, 2010) to account for measurement error in the value-added estimates. To address concerns about bias in value-added measures, I follow Koedel and Betts (2011) and estimate a teacher's value-added using the test scores of her students over multiple years. Because there are separate math and reading tests, I average a teacher's value-added across both subjects.

2.6 Results

In this section I present the results from my analysis on first and second spells, in addition to my findings on the teacher quality and school characteristics of returning retirees. I find that the RTW policy caused teachers to end their first spell earlier than they would otherwise, potentially in order to return to work under the generous conditions of the policy. Second-spell exits end at half the rate of first spells, implying that some teachers would teach longer in the absence of pension incentives "pushing" them out. Returning retirees are of higher quality than the retirees that did not return, as well as novice teachers, making them a potentially valuable asset to schools. Lastly, retirees returned to schools that served higher poverty populations than the schools they retired from, possibly easing administrative problems in hard-to-staff schools.

Estimating RTW Policy Effect on First Spells. My results describe differences in the propensity for teachers to end their first spell as a response to the RTW policy. In Table 2.8, I display the hazard ratios (column A) and coefficients (column B) for the proportional hazard model shown in specification (2.2), while in Figure 2.5 I show the graphical effect of RTW on the hazard rate (probability of ending one's first spell). Column (B) gives the coefficients on the model as described in equation (2.2), but the hazard ratios in column (A) are more readily interpretable. Hazard ratios are the exponential of the coefficients, and describe the proportional shift in the baseline hazard due to the covariate (assuming all other covariates stay constant). A hazard ratio greater than 1 signifies that individuals with this covariate have a higher hazard (probability of exit), and a lower hazard if less than 1. The hazard ratio on the interaction between pension eligibility equal to 0 and RTW is 1.16. This means that, holding all else constant, the hazard rate for individuals who are just eligible for their pension during RTW is 1.16 times (or 16 percent higher than) the hazard without the policy. Given the uncertainty around the policy expiration, this increase would likely be higher if the policy were made permanent. The hazard rate is statistically higher during RTW for individuals with pension eligibility between -5 (5 years away from eligibility) and 2 (2 years past eligibility), showing individuals near eligibility for their pension ended their first spell at higher rates during RTW.

Figure 2.5 shows the survival functions and marginal hazards for before and during RTW. The survival function can be thought of as the number of individuals at a given level of pension eligibility who are still in their first spell of employment divided by the number of individuals who were in their first spell at pension eligibility -20. The survival function is a prediction based on the estimates from my model evaluated at covariates set equal to their mean for each level of pension eligibility. The difference between the two survival functions is determined by the coefficients on the interaction of the pension eligibility indicator variables and the RTW policy. Hollow dots on both graphs in Figure 2.5 indicate that the hazard ratios corresponding to these interactions are statistically significant, meaning there is a significant difference in the pattern of first spell exits before and during the RTW policy. Similarly, the marginal hazard graph shows the hazard evaluated at covariates set equal to their mean for each level of pension eligibility, but the RTW line includes the effect of RTW and the pre-RTW line does not.

Looking at the survival function, around three-quarters of individuals are still in their first spell at pension eligibility equal to -10, but as individuals get closer to pension eligibility, the survival function for those during the RTW policy drops off faster than the pre-RTW period.[12] This is reflected in the marginal hazard, which displays the proportion of people who retire at each value of pension eligibility, conditional on having worked for that long. The marked increase in hazard rates between the pre- and during RTW periods is right at pension eligibility. Pre-RTW 21 percent of teachers retired upon reaching eligibility, while during RTW 24 percent do – this is the 16 percent increase that the hazard ratio reported in Table 2.8 denotes. Also visible in the marginal hazard graph is the relatively small relevance of the high hazard ratios for pension eligibility less than -1. For instance, the RTW hazard ratio for pension eligibility -4 (4 years before one is eligible) is 1.35, meaning that the hazard rate during RTW is 35 percent higher for these individuals than it was pre-RTW. However, given that the baseline hazard is only 0.03, a

[12] One assumption of the hazard model in (2.2) is that the probability of exiting is the same pre- and during RTW for all individuals who have pension eligibility below -10, after controlling for year effects. The survival and marginal hazard functions from -20 to -10 are identical by design.

35 percent increase at pension eligibility -4 is not as important as the 16 percent increase at pension eligibility 0.

Estimating Differences in First versus Second Spells. These results describe differences in the propensity for teachers to end first spells (when pensions are “pushing” them out) versus second spells (when pension incentives are not present). The coefficients from specification (2.3) are in Table 2.9, with the survival functions and marginal hazard rates in Figure 2.6. Teachers past eligibility in their first spell face a hazard rate that is twice that of a returning retiree. The marginal hazard for second-spell teachers is still higher than it was for first-spell teachers prior to eligibility, meaning the pension “push” was not completely negated for second-spell teachers; however, 12 percent of teachers are still working 10 years after pension eligibility during the RTW – a substantial increase compared to two percent without the policy. Note that self-selection plays a large role in which individuals work past pension eligibility in their first spell, and which individuals retire and return for a second spell. These selection issues make comparisons across first- and second-spell individuals less than ideal. However, it is likely that post-eligibility first-spell teachers are more attracted to continued teaching than second-spell teachers (who have left and returned). Theoretically, if these first-spell teachers had chosen to retire and return to work for a second spell, then they would be even *more* likely to keep teaching than the current second-spell teachers. Thus, the difference in first- and second-spell behavior is a lower bound for how teacher retention might change if RTW were instituted permanently.

Teacher Quality Differences. Next, I look at the teacher-stage value-added of teachers who return versus those who do not. I calculate value-added for 7,819 teachers, including 460 teachers who retire and return. I compare the mean (pre-retirement) value-added of retirees who return, to the value-added of two other groups: retirees who did not return, and novice teachers. Figure 2.7 displays the distribution of value-added for these groups.

The value-added of retirees who returned is 0.02 higher than the value-added of retirees who did not return (Figure 2.7 (A)). Value-added is in units of the standard deviation of student test scores – so, returning retirees’ students gained 2 percent of a standard deviation more than the students of retirees who did not return. Hill et al. (2008)

find that students gain about 0.25 standard deviations during a nine-month school year. This implies that the difference between a returning retiree and a retiree that does not return is approximately three-quarters of a month of learning. A reason for this positive selection back into teaching may be that schools choose to hire the higher quality retirees over the lower quality ones. Returning retirees were no longer tenured and had no job security or regulations to prevent schools from simply choosing to hire the best teachers. Schools may be choosing between novice teachers and a returning retiree, leading me to compare the value-added of these two groups in Figure 2.7 (B). I find that returning retirees have a value-added that is 0.04 standard deviations higher than novice teachers – about one and a half months of a nine-month school year. While the mean value-added of returning retirees is higher than those of the other groups, it is important to note that Figure 2.7 displays considerable overlap across these groups. Thus, the average individual from these groups may be different, but there are plenty of novices who have higher value-added than a low-quality returning retiree. Additionally, schools may be choosing returning retirees based on other skills, such as their ability to mentor teachers, their positive contributions to school climate, or a variety of other reasons that are not observable in my data.

Schools to Which Retirees Returned. Lastly, I look at the schools where teachers return. 53 percent of teachers returned to the same school from which they retired. Recall that the original intention of the policy was to encourage retired teachers to return to low-performing schools. While this was not a rule of the policy for very long, there is some evidence that this did occur. Figure 2.8 shows the proportion of different types of retirees present in schools with different characteristics. Panel A shows the breakdown by the quartile of percent black students, meaning 25 percent of all teachers are in each quartile. The dark bar shows the distribution of schools that all retirees returned from. The middle bar shows the distribution of returning retirees based on the school they retired from; the light bar shows the schools they returned to. These results show that returning retirees were at schools with a slightly higher percentage of black students than the average retiree (before retiring), and returned to schools that looked similar along this dimension. Panel B displays a slightly different story with respect to the proportion of students who are eligible for free lunch. First, notice that many more retirees come from schools with the lowest percentage of free lunch students than the highest – this affirms how teachers sort across schools as they gain experience (Clotfelter et al., 2006; Boyd et al., 2007). Second, returning retirees generally come from higher poverty schools than the typical retirees; and, third, they return to schools that have an even higher proportion of free lunch students. This provides evidence that some retirees might have been filling positions in hard-to-staff schools.

2.7 Summary and Policy Implications

I look at four ways in which North Carolina's RTW policy affected the school system. First, I show that teacher retirement around pension eligibility increased 16 percent as a result of this policy, suggesting that some teachers retired early in order to return. Second, I find that the policy greatly diminished the pension "push" for the teachers who returned, keeping them in the workforce longer after retirement eligibility than first-spell teachers. This is not surprising given that these teachers were rewarded with a 50 percent increase in their salary (their annuity) for doing the same job. I argue that these effects – both the effect on first spells ending earlier, and second spells ending later – are a lower bound for what might happen if the policy were to be instated permanently.

Third, I find that returning retirees are of higher quality than retirees who do not return, and of higher quality than novices. Both of these quality comparisons show that hiring these retired returnees might have resulted in increased educational quality. Fourth, I look at the schools where returning retirees take jobs. I find that most teachers return to the school they retired from, but there is substantial movement to higher poverty schools. Thus, the RTW policy may be allowing the school system to fill positions in hard-to-staff schools.

Whether the benefits of this policy outweighed the monetary costs is ultimately unclear, but it is clear that retired teachers can be mobilized with this sort of incentive. Furthermore, many of the positive effects of this policy could be driven by the demand-side of the market: the fact that schools were able to choose which retirees to return. This policy is a potentially interesting response to criticism that DB plans "push" all teachers, regardless of quality, out of the system at once. The RTW policy allowed the school-selected retirees, likely the most effective ones (by some definition), to return to work. One improvement to a similar RTW policy is to decrease the risk around an individual retiring and returning. For instance, allow individuals to continue working without a break in employment, and let schools make agreements with teachers about re-employment upon retirement (a practice that was deemed unlawful). Given the likely complaints that such a policy allows for favoritism, a second-best option would be to reinstate RTW in the way it was originally written in 1999 – to allow retired teachers to return to particularly failing schools. From my results it is clear that some teachers are willing to work in hard-to-staff environments (if offered this level of compensation), and having experienced teachers working with high-risk students could make the benefits of such a policy exceed the costs.

Table 2.1: History of NC Return-to-Work Policy

Law passed	10/30/98	6/30/00	9/26/01	9/30/02	7/20/04	8/11/05	7/31/07
Law effective	1/1/99	6/30/00	7/1/01	9/30/02	6/30/04	8/1/05	10/2/07
Expiration	6/30/03			6/30/04	6/30/05	6/30/07	10/1/09
Specifics of law:							
Restrictions on who can return with respect to their retirement date	None						No restrictions if retire prior to 10/07; only those eligible for normal retirement if retire after 10/07
Mandatory break in employment before returning to work	1 year (other than as a substitute teacher)	1 year immediately preceding reemployment (other than as substitute teacher)	6 months immediately preceding reemployment (other than as substitute teacher or part-time tutor)			6 months immediately preceding re-employment	
Restrictions on returning school	Must be low-performing	None					
Restrictions on returning employment	**Not permanent (only sub or interim)**	None					
Restrictions on returning teacher certification	Employed in area of certification; school in area where there is shortage of teachers with beneficiary's certification	None					
% of returning salary that LEAs must pay to retirement system	0 %				11.7 %		

Notes: Author's summary of North Carolina General Assembly Legislation S.L. 1998-212, S.L. 1998-217, S.L. 2000-67, S.L. 2001-424, S.L. 2002-126, SL. 2004-124, S.L. 2005-144, S.L. 2005-276, S.L. 2005-345, S.L. 2007-145, and S.L. 2007-326.

Table 2.2: Composition of Full-Time Workforce by Retirement Status and Year

Year	N teachers working	N non-retired teachers working	N returning retired teachers	Proportion of working who are retired
1995	30,411	30,411	0	0.0%
1996	31,112	31,112	0	0.0%
1997	31,924	31,924	0	0.0%
1998	32,376	32,376	0	0.0%
1999	32,415	32,404	11	0.0%
2000	32,566	32,517	49	0.2%
2001	32,505	32,279	226	0.7%
2002	32,773	32,499	274	0.8%
2003	32,804	32,371	433	1.3%
2004	32,239	31,623	616	1.9%
2005	32,191	31,250	941	2.9%
2006	31,812	30,640	1,172	3.7%
2007	32,007	30,493	1,514	4.7%
2008	32,051	30,433	1,618	5.0%
2009	32,583	30,920	1,663	5.1%

Notes: Tabulated from full sample. Returning retired teachers are those who have ended their first spell of teaching and have returned full-time for their second spell.

Table 2.3: Returning Retirees by Retirement Year and Returning Time

Year retired	N teachers retiring this year	Retired teachers who ever return		Retired teachers who return within 3 yrs	
		N	% of all retired	N	% of all retired
1995	1,962	28	1.4%	0	0.0%
1996	1,878	43	2.3%	3	0.2%
1997	2,016	48	2.4%	8	0.4%
1998	2,240	104	4.6%	45	2.0%
1999	2,177	142	6.5%	74	3.4%
2000	2,638	297	11.3%	238	9.0%
2001	2,461	238	9.7%	173	7.0%
2002	2,676	336	12.6%	277	10.4%
2003	3,248	489	15.1%	408	12.6%
2004	2,898	373	12.9%	338	11.7%
2005	3,182	518	16.3%	482	15.1%
2006	2,908	372	12.8%	372	12.8%
2007	2,893	261	9.0%	261	9.0%
2008	2,474	9	0.4%	9	0.4%
Total	35,651	3,258	9.1%	2,688	7.5%

Notes: Tabulated from full sample. Retired teachers who return are those who have ended their first spell of employment (in the given year retired) and return full-time at some later point for their second spell.

Table 2.4: From the Perspective of a Retiring Teacher: When can I return from retirement under the RTW policy?

Considering retirement on June 30th of the	Years one could knowingly return to work full-time when considering
1999	2001, 2002, 2003
2000	2002, 2003
2001	2003
2002	
2003	
2004	
2005	
2006	
2007	2009
2008	

Notes: Given the expiration date of the RTW policy (see Table 2.1), those considering retirement in a given year may have different expectations for how many school years they can return to work under RTW. For example, a teacher considering retirement on June 30, 1999 could return for the 2001, 2002 and 2003 school year (as of June 30, 1999, the RTW policy expired at the end of the 2003 school year). A teacher considering retirement on June 30, 2003 could not knowingly return for any school years because the RTW was set to expire at the end of the 2004 school year, not giving her enough time to take a break from work and return. In actuality, the policy was extended, but this was not known to a teacher considering retirement in 2003.

Table 2.5. Percentage of Each Returning Retirement Cohort Working in Each Year

Year Retired	Year Working as a Returning Retiree											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1995	3.6%	25.0%	32.1%	39.3%	32.1%	32.1%	32.1%	28.6%	28.6%	17.9%	17.9%	0.0%
1996	7.0%	9.3%	32.6%	30.2%	23.3%	39.5%	32.6%	44.2%	32.6%	27.9%	18.6%	7.0%
1997	0.0%	16.7%	29.2%	54.2%	37.5%	43.8%	45.8%	39.6%	29.2%	18.8%	12.5%	0.0%
1998	6.7%	13.5%	33.7%	39.4%	45.2%	37.5%	35.6%	33.7%	33.7%	26.0%	20.2%	2.9%
1999		11.3%	27.5%	35.9%	50.7%	47.2%	35.9%	31.7%	29.6%	22.5%	18.3%	3.5%
2000			38.7%	29.3%	39.4%	39.7%	36.7%	31.6%	24.6%	21.2%	13.1%	2.7%
2001				18.9%	46.2%	50.8%	52.5%	50.8%	45.4%	39.9%	32.4%	7.1%
2002					14.9%	55.7%	64.6%	60.4%	52.4%	40.5%	33.0%	6.8%
2003						7.6%	63.0%	66.3%	64.0%	52.4%	43.1%	8.4%
2004							13.1%	72.4%	76.1%	66.8%	57.4%	11.3%
2005								6.6%	79.0%	79.0%	73.7%	13.5%
2006									10.2%	83.3%	82.3%	14.5%
2007										5.7%	96.9%	23.0%
2008											44.4%	66.7%
2009												100.0%
Total	4.9%	13.4%	34.1%	30.4%	35.0%	29.4%	44.9%	44.8%	50.7%	49.8%	51.0%	10.2%

Notes: A retiree cohort is defined by the year in which the cohort ended their first spell of teaching (the year they retired). A returning retiree cohort is the subset of a retiree cohort who returned to full-time teaching for a second spell. The sizes of retiree cohorts and returning retiree cohorts are given in Table 2.3. The table above shows the percentage of a returning retiree cohort that was teaching in their second spell in a given school year.

Table 2.6: Sample Selection

	N	Percent
Full-time teacher, age 40 or more, vested in retirement system	89,676	100%
Not in sample because:		
Ever not a teacher	10,910	12.2%
Unknown/unreasonable salary or hours worked	2,322	2.6%
Unreasonable/inconsistent values of experience	2,736	3.1%
Unreasonable/unknown value of age	6,244	7.0%
Unknown sex or race/ethnicity	3,641	4.1%
In sample:	63,823	71.2%
In sample who retire and return at any time:	3,258	5.1%
with value-added:	556	
In sample who retire and return within 3 years of retirement:	2,688	4.2%
with value-added:	460	

Table 2.7. Teacher Value-Added Specification: Estimated using Specification (2.4)
Dependent variable=standardized (mean 0, s.d. 1 in grade and year) EOG test score

	math	reading
Previous score (standardized by grade and year)	0.741 ** (0.001)	0.695 ** (0.001)
Female	-0.010 ** (0.001)	0.014 ** (0.001)
Black	-0.102 ** (0.002)	-0.131 ** (0.002)
Hispanic	0.012 ** (0.003)	-0.022 ** (0.004)
Other race	0.011 ** (0.003)	-0.026 ** (0.003)
Limited English proficiency status	-0.021 ** (0.005)	-0.077 ** (0.006)
Eligible for free/reduced price lunch	-0.072 ** (0.002)	-0.092 ** (0.002)
Student variables (switching schools, repeating a grade, age in 3rd grade)	X	X
Year indicators	X	X
Grade 4 indicator	X	X
Student exceptionality status (gifted, speech or language disability, physical disability, emotional disability, mental disability, learning disability, or other disability indicators)	X	X
Class-level variables (membership, lagged achievement, % non-white, % female, % LEP, % free lunch)	X	X
School-level variables (% black, % Hisp, % free lunch)	X	X
N	679,065	681,400
R-squared	0.75	0.69

Notes: Standard errors shown in parentheses. ** signify significance at the 1% level.

Table 2.8. Proportional Hazard Estimates: Effect of RTW on First-Spell Exits

	(A) Hazard Ratio		(B) Coefficients	
Pension Eligibility X RTW				
-10	0.9605		-0.0403	
	(0.0863)		(0.0898)	
-9	1.1463		0.1365	
	(0.1041)		(0.0908)	
-8	1.3602	**	0.3077	**
	(0.1289)		(0.0948)	
-7	1.1869	+	0.1713	+
	(0.1130)		(0.0952)	
-6	1.1418		0.1326	
	(0.1052)		(0.0921)	
-5	1.2372	*	0.2129	*
	(0.1049)		(0.0848)	
-4	1.3509	**	0.3008	**
	(0.1176)		(0.0870)	
-3	1.3238	**	0.2805	**
	(0.1114)		(0.0841)	
-2	1.1742	*	0.1606	*
	(0.0880)		(0.0750)	
-1	1.108	+	0.1026	+
	(0.0654)		(0.0590)	
0	1.1558	**	0.1448	**
	(0.0622)		(0.0539)	
1	1.257	**	0.2288	**
	(0.0751)		(0.0597)	
2	1.1141	+	0.1081	+
	(0.0727)		(0.0653)	
3	1.0377		0.037	
	(0.0717)		(0.0691)	
4	0.9539		-0.0472	
	(0.0725)		(0.0760)	
5	1.034		0.0334	
	(0.0827)		(0.0800)	
6	0.9564		-0.0446	
	(0.0868)		(0.0907)	
7	0.8502	+	-0.1623	+
	(0.0808)		(0.0951)	
8	0.8542		-0.1576	
	(0.1112)		(0.1301)	
9	1.0744		0.0718	
	(0.1686)		(0.1569)	
10	0.8075	+	-0.2138	+
	(0.1000)		(0.1238)	

(continued on next page)

Table 2.8 (continued)

Age	1.2249 (0.0300)	**	0.2029 (0.0245)	**
Age^2	0.9983 (0.0002)	**	-0.0017 (0.0002)	**
Experience	0.9573 (0.0098)	**	-0.0437 (0.0102)	**
$Experience^2$	1.0005 (0.0003)	+	0.0005 (0.0003)	+
Salary/month ($1K)	0.8224 (0.0145)	**	-0.1955 (0.0176)	**
Months worked/ year	0.5500 (0.0053)	**	-0.5979 (0.0096)	**
Female	0.9398 (0.0133)	**	-0.0621 (0.0142)	**
Black	0.9364 (0.0140)	**	-0.0657 (0.0149)	**
Other Race	0.9372 (0.0487)		-0.0648 (0.0519)	
Year Indicators	X			
District Indicators	X			
N Observations	378,509			
N Subjects	56,554			
N Failures	31,051			

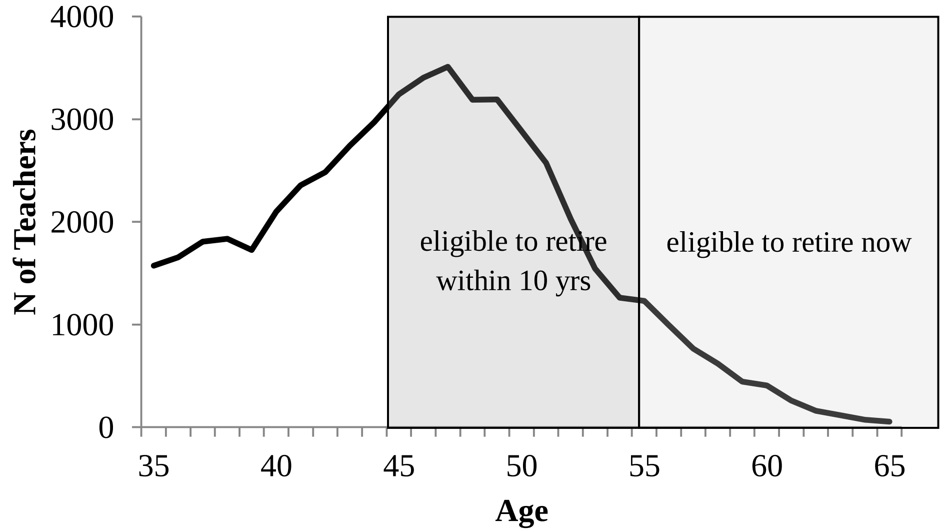
Notes: Standard errors are clustered at the teacher level, and shown in parentheses. +, *, ** signify significance at the 10%, 5%, 1% level respectively. Monetary values are in 2009 dollars. Pension eligibility is how many years since eligible to receive full pension annuity immediately upon exit.

Table 2.9. Multiple-Failure Proportional Hazard Estimates: First- vs. Second-Spell Exits

	(A) Hazard Ratio		(B) Coefficients	
Pension Eligibility X Second Spell				
0	0.8251 (0.0942)	+	-0.1923 (0.1142)	+
1	0.6547 (0.0620)	**	-0.4236 (0.0947)	**
2	0.638 (0.0579)	**	-0.4494 (0.0908)	**
3	0.571 (0.0526)	**	-0.5603 (0.0921)	**
4	0.6074 (0.0588)	**	-0.4986 (0.0969)	**
5	0.5543 (0.0600)	**	-0.59 (0.1082)	**
6	0.6114 (0.0691)	**	-0.492 (0.1130)	**
7	0.4522 (0.0589)	**	-0.7936 (0.1303)	**
8	0.5137 (0.0843)	**	-0.6662 (0.1642)	**
9	0.551 (0.1100)	**	-0.5961 (0.1997)	**
10	0.2738 (0.0588)	**	-1.2953 (0.2149)	**
Age, Age^2, Experience, Experience^2	X			
Salary/month, Months worked/year	X			
Teacher demographics (female, black, other race)	X			
District Indicators	X			
Year Indicators	X			
Pension Eligibility X RTW	X			
N Observations	384,253			
N Subjects	56,569			
N Failures	32,283			

Notes: Standard errors are clustered at the teacher level, and shown in parentheses. +, *, ** signify significance at the 10%, 5%, 1% level respectively. Monetary values are in 2009 dollars. Pension eligibility is how many years since eligible to receive full pension annuity immediately upon exit. Interactions of second spell with indicators for pension eligibility for values -10 to 0 are included but not shown.

Figure 2.1. Age Distribution of North Carolina Teachers in 1999



Notes: Authors tabulation. Count of full-time non-retired teachers 35 years-old and above in 1999. Most teachers are eligible to retire when they reach age 54.

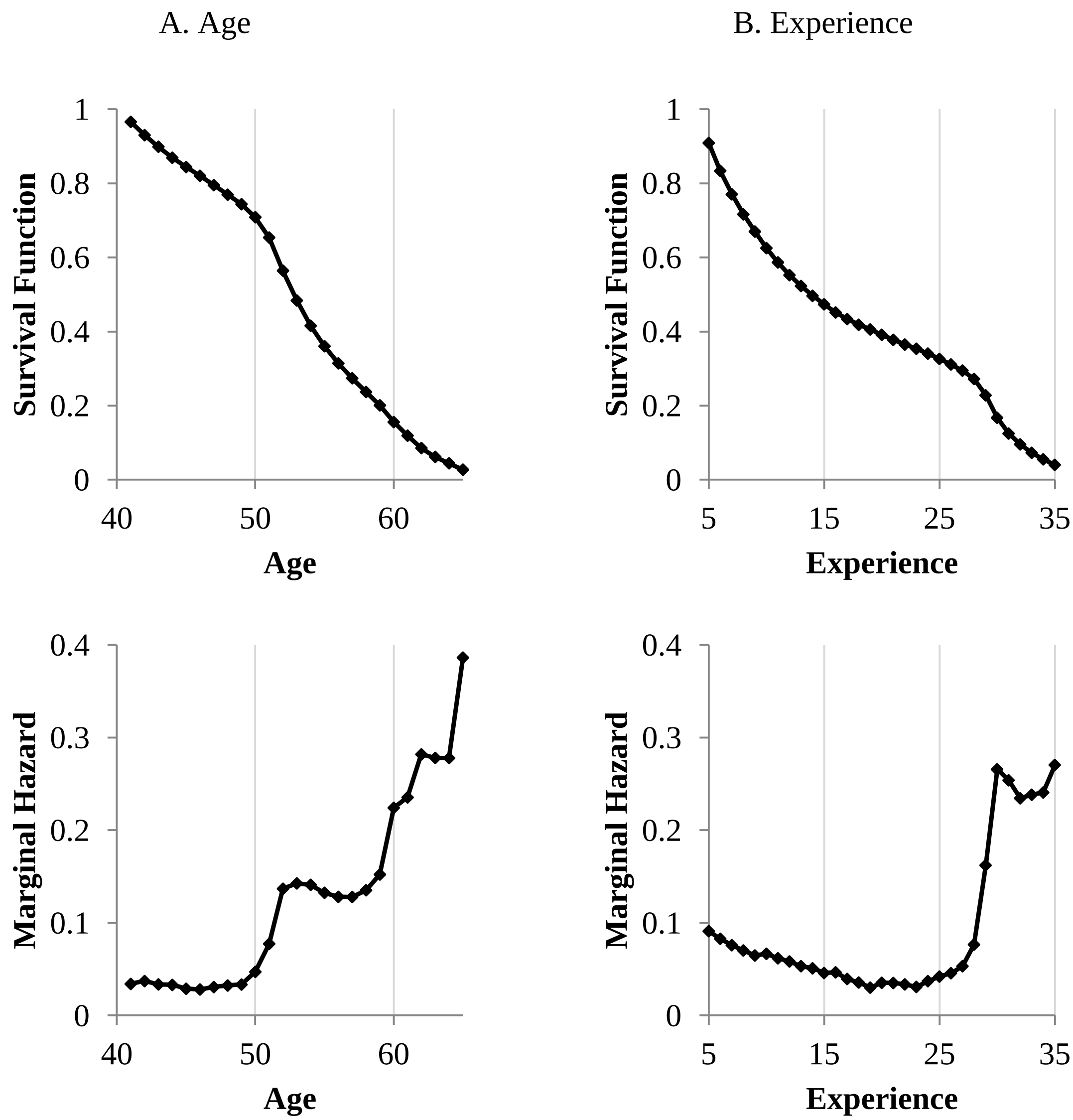
Figure 2.2. Pension Wealth

A. Pension Wealth by Exit Age

B. Change in Pension Wealth for Each Additional Year of Teaching by Exit Age

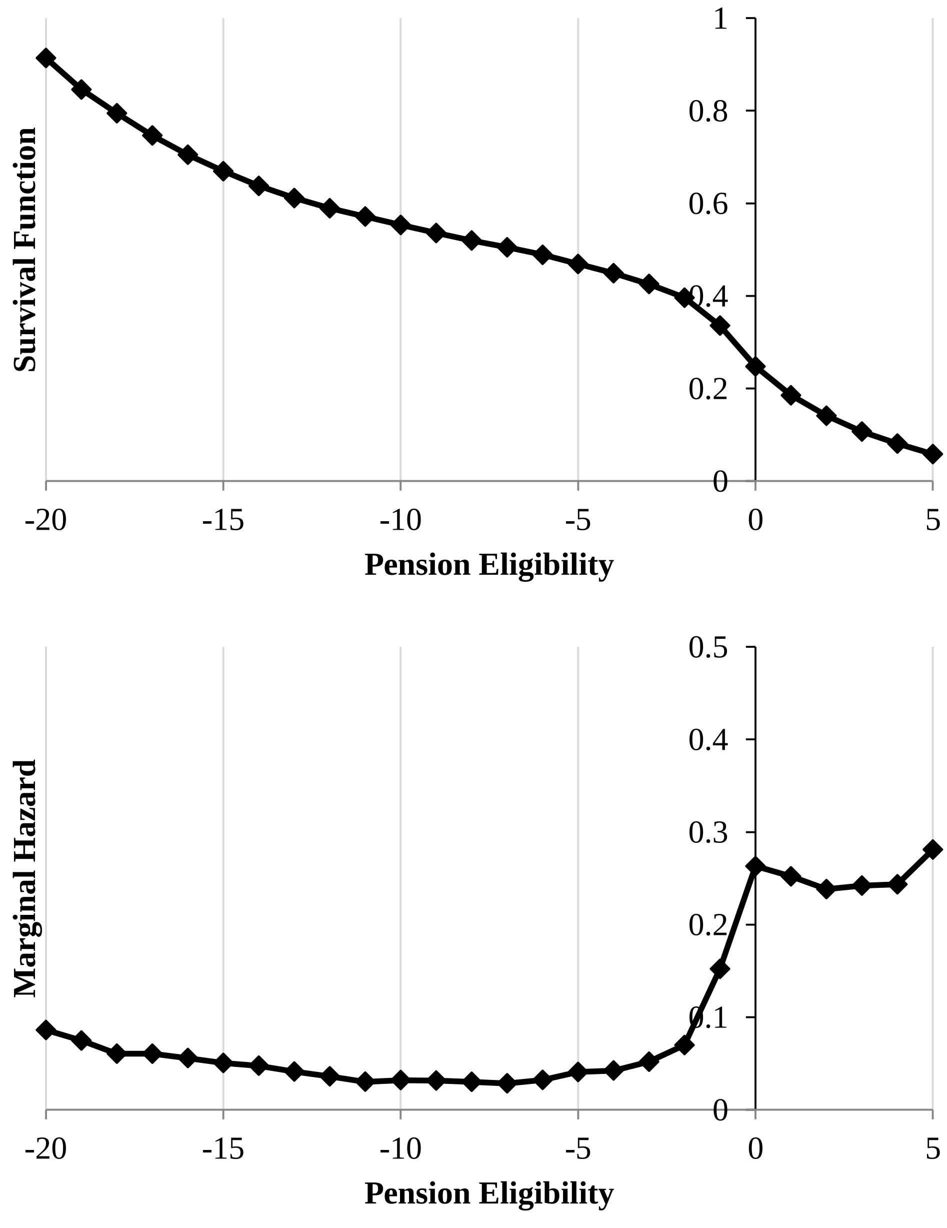
Notes: Pension wealth for a hypothetical teacher who starts teaching at age 21 and faces 2000-01 North Carolina salary schedule during entire career.

Figure 2.3. Survival Functions and Hazard Rates for First Employment Spells



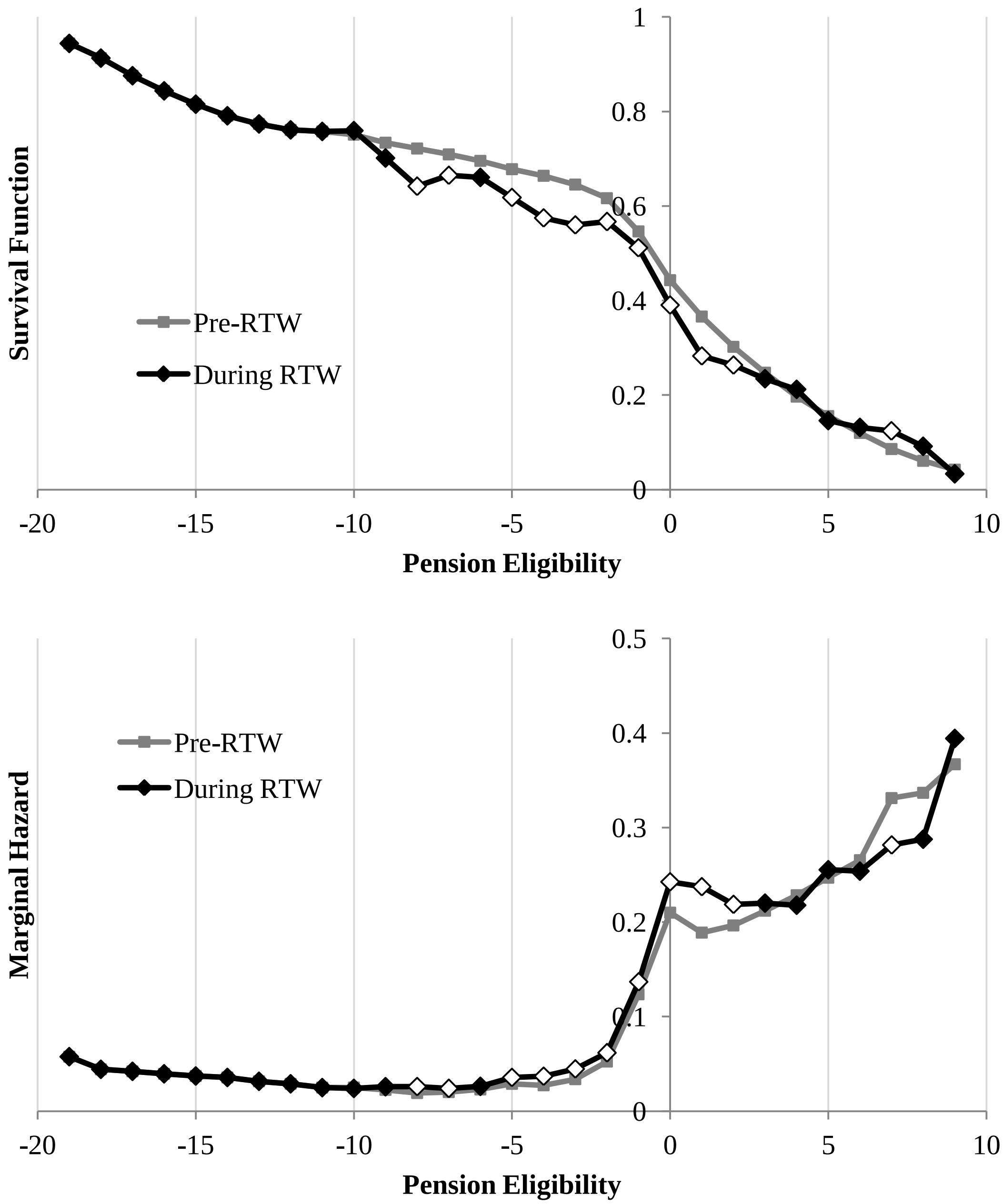
Notes: The sample is all non-retired individuals. The survival function is the proportion of individuals still teaching in North Carolina at a given age (experience), conditional on working at age 40 (experience 5). The conditional hazard shows the proportion of individuals who end their first spell at a given age (experience).

Figure 2.4. Survival Function and Hazard Rate for First Employment Spells by Pension Eligibility



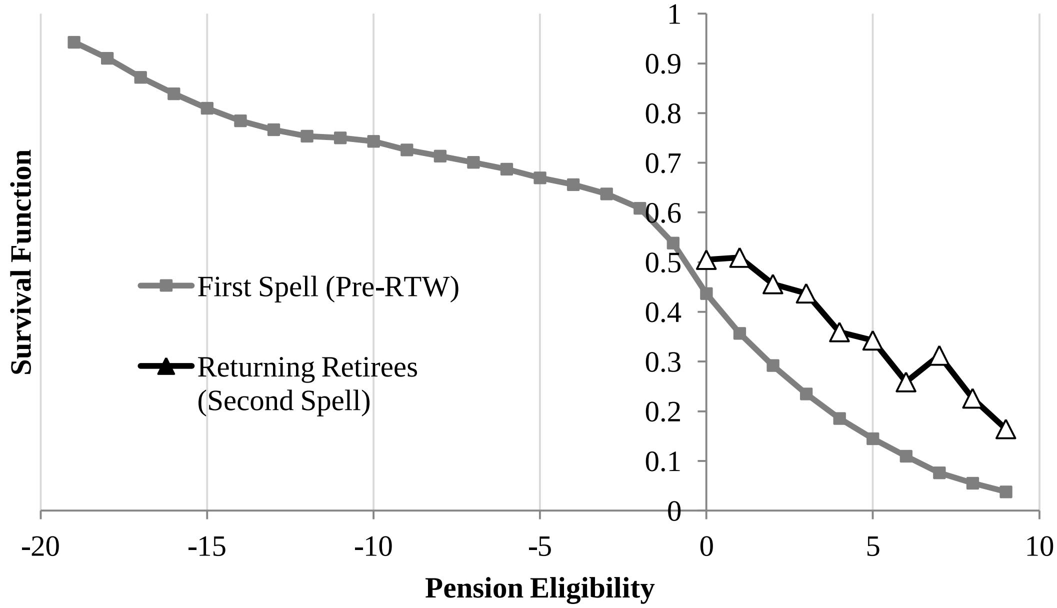
Notes: The sample is all non-retired individuals. Pension eligibility is the number of years since one is entitled to immediate annuity receipt upon retirement; negative when one has to work additional years, positive when one has been eligible for some time. See notes for Figure 2.3.

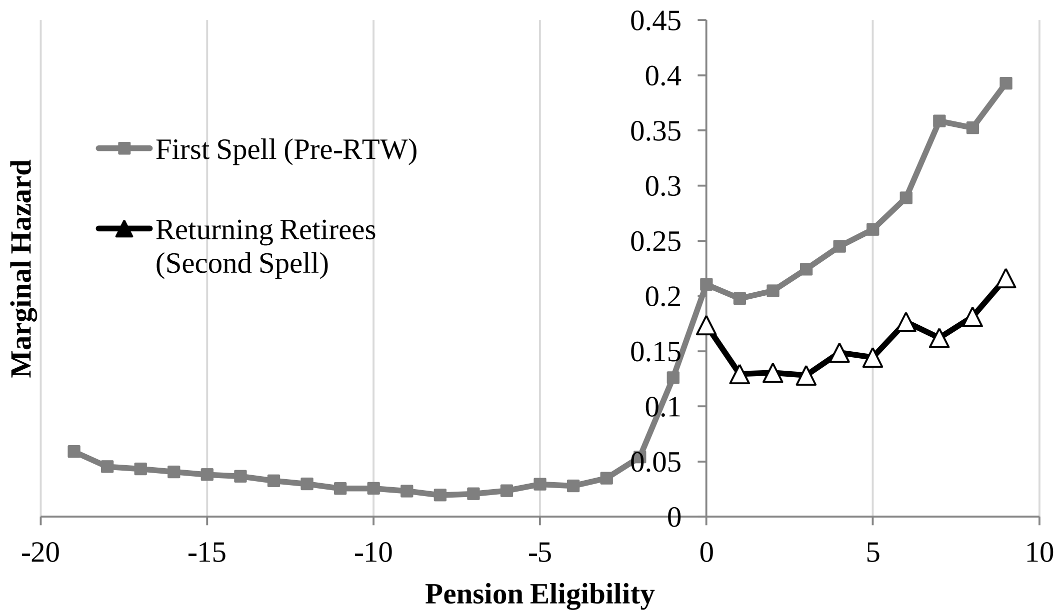
Figure 2.5. Survival Function and Hazard Estimates: Effect of RTW on First Spell Exits



Notes: The survival function is equal to exp{-H(t)} where H(t) is the cumulative hazard. The cumulative hazard is calculated by multiplying the baseline hazard with the shifting amount. The shifting amount = exp(Table 8 B coefficients * Covariate values). The covariate values for age, experience, salary and time working are set equal to the mean amount for a given pension eligibility. The values of pension eligibility X RTW are all equal to 0 for the "Pre-RTW" survival function. For the "During RTW" hazard, these indicators =1 at the corresponding value of pension eligibility. The marginal hazard for time t = H(t) – H(t-1). Hollow points indicate that the hazard ratios during RTW are statistically different from the pre-RTW hazard ratios at the 10% level.

Figure 2.6. Survival Function and Hazard Estimates: First versus Second Spell

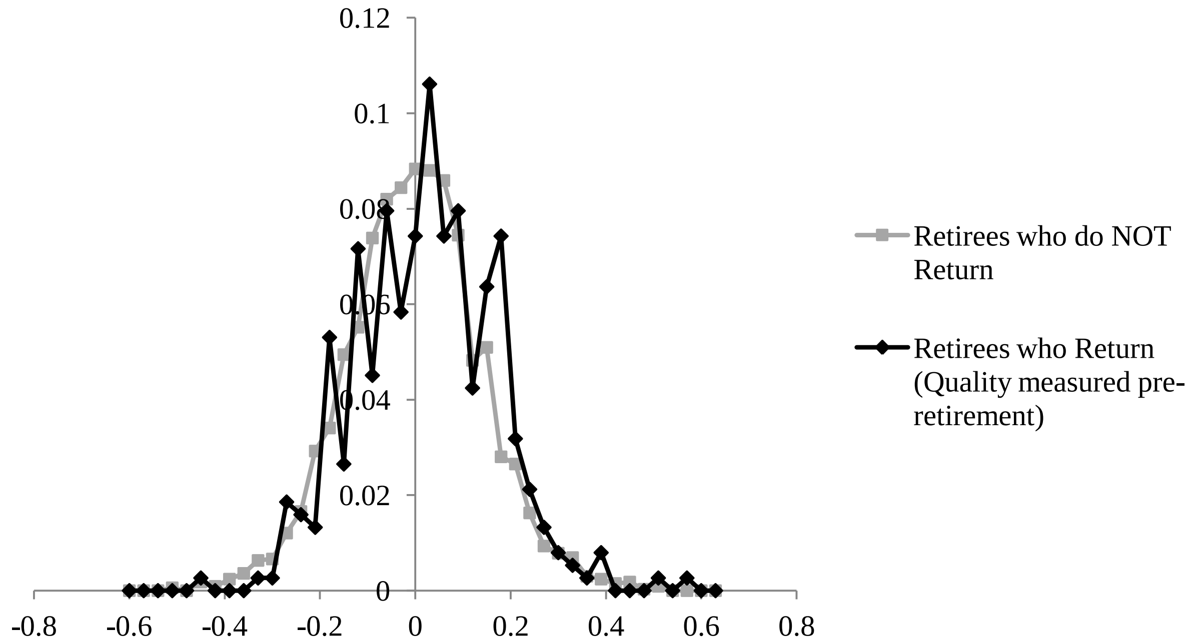




Notes: The survival function is equal to exp{-H(t)} where H(t) is the cumulative hazard. The cumulative hazard is calculated by multiplying the baseline hazard with the shifting amount. The shifting amount = exp(Table 9 B coefficients * Covariate values). The covariate values for age, experience, salary and time working are set equal to the mean amount for a given pension eligibility. The values of pension eligibility X second spell and pension eligibility X RTW are all equal to 0 for the “First Spell” survival function. For the “Returning Retirees” hazard, second spell indicators =1 at the corresponding value of pension eligibility. The marginal hazard for time t = H(t) – H(t-1). Hollow points indicate that the hazard ratios during second spell are statistically different from the pre-RTW (first-spell) hazard ratios at the 10% level.

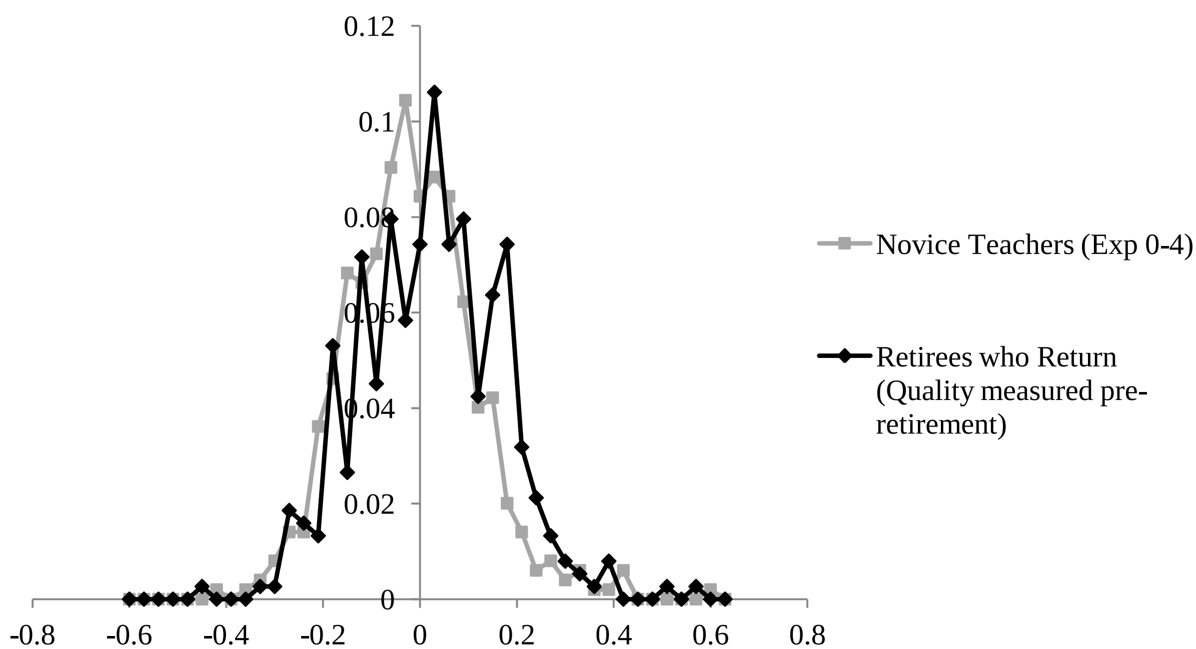
Figure 2.7. Teacher Value-Added

A. Value-Added for Retirees who do and do not Return



Notes: The difference between the mean value-added for these two groups is 0.0238, and is significant at the 1% level.

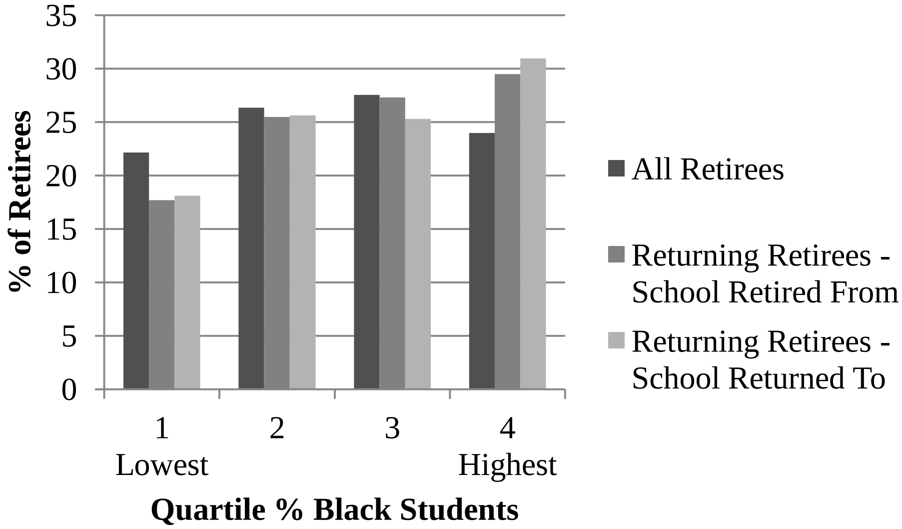
B. Value-Added for Novice Teachers and Returning Retirees



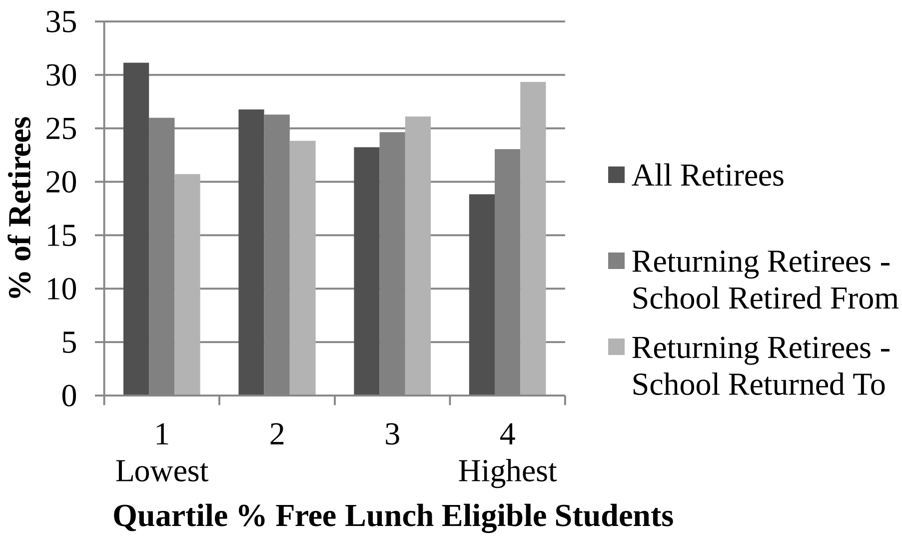
Notes: The difference between the mean value-added for these two groups is 0.0406 and is significant at the 1% level. Value-added estimates are calculated with eq. 4. The value-added reported above is the average of the shrunken math and reading value-added measurement. Value-added for returning retirees is only calculated from the years after retirement.

Figure 2.8. Retirees' School Characteristics

A. Percent Black Students



B. Percent Free Lunch Eligible Students



Notes: Schools are split into quartiles based on the percentage of students of a certain demographic. I look at the demographics of the last school where a retiring teacher worked, the last school where a retiring teacher (who returns) worked, and the school where a retiring teacher first returns to work. These tabulations shown above are at the teacher level, although the quartiles are constructed at the school level (25% of schools in each quartile).

Chapter 3

How Alternative Certification Changed the Supply of Teachers: A Decade of Evidence from New York City

Co-authored work with Susanna Loeb (Stanford University), Rachel O'Brien (Stanford University), and James Wyckoff (University of Virginia)

3.1 Introduction

Many school districts struggle to hire qualified teachers, especially in special education, math, English as a second language (ESL), and science. Some schools have trouble hiring qualified individuals in even customary subject areas due to the challenging working conditions in schools serving high-needs students. The introduction of alternatively certified teachers has the potential to moderate these staffing problems either through influencing the overall quality or the flexibility of the teacher labor supply. Most of the emphasis on evaluating alternative certification has been on teacher quality, but less attention has been paid to the second effect of alternative certification – the ability of a labor force to adapt quickly to a school system's changing needs.

The increased numbers of alternatively certified teachers corresponds to, and in fact is often caused by, the elimination of temporary licensed (uncertified) teachers. Thus, it is impossible to tease out the effect of one versus the other, but instead one should analyze their combined effect. The focus of this paper is to provide a description of how the end of temporary licensed teachers and ramp-up of alternatively certified teachers has affected the teaching labor force from all teaching pathways. We describe these changes

---

We are grateful to the New York City Department of Education and the New York State Education Department for the data employed in this paper. We appreciate financial support from the Noyce Foundation and the National Center for the Analysis of Longitudinal Data in Education Research (CALDER). CALDER is supported by IES Grant R305A060018 to the Urban Institute. The views expressed in the paper are solely those of the authors and may not reflect those of the funders. Any errors are attributable to the authors.

in terms of the number of teachers supplied as well as their certification area and the student populations they serve.

An increasing body of research finds that alternatively certified teachers disproportionately teach in high-needs schools and subjects (Boyd et al., 2006, 2008, 2009, 2012; Constantine et al., 2009; Decker et al., 2004; Feistritzer, 2008; Grossman and Loeb, 2008; Kane et al., 2008; Xu et al., 2008). This literature mostly focuses on the effects of alternative certification pathways in the first few years after their introduction, but these effects likely change as alternatively certified teachers become a larger proportion of the teaching workforce and pathways are honed and specialized to meet the needs of the local teacher labor market. Additionally, other teaching pathways may alter their recruitment and preparation as a function of these temporary licensed teachers exiting and alternatively certified teachers entering the market. Lastly, the characteristics of teachers who are recruited to become alternatively certified may change over time as the route becomes more popular or changes its focus. Studies show that some teacher characteristics, such as having a teacher of the same race or a teacher with high standardized test scores, have positive effects on student achievement (Boyd et al., 2008; Dee, 2005). These may be ways in which alternatively certified teachers are different from their uncertified predecessors or from peers in other teaching pathways.

New York City (NYC) provides an excellent opportunity for understanding the long-run effects of alternative routes to certification, as the school district has employed large numbers of alternatively certified teachers for the past ten years. In 1998 New York State Board of Regents passed regulations ending the use of temporary licensed teachers by the fall of 2003. This law barred a large portion of the teacher labor supply, as over half of new teachers hired in 2000 were uncertified. In fall 2001, the NYC Department of Education (NYCDOE) hired its first cohort of NYC Teaching Fellows (NYCTF), a highly-selective alternative certification program. In 2003-04 NYCDOE hired nearly 2,500 NYCTF teachers, making up approximately 30 percent of all new hires. NYCTF was not the first to supply alternatively certified teachers. Another highly-selective alternative route, Teach for America (TFA), had taught in NYC prior to 2000, although the number of teachers hired per year had been relatively small (typically less than 100).

Like NYCTF, the hiring of TFA teachers also grew to replace unlicensed teachers. In 2003-04 more than 300 new TFA teachers were hired.

In this paper we employ a detailed database of all teachers in NYC from 2000-01 through 2009-10. We focus on differences within and across three teacher pathways: college recommending (teachers who have completed a traditional teacher preparation program), TFA, and NYCTF. We examine three research questions:

- Have the subject certification areas of teachers within or across teaching pathways changed over time?
- Have the types of schools where teachers are placed changed over time within or across teaching pathways?
- Have the characteristics (academic ability, demographics) of recruited teachers changed over time within or across teaching pathways?

To answer these questions we examine changes in the positions that first-year teachers take (e.g. subject matter, student population, and school level) as well as changes in their background characteristics (qualifications and demographics).

With respect to our first research question we find that both college recommending and alternative certification pathways grow to accommodate the elimination of uncertified teachers, but the certification specialty of teachers hired varies widely across pathways and changes over time. In 2000, when temporary licensed teachers were still being hired, college recommending programs were the largest supplier of all certification types. By 2004, even though there were 24 percent more first-year college recommending teachers than NYCTF, NYCTF was the largest supplier of math, science, ESL, and special education teachers. This result is noteworthy because NYCTF shifted from producing mostly childhood-certified (the certification most elementary school jobs require) teachers to becoming a major supplier of these hard-to-staff subject areas. College recommending programs have always been the largest supplier of childhood-certified teachers, although they have meaningfully increased their number of math-certified teachers. TFA increased their placement of ESL and special education teachers more quickly than college recommending programs, but not as quickly as NYCTF. This pattern would be consistent with the notion that NYC had a large need for teachers with non-childhood certifications, but college recommending programs had a hard time meeting these needs quickly due to the inherent lag between recruitment and school placement in a traditional certification program. Given the quick turnaround between recruitment and school placement in an alternatively certified program, teacher supply could almost immediately respond to teacher demand. TFA was likely a bit slower picking up on the district's needs likely because they recruit for districts nationwide instead of focusing on NYC.

In analyzing our second research question we find another difference between these teaching pathways in terms of the schools where first-year teachers were placed. NYCTF started out supplying teachers to elementary schools serving a high proportion of poor students, but after 2004 placements were split evenly across all the three school levels (elementary, middle, and high) that served a slightly larger distribution of student populations. This shift corresponds with the shift to hard-to-staff subject areas that were taught in older grades. Over this time period TFA teachers consistently taught in schools with particularly low student achievement scores. Approximately half of TFA teachers worked in elementary and half in middle schools, although there has been a shift to high schools during the last few years. Throughout the decade, teachers entering through college recommending programs were placed across school levels and serve students who score average on student achievement tests. Over half of college recommending teachers work in elementary schools, with the remaining divided evenly among middle and high school.

To our third research question we find little differences over time in terms of teacher characteristics, but large differences across pathways. The NYCTF program has consistently recruited teachers with higher certification scores, higher SAT scores and more competitive college backgrounds than teachers in college recommending teacher preparation programs. NYCTF teachers were considerably less racially diverse than the uncertified teachers they replaced; however, they are more racially diverse than any of the other large pathways supplying teachers to NYC.

In Section 3.2 we describe the variety of policy changes that were occurring in NYC over this decade as well as the major differences in the teaching pathways. Section 3.3 details the data we use for this study. In Section 3.4 we explain our results for each of the three research questions outlined above. Section 3.5 concludes.

3.2 Background

In the years prior to 2000, teacher hiring and retention in NYC was bleak. As evidence of NYC's difficulty in hiring, from at least as early as 1995–96 through 2001–02 roughly half of all new teachers were temporarily licensed (uncertified). Other measures of teacher qualifications were also notably weak. For example, 25 percent of newly hired teachers in 1999–2000 had failed the New York State general knowledge certification exam on the first taking, 26 percent had attended undergraduate institutions rated by Barron's as uncompetitive, and, on average, newly hired teachers had average math and verbal SAT scores of 466 and 477, respectively, which is approximately the 30th percentile of SAT takers.

NYC also had a weak record of teacher retention, especially in the most challenging schools and among their most qualified teachers. For example, between 1996 and 2002, 20 percent of new teachers in the top quartile on the certification exam left high-achieving schools following their first year, while teachers in low-achieving schools left at an even higher rate of 34 percent. By contrast, only 14 percent of teachers in the bottom quartile on the certification exam left high-achieving schools after one year, and 17 percent left low-achieving schools (Boyd et. al, 2005).

A number of reforms beginning in 2000 dramatically changed the recruitment and retention of teachers. Teacher compensation increased, especially for entering teachers. Between 2000 and 2008, the salary of starting teachers with a BA jumped by more than 35 percent from $33,186 to $45,530. The district also focused on training and hiring effective school leaders, including developing its own leadership academy, enhancing financial incentives and supports for teachers, and making human resource processes more transparent and tied to measures of performance.

Arguably one of the more dramatic changes at the beginning of the 21st century was the series of reforms in policy and practice that led to the expansion of alternatively certified teachers. In 1998 the New York State Board of Regents passed regulations ending the use of temporary licensed teachers by fall of 2003. In response, the NYCDOE, working with The New Teacher Project, developed and implemented the NYCTF program in 2000. Also in 2000, the New York State Board of Regents created a certification pathway for alternative certification, allowing both NYCTF and TFA teachers to receive certification. The NYCDOE built the NYCTF program into a source for recruiting between 20 and 30 percent of all new teachers.

Participants in these alternative-route programs including NYCTF and TFA are expected to complete two hundred hours of pre-service training and pass the Liberal Arts and Science Test (LAST) and the relevant Content Specialty Test (CST) before entering the classroom. These teachers are issued “Transitional B” certificates, good for three years, following the introductory component. As teachers of record, they are expected to enroll in teacher education programs at partner colleges to fulfill certification requirements. Participants enrolled in alternative-route programs must fulfill the same requirements as all other candidates for teaching certificates; thus, by the end of their programs, they have completed courses similar to those taken by graduates of college-recommended programs. However, the costs of entering teaching through an alternative route are substantially less for the individual teacher than the costs of traditional university-based teacher preparation, both because alternative-route teachers earn a salary throughout their training and because, in NYCTF and TFA, teachers pay a reduced rate for the coursework taken. Conversely, the cost to the City is higher for these teachers because of the subsidized education.

TFA hires teachers for high-poverty schools in a number of districts around the country. TFA corps members are recruited nationally from the pool of recent graduates of elite colleges and universities; the recruitment process is exceptionally selective. Once corps members are selected, they must attend a summer training institute, run by TFA, prior to being placed in a classroom. The pre-service curriculum is designed by TFA but once corps members begin teaching, they continue to take courses with a local partner university. TFA requires a two-year commitment; at the end of this period, corps members earn certification, and many also earn a master’s degree.

The NYCTF program is one of the largest alternative-route programs in the country. Prior to entering the classroom as teachers of record, NYCTF Fellows complete an introductory component, usually offered in the summer, which includes some teaching time in local classrooms. The courses are taught by instructors at the partner universities. Once Fellows begin teaching, they continue to take classes at their partner institution. Most Fellows complete their programs within two years. Fellows are generally older than

TFA corps members, and approximately 20 percent of Fellows have completed graduate degrees. Fellows are typically placed in shortage subjects and schools and in the last few years are more likely to teach math, science, and special education than childhood education.

While TFA and the NYCTF are the focus of this article, they are not the only alternative routes serving NYC. For example, the Teaching Opportunity Program (TOP) is a collaborative initiative between the City University of New York (CUNY) and the NYCDOE to produce middle and high school math, science, and Spanish teachers. Participants in TOP also take part in an intensive summer program run by a CUNY campus that includes experiences in local schools. Once they enter the classroom, they continue to take courses at CUNY that count toward both their certification and master's degrees. TOP participants generally complete their requirements for certification and a master's degree in two to three years, after which they are committed to teaching in NYC public schools for an additional two years.

The distinction between alternative and traditional can be quite blurry. For example, many participants in traditional graduate programs in teacher education apply for an internship certificate when they have completed sufficient coursework. With this certificate they are able to become the teacher of record in the classroom, earning a salary while they complete the rest of their program and obtain a master's degree. The distinction with regard to the nature of traditional and alternate routes in the nature of programs and entry into teaching is muddled in other ways. As a result, in this analysis, we consider only three groups of teachers: those entering teaching through college recommended routes, those entering through the NYCTF program, and those entering through TFA.

The introduction of teacher preparation programs with reduced requirements is likely to increase the supply of teachers and change the composition of the teacher workforce. Although there is wide variation in the qualifications of teachers recruited to various alternative certification programs, NYCTF and TFA are both very selective, recruiting teachers who score highly on measures of academic ability such as the SAT, and teacher certification exams (Boyd et al, 2006, 2012).

A substantial body of research has estimated the effectiveness of early career TFA teachers in comparison to other teachers in their school as well as to traditionally certified teachers (see for example, Henry et al., 2010; Boyd et al., 2006, 2012; Decker et al., 2004). Using a variety of methodologies, on average, these studies find that TFA teachers are somewhat more effective at teaching math especially in the upper grades, where effectiveness is measured by the achievement gains of their students.

While a large literature speaks to the effectiveness of TFA teachers, far fewer studies have looked at the effectiveness of other alternative routes. Constantine et al. (2009) examine a broad set of alternative route programs finding no discernible difference in the effectiveness of alternative and traditional route teachers. In their study, other alternative routes were quite different from the NYCTF and TFA with few differences between the alternative and traditional route teachers in their average scores on college entrance exams, the selectivity of the college that awarded their bachelor's degree, or their level of educational attainment.

In considering how alternative certification programs might change over time a number of factors may come into play. First, alternative routes were developed initially, as described above, to fill holes in the district's ability to staff its teaching positions with certified teachers. When the NYCTF program began, approximately half of all new teachers were uncertified and, given the new policy that required the district to hire only certified teachers, the need for teachers that met the qualification was spread across many specialties, particularly in the most difficult to staff schools. In the ensuing years, both the district and local teacher education programs have had time to respond to the new demands and the needs for alternative certified teachers may have changed. The first two questions that guide this analysis is whether the schools that hire alternatively certified teachers and the specialties for which they are hired (e.g. elementary education, math, science, special education) have changed over time.

The background characteristics of alternative route teachers may also change over time. These changes could be driven by either supply or demand. As the NYCTF and TFA learn which types of candidates for their program are more likely to succeed, they may focus their recruitment more on those individuals. On the other hand, as the economy has changed, the supply of different types of workers interested in teaching may have changed. We ask simply whether the observable characteristics of teachers entering through different routes have changed over the decade.

3.3 Data

For this analysis we employ a range of linked data files from NYCDOE and from the New York State Education Department (NYSED) from 2000-2010. These include individual-level administrative data characterizing the teaching pathway, qualifications, and career histories of all NYC public school teachers. Teachers are assigned to the earliest teaching pathway they completed prior to becoming a teacher in New York State public schools. Teacher qualifications include the Liberal Arts and Science Test (LAST), which is a general knowledge exam required for certification (we use score from the first taking of LAST), as well as the undergraduate institution where the teacher received her degree, which we categorize according to Barron's competitiveness categories. We also have data on the characteristics of students who attend schools where teachers were placed, including student-level achievement test results for grades 3-8 in math and English language arts, free and reduced price lunch eligibility, and race/ethnicity. We normalize student-level achievement test scores by grade and year, so a school's average normalized scores show how far the school's students' scores are from the mean (higher or lower) as a proportion of the standard deviation of test scores.

For our analysis we focus on 84,559 entering first-year teachers. We are missing the teaching pathway for 10.8 percent of these individuals, and missing certification type for 5.8 percent (if a teacher is known to be uncertified then her certification type is not missing). We have reliable data on the college where teachers received their undergraduate degrees from 2000 to 2005, but most of these data are missing for alternative certification pathways from 2006 onward. Teacher race is missing for 1.9 percent of teachers. Section 3.4 highlights differences in teacher and school characteristics by pathways and over time.

3.4 Results

As shown in Figure 3.1, the number of temporary licensed (uncertified) first-year teachers fell from 5,000 teachers in 2000, to virtually zero by 2005. This transition was accomplished by the creation of the NYCTF, increases in the number of teachers from traditional teacher preparation programs and a smaller increase in TFA teachers. In 2004, only four years after its inception, NYCTF supplied more than 2,500 teachers. The changes in the pathways through which teachers were recruited affected the attributes of the teaching workforce. We focus on a few of the more striking differences below. The tables include more detailed tabulations.

Certification Area. Among the most remarkable changes has been the evolution of the recruitment goals of NYCTF program over time. As shown in Figure 3.2, at its inception the NYCTF program was dominated by teachers whose certification was in Childhood Education (elementary school teachers). Over two-thirds of new NYCTF teachers were certified in Childhood Education, which comprised about 30 percent of all teachers being hired by NYCDOE with this certification area (Table 3.1). However, this quickly changed so that by 2006 fewer than 15 percent of all NYCTF teachers were Childhood Education certified and NYCTF teachers accounted for just over 10 percent of all Childhood Education certified teachers hired that year.

The NYCTF program shifted its focus to supplying teachers in key shortage subjects, such as mathematics, science, special education and English as a second language. As shown in Figure 3.3 (and Tables 3.2 through 3.5), NYCTF became the dominant source of supply for teachers in each of these certification areas. By 2006 NYCTF was supplying about 60 percent of all new math certified teachers, 35 percent of teachers certified in science, 50 percent of ESL teachers, and 50 percent of special education certified teachers. In many respects, NYCTF has become the supplier of last resort for difficult-to-staff subjects in NYC.

NYCTF was not the only pathway to decrease its relative emphasis on childhood certification. In fact, all pathways did the same over this period, just not as dramatically and not as early. TFA went from producing hardly any ESL teachers in 2005 to over 10 percent of total first-year ESL teachers in 2006 and 2007. They also began producing special education teachers in 2004. The proportion of new math- and science-certified supplied by TFA was relative constant over this time period, but this masks the large increase of these teachers supplied by TFA. The actual number of teachers increased five-fold between 2000 and 2007, but the total number of teachers with these certifications increased proportionally – keeping the relative share of TFA teachers constant. The composition of teachers coming out of college recommending programs also changes over this time period, particularly an increase in the proportion of math-certified teachers in 2006. The last few years of data are difficult to interpret as the Great Recession caused a dramatic decrease in the number of first-year teachers hired by all pathways (see Figure 3.1).

School Student Body Characteristics. For NYCTF this change in the focus of teacher certification from childhood to hard-to-staff subjects was accompanied by other changes in the nature of teacher placements. We take note of two in particular – the grade assignment of teachers and the poverty status of schools to which they are assigned. The change in certification areas inevitably led to a change in school assignments. In 2002, 68 percent of NYCTF teachers were assigned to elementary schools; by 2010 that figure had fallen to 22 percent (Table 3.7). The decline in elementary teacher assignments is roughly matched by equal increases in assignments to middle and high schools (Tables 3.8 and 3.9). Teachers from traditional teacher preparation programs are disproportionately assigned to elementary schools (66 percent in 2010) while TFA teachers are almost exclusively assigned to elementary and middle schools (although there is a small shift of TFA teachers placed in high schools in later years).

Another, less obvious, implication of the change in recruitment focus is the distribution of NYCTF teachers across the distribution of schools by poverty status of the students. As shown in Figure 3.4, between 2002 and 2010, the percentage of NYCTF teachers working in the poorest quintile of schools declined from 36 percent to 23 percent with a nearly equal increase in the percentage of teachers working in the 40 percent most affluent schools.[1] By 2010, it was still the case that NYCTF teachers disproportionately served in the poorest 40 percent of schools, but did so less frequently than had been the case in the early years of the program. This coincides with the shift in focus from placements in poor elementary schools to placements in difficult-to-staff subjects, especially special education, ESL and mathematics. For example, in 2004 only 29 percent of special education teachers and 25 percent of math teachers taught in the poorest

[1] This change should not be over emphasized as the difference in poverty among NYC schools is not great. As is discussed below, the average first-year NYCTF teacher had 96 percent of students eligible for free or reduced price lunch in 2002. By 2010, that figure had declined to 89 percent.

quintile of schools. The shift in NYCTF recruitment focus reflects the substantial increase in hiring in these shortage subjects by NYCDOE since 2003. Special education is a good example. More than twice as many special education certified teachers were hired in each year since 2003 as were hired from 2000 to 2002. College Recommended teachers filled some of this growth; however, over 80 percent of the growth was filled by NYCTF teachers (See Table 3.5). A similar, but less dramatic, increase occurred for math and ESL (Tables 3.2 and 3.4).

Other student characteristics of schools where teachers from different pathways are placed do not change over this time period. Teachers from college recommending programs are placed in average schools, as seen in Table 3.11 with average prior normalized test scores in math and ELA hovering around zero. By the same measure, TFA and NYCTF teachers are consistently placed in schools where prior student achievement is generally well below average. For example, in 2010, the students of an average first-year NYCTF teacher in grades 3-8 scored 28 percent of a standard deviation below those of the average traditional teacher preparation teachers and about 0.04 standard deviations above the students entering the average first-year TFA teacher's classroom. While there is some variation, similar patterns exist across other measures and over time. In short, NYCTF and TFA teachers have consistently been assigned to what appear to be more challenging classrooms.

Teachers' Academic Ability. The NYCTF program has consistently recruited teachers with strong credentials as measured by the competitiveness of their undergraduate colleges (Tables 3.12 through 3.15) tests of academic ability (Table 3.17). NYCTF recruits teachers who on average score consistently better than teachers entering NYC public schools through the college recommending or through the other pathways group and consistently somewhat worse than those entering through TFA. This pattern is replicated in the Barron's rankings of the undergraduate colleges of teachers. About a third of NYCTF teachers graduated from the most competitive colleges, while about 12 percent of CR teachers and more than 60 percent of TFA did so (Table 3.12).

Racial/Ethnic Composition of Teachers. In 2000, 77 percent of first-year teachers who were black entered teaching with temporary licenses. As seen in Figure 3.5, the percentage of black teachers fell significantly when temporary licenses were phased out (see right vertical axis and solid black line). Uncertified teachers were much more likely to be black than teachers entering through other pathways, including the NYCTF teachers who replaced the uncertified teachers. However, NYCTF teachers are more racially diverse than teachers from other certified pathways. In 2008, 44 percent of NYCTF teachers were nonwhite, while 33 percent of CR teachers and 27 percent of TFA teachers were nonwhite (Tables 3.18 to 3.21).

3.5 Conclusion

This paper explores some consequences of the end of uncertified teachers and the development of a large, highly selective alternative certification program in NYC over a ten-year period. We find that the composition of NYCTF teachers mirrors important changes in the teaching needs of NYCDOE from 2001 to 2010. Most notably, in contrast to its origins as a supplier of teachers to difficult-to-staff schools, today NYCTF is best described as a supplier of teachers to difficult-to-staff subject areas. College recommending and TFA pathways have also made shifts in this direction, but not as quickly or dramatically. Additionally, NYCTF offers an important source of racial diversity to NYC teachers, especially given the substantial drop in the racial diversity of the teaching force which came with the elimination of temporary licensure.

Alternative certification has been a bold experiment in the recruitment and preparation of teachers in many states and school districts across the nation. Often, this innovation was born of necessity as some states, and subsequently the Highly Qualified Teacher Provision of the No Child Left Behind Act, virtually eliminated the hiring of uncertified teachers. Alternatively certified teachers frequently filled the shortage of traditionally prepared teachers who were willing to take positions in difficult-to-staff schools and subjects. Our analysis suggests that alternative pathways to teaching, particularly NYCTF, have been responsive to changing circumstances and demands for teachers.

Table 3.1. Childhood-Certified First-Year Teachers (child)

	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
Year	freq	% of child	% of CR	freq	% of child	% of NYCTF	freq	% of child	% of TFA	freq	% of child	% of Other
2000	2,013	80	66	0	0	0	28	1	27	479	19	8
2001	1,849	73	65	271	11	73	17	1	14	405	16	8
2002	1,392	56	61	759	31	68	61	2	56	269	11	6
2003	1,699	53	60	1,047	32	58	102	3	58	382	12	14
2004	1,828	55	58	863	26	34	176	5	54	428	13	30
2005	1,777	65	54	431	16	22	173	6	55	371	13	32
2006	1,649	70	48	230	10	12	173	7	35	288	12	32
2007	1,721	71	48	310	13	16	161	7	32	238	10	41
2008	1,871	79	49	198	8	11	86	4	18	221	9	37
2009	1,318	76	45	168	10	11	90	5	19	152	9	39
2010	549	82	42	49	7	7	9	1	5	64	10	33

Table 3.2. Math-Certified First-Year Teachers (math)

	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
Year	freq	% of math	% of CR	freq	% of math	% of NYCTF	freq	% of math	% of TFA	freq	% of math	% of Other
2000	46	64	2	0	0	0	8	11	8	18	25	0
2001	32	46	1	11	16	3	9	13	8	17	25	0
2002	30	34	1	39	44	4	9	10	8	10	11	0
2003	60	26	2	133	58	7	15	7	9	21	9	1
2004	87	14	3	425	67	17	27	4	8	92	15	6
2005	83	15	3	367	67	19	28	5	9	67	12	6
2006	125	18	4	452	65	23	48	7	10	69	10	8
2007	163	27	5	346	57	18	54	9	11	46	8	8
2008	174	34	5	281	54	15	14	3	3	47	9	8
2009	130	36	4	180	49	12	31	8	6	24	7	6
2010	92	48	7	49	25	7	28	15	15	24	12	12

Table 3.3. Science-Certified First-Year Teachers (sci)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of sci	% of CR	freq	% of sci	% of NYCTF	freq	% of sci	% of TFA	freq	% of sci	% of Other
2000	29	54	1	0	0	0	9	17	9	16	30	0
2001	46	54	2	13	15	4	7	8	6	19	22	0
2002	27	33	1	32	40	3	10	12	9	12	15	0
2003	52	33	2	63	40	3	20	13	11	23	15	1
2004	75	25	2	118	39	5	30	10	9	78	26	5
2005	72	24	2	110	37	6	31	10	10	83	28	7
2006	63	22	2	116	41	6	46	16	9	61	21	7
2007	86	23	2	194	52	10	54	14	11	42	11	7
2008	84	27	2	180	57	10	11	4	2	39	12	7
2009	83	31	3	113	42	8	30	11	6	42	16	11
2010	77	32	6	107	44	15	30	12	16	27	11	14

Table 3.4. English as a Second Language-Certified First-Year Teachers (ESL)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of ESL	% of CR	freq	% of ESL	% of NYCTF	freq	% of ESL	% of TFA	freq	% of ESL	% of Other
2000	51	70	2	0	0	0	0	0	0	22	30	0
2001	46	74	2	3	5	1	0	0	0	13	21	0
2002	34	35	1	52	53	5	0	0	0	12	12	0
2003	47	36	2	66	51	4	0	0	0	16	12	1
2004	63	37	2	66	39	3	1	1	0	40	24	3
2005	60	34	2	91	51	5	2	1	1	26	15	2
2006	75	25	2	161	53	8	38	13	8	29	10	3
2007	66	25	2	150	57	8	35	13	7	14	5	2
2008	81	32	2	144	56	8	7	3	1	24	9	4
2009	74	37	3	97	49	7	7	4	1	20	10	5
2010	72	83	5	0	0	0	1	1	1	14	16	7

Table 3.5. Special Education-Certified First-Year Teachers (SpEd)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of SpEd	% of CR	freq	% of SpEd	% of NYCTF	freq	% of SpEd	% of TFA	freq	% of SpEd	% of Other
2000	387	75	13	0	0	0	0	0	0	127	25	2
2001	356	74	12	9	2	2	1	0	1	112	23	2
2002	312	63	14	75	15	7	0	0	0	106	22	2
2003	389	53	14	183	25	10	2	0	1	163	22	6
2004	448	31	14	714	49	28	66	5	20	216	15	15
2005	388	31	12	683	55	35	29	2	9	141	11	12
2006	373	29	11	722	57	36	63	5	13	114	9	13
2007	463	34	13	726	54	38	78	6	16	82	6	14
2008	530	39	14	694	52	38	13	1	3	108	8	18
2009	490	40	17	606	49	41	57	5	12	78	6	20
2010	396	40	30	482	49	68	55	6	29	49	5	25

Table 3.6. Other-Certified First-Year Teachers (oth)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of oth	% of CR	freq	% of oth	% of NYCTF	freq	% of oth	% of TFA	freq	% of oth	% of Other
2000	590	74	19	0	0	0	3	0	3	202	25	3
2001	555	74	19	50	7	14	4	1	3	145	19	3
2002	408	59	18	151	22	14	30	4	28	106	15	2
2003	654	54	23	324	27	18	43	4	24	184	15	7
2004	745	47	24	448	28	18	84	5	26	304	19	21
2005	760	52	23	384	26	20	79	5	25	239	16	20
2006	857	55	25	350	22	18	130	8	27	226	14	25
2007	898	63	25	274	19	14	123	9	25	131	9	22
2008	1,022	53	27	396	21	21	354	18	74	156	8	26
2009	850	53	29	368	23	25	281	18	59	93	6	24
2010	362	67	28	63	12	9	77	14	41	39	7	20

Table 3.7. Elementary School First-Year Teachers (ES)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of ES	% of CR	freq	% of ES	% of NYCTF	freq	% of ES	% of TFA	freq	% of ES	% of Other
2000	2,046	41	67	8	0	73	53	1	52	2,891	58	50
2001	1,884	41	66	255	6	69	69	1	58	2,408	52	45
2002	1,409	35	62	756	19	68	61	2	56	1,759	44	37
2003	1,623	47	57	991	29	55	95	3	54	767	22	28
2004	1,640	50	52	1,029	31	41	136	4	42	471	14	33
2005	1,851	60	56	627	20	32	156	5	49	439	14	37
2006	1,948	63	56	572	18	29	226	7	46	362	12	41
2007	2,045	65	57	633	20	33	196	6	39	283	9	48
2008	2,190	70	57	490	16	27	193	6	40	272	9	46
2009	1,539	70	53	338	15	23	127	6	27	188	9	48
2010	528	65	40	157	19	22	58	7	31	75	9	38

Table 3.8. Middle School First-Year Teachers (MS)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of MS	% of CR	freq	% of MS	% of NYCTF	freq	% of MS	% of TFA	freq	% of MS	% of Other
2000	501	25	16	3	0	27	44	2	43	1,483	73	25
2001	476	22	17	63	3	17	50	2	42	1,607	73	30
2002	418	19	18	202	9	18	48	2	44	1,506	69	32
2003	526	28	18	427	23	24	81	4	46	853	45	32
2004	677	36	22	664	36	26	175	9	54	342	18	24
2005	588	40	18	481	33	25	139	9	44	256	17	22
2006	599	41	17	494	34	25	191	13	39	170	12	19
2007	572	42	16	487	36	25	211	16	42	89	7	15
2008	572	43	15	466	35	25	163	12	34	114	9	19
2009	391	40	13	377	38	26	160	16	33	60	6	15
2010	185	43	14	174	40	25	46	11	24	25	6	13

Table 3.9. High School First-Year Teachers (HS)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of HS	% of CR	freq	% of HS	% of NYCTF	freq	% of HS	% of TFA	freq	% of HS	% of Other
2000	287	26	9	0	0	0	0	0	0	805	74	14
2001	308	27	11	31	3	8	0	0	0	788	70	15
2002	289	23	13	99	8	9	0	0	0	869	69	18
2003	446	32	16	211	15	12	0	0	0	742	53	27
2004	505	37	16	486	36	19	5	0	2	361	27	25
2005	452	38	14	477	40	24	6	1	2	265	22	23
2006	500	42	15	463	39	23	24	2	5	196	17	22
2007	491	46	14	436	41	23	29	3	6	101	10	17
2008	587	47	15	495	40	27	59	5	12	106	9	18
2009	429	49	15	330	37	22	62	7	13	61	7	15
2010	125	40	10	126	40	18	31	10	16	32	10	16

Table 3.10. Other School First-Year Teachers (OS) (Other School: School not categorized as elementary, middle, or high)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of HS	% of CR	freq	% of HS	% of NYCTF	freq	% of HS	% of TFA	freq	% of HS	% of Other
2000	215	24	7	0	0	0	5	1	5	660	75	11
2001	192	23	7	20	2	5	0	0	0	547	72	10
2002	172	19	8	54	6	5	0	0	0	589	72	12
2003	252	29	9	178	21	10	0	0	0	341	44	13
2004	323	26	10	353	29	14	9	1	3	257	27	18
2005	387	33	12	374	32	19	15	1	5	216	22	18
2006	401	32	12	458	37	23	47	4	10	163	15	18
2007	463	38	13	357	29	19	61	5	12	112	11	19
2008	493	40	13	391	32	21	64	5	13	103	10	17
2009	542	40	19	427	32	29	129	10	27	85	7	22
2010	473	51	36	247	27	35	53	6	28	64	8	33

Table 3.11. Mean Attributes of Students of First Year Teachers by Pathway

	% Black or Hispanic Students				% Free/Reduced Price Lunch Students				Mean Suspensions per 100 Students			
Year	CR	NYCTF	TFA	Other Paths	CR	NYCTF	TFA	Other Paths	CR	NYCTF	TFA	Other Paths
2000	75	94	98	87	86	97	99	92	4.2	5.5	6.0	5.6
2001	72	97	98	83	85	98	98	90	4.6	6.4	6.2	6.3
2002	70	94	98	79	84	96	98	88	2.0	1.8	2.8	2.3
2003	70	93	98	78	85	96	97	89	2.0	2.2	2.6	2.9
2004	70	88	96	72	86	94	97	88	2.4	2.4	2.0	2.8
2005	70	85	96	73	86	93	96	88	2.8	4.3	3.5	4.1
2006	73	86	96	77	86	92	96	86	4.3	6.7	6.2	5.3
2007	73	87	96	77	86	92	95	89	11.6	17.9	16.8	13.2
2008	71	85	95	73	85	92	95	87	8.7	15.0	13.8	9.9
2009	70	86	94	75	83	89	92	85	4.8	9.2	7.1	6.1
2010	71	88	90	76	82	89	92	84	5.4	9.3	7.2	6.6

	Mean Student Absences				Average Prior Normalized Math Score				Average Prior Normalized ELA Score			
Year	CR	NYCTF	TFA	Other Paths	CR	NYCTF	TFA	Other Paths	CR	NYCTF	TFA	Other Paths
2000	12.6	15.1	15.0	14.4	-0.04	-0.40	-0.37	-0.21	-0.04	-0.37	-0.36	-0.21
2001	12.8	17.1	16.1	14.4	0.00	-0.50	-0.43	-0.14	-0.01	-0.49	-0.43	-0.14
2002	12.1	14.8	15.6	13.8	0.05	-0.35	-0.43	-0.09	0.03	-0.33	-0.46	-0.09
2003	12.2	14.8	14.9	13.8	0.02	-0.33	-0.44	-0.09	0.01	-0.34	-0.44	-0.10
2004	12.1	14.6	15.4	12.9	0.03	-0.23	-0.36	-0.04	0.03	-0.25	-0.39	-0.04
2005	12.2	14.4	15.7	12.9	0.02	-0.21	-0.32	-0.04	0.03	-0.23	-0.35	-0.04
2006	13.0	15.1	17.8	13.6	-0.01	-0.20	-0.32	-0.06	-0.01	-0.21	-0.33	-0.04
2007	12.4	14.7	15.6	13.0	0.00	-0.20	-0.33	-0.08	-0.01	-0.20	-0.29	-0.10
2008	11.4	13.5	14.7	11.9	0.01	-0.22	-0.38	-0.06	0.01	-0.21	-0.35	-0.04
2009	11.5	13.8	14.7	12.0	-0.01	-0.25	-0.37	-0.07	-0.01	-0.21	-0.35	-0.07
2010	11.7	13.9	13.8	12.6	-0.03	-0.28	-0.32	-0.11	-0.02	-0.23	-0.29	-0.08

Table 3.12. First-Year Teachers from Most Competitive Colleges (MCC)

	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
Year	freq	% of MCC	% of CR	freq	% of MCC	% of NYCTF	freq	% of MCC	% of TFA	freq	% of MCC	% of Other
2000	274	28	9	4	0	36	70	7	69	626	64	11
2001	282	27	10	106	10	29	75	7	63	582	56	11
2002	255	23	11	240	22	22	23	2	21	593	53	13
2003	325	23	11	596	42	33	99	7	56	391	28	14
2004	358	21	11	967	56	38	201	12	62	201	12	14
2005	421	30	13	599	43	31	208	15	66	158	11	13
2006	467	38	14	580	47	29	84	7	17	109	9	12
2007	236	64	7	68	18	4	10	3	2	54	15	9
2008	206	67	5	48	16	3	5	2	1	48	16	8
2009	159	72	5	28	13	2	5	2	1	29	13	7
2010	79	66	6	25	21	4	3	3	2	12	10	6

Table 3.13. First-Year Teachers from Competitive Colleges (CC)

	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
Year	freq	% of CC	% of CR	freq	% of CC	% of NYCTF	freq	% of CC	% of TFA	freq	% of CC	% of Other
2000	545	36	18	2	0	18	14	1	14	967	63	17
2001	542	35	19	57	4	15	20	1	17	908	59	17
2002	417	30	18	169	12	15	5	0	5	812	58	17
2003	571	40	20	357	25	20	19	1	11	467	33	17
2004	573	42	18	473	35	19	56	4	17	256	19	18
2005	619	49	19	404	32	21	43	3	14	202	16	17
2006	631	56	18	335	30	17	22	2	5	138	12	15
2007	524	76	15	50	7	3	4	1	1	111	16	19
2008	491	78	13	23	4	1	2	0	0	111	18	19
2009	338	79	12	19	4	1	2	0	0	70	16	18
2010	119	80	9	15	10	2	0	0	0	15	10	8

Table 3.14. First-Year Teachers from Less Competitive Colleges (LCC)

	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
Year	freq	% of LCC	% of CR	freq	% of LCC	% of NYCTF	freq	% of LCC	% of TFA	freq	% of LCC	% of Other
2000	1,394	38	46	2	0	18	6	0	6	2254	62	39
2001	1,261	37	44	91	3	25	14	0	12	2008	60	38
2002	997	32	44	372	12	33	58	2	53	1672	54	35
2003	1,222	48	43	388	15	21	19	1	11	935	36	35
2004	1,357	57	43	578	24	23	23	1	7	429	18	30
2005	1,338	61	41	483	22	25	20	1	6	342	16	29
2006	1,364	65	40	400	19	20	43	2	9	285	14	32
2007	1,108	81	31	73	5	4	18	1	4	163	12	28
2008	1,054	82	27	54	4	3	11	1	2	167	13	28
2009	683	83	24	46	6	3	0	0	0	94	11	24
2010	285	80	22	28	8	4	2	1	1	43	12	22

Table 3.15. First-Year Teachers from Not Competitive Colleges (NCC)

	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
Year	freq	% of NCC	% of CR	freq	% of NCC	% of NYCTF	freq	% of NCC	% of TFA	freq	% of NCC	% of Other
2000	782	35	26	3	0	27	3	0	3	1477	65	25
2001	721	34	25	48	2	13	5	0	4	1337	63	25
2002	535	32	23	143	8	13	0	0	0	1011	60	21
2003	657	45	23	232	16	13	6	0	3	579	39	21
2004	741	57	24	271	21	11	12	1	4	287	22	20
2005	779	60	24	235	18	12	12	1	4	268	21	23
2006	805	67	23	211	17	11	6	0	1	187	15	21
2007	598	80	17	22	3	1	0	0	0	127	17	22
2008	576	82	15	19	3	1	1	0	0	105	15	18
2009	381	80	13	22	5	1	1	0	0	70	15	18
2010	156	80	12	11	6	2	1	1	1	27	14	14

Table 3.16. First-Year Teachers for whom College Competitiveness is Missing (Miss)

	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
Year	freq	% of Miss	% of CR	freq	% of Miss	% of NYCTF	freq	% of Miss	% of TFA	freq	% of Miss	% of Other
2000	54	9	2	0	0	0	9	2	9	515	89	9
2001	54	8	2	67	10	18	5	1	4	515	80	10
2002	84	9	4	187	20	17	23	2	21	635	68	13
2003	72	11	3	234	35	13	33	5	19	331	49	12
2004	116	18	4	243	37	10	33	5	10	258	40	18
2005	121	20	4	238	40	12	33	6	10	206	34	18
2006	181	16	5	461	40	23	333	29	68	172	15	19
2007	1,105	33	31	1,700	50	89	465	14	94	130	4	22
2008	1,515	39	39	1,698	44	92	460	12	96	164	4	28
2009	1,340	41	46	1,357	41	92	470	14	98	131	4	33
2010	672	43	51	625	40	89	182	12	97	99	6	51

Table 3.17. Average Test Scores of First-Year Teachers

Year	Test	College Recommended	NYC Teaching Fellows	Teach for America	All Other Paths
2000	SAT Verbal	483	n/a	611	470
	SAT Math	470	n/a	576	459
	LAST	250	n/a	276	232
2001	SAT Verbal	490	574	598	474
	SAT Math	477	544	587	464
	LAST	246	268	273	232
2002	SAT Verbal	484	535	629	484
	SAT Math	475	506	615	476
	LAST	244	255	271	235
2003	SAT Verbal	492	562	608	495
	SAT Math	480	534	609	494
	LAST	245	262	270	239
2004	SAT Verbal	496	565	650	501
	SAT Math	490	547	622	495
	LAST	245	267	276	246
2005	SAT Verbal	499	552	625	503
	SAT Math	493	541	640	502
	LAST	247	271	279	245
2006	SAT Verbal	497	574	660	498
	SAT Math	494	558	638	497
	LAST	250	275	282	248
2007	SAT Verbal	495	557	648	488
	SAT Math	494	546	635	484
	LAST	252	271	280	248
2008	SAT Verbal	492	558	640	493
	SAT Math	493	548	651	484
	LAST	251	273	282	248
2009	SAT Verbal	496	550	640	500
	SAT Math	495	540	634	476
	LAST	253	271	280	248
2010	SAT Verbal	492	554	642	487
	SAT Math	498	540	634	488
	LAST	254	271	281	254

Table 3.18. White First-Year Teachers (wht)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of wht	% of CR	freq	% of wht	% of NYCTF	freq	% of wht	% of TFA	freq	% of wht	% of Other
2000	2,138	47	70	3	0	27	60	1	59	2,360	52	40
2001	1,948	43	68	232	5	63	73	2	61	2,238	50	42
2002	1,553	35	68	571	13	51	74	2	68	2,187	50	46
2003	2,031	44	71	1,051	23	58	119	3	68	1,430	31	53
2004	2,267	46	72	1,620	33	64	232	5	71	863	17	60
2005	2,403	53	73	1,185	26	60	214	5	68	719	16	61
2006	2,413	53	70	1,233	27	62	379	8	78	533	12	60
2007	2,462	57	69	1,118	26	58	363	8	73	347	8	59
2008	2,584	60	67	1,040	24	56	348	8	73	370	9	62
2009	1,905	58	66	826	25	56	343	10	72	233	7	59
2010	838	58	64	358	25	51	130	9	69	115	8	59

Table 3.19. Black First-Year Teachers (blk)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of blk	% of CR	freq	% of blk	% of NYCTF	freq	% of blk	% of TFA	freq	% of blk	% of Other
2000	356	16	12	5	0	45	14	1	14	1908	84	33
2001	351	17	12	67	3	18	20	1	17	1680	79	31
2002	288	15	13	281	14	25	12	1	11	1378	70	29
2003	262	21	9	308	25	17	20	2	11	642	52	24
2004	317	33	10	391	40	15	21	2	6	237	25	17
2005	305	36	9	330	39	17	26	3	8	190	22	16
2006	369	44	11	301	36	15	25	3	5	139	17	16
2007	398	46	11	329	38	17	42	5	8	92	11	16
2008	411	49	11	312	37	17	31	4	6	83	10	14
2009	326	47	11	263	38	18	33	5	7	71	10	18
2010	127	41	10	145	47	21	12	4	6	24	8	12

Table 3.20. Hispanic First-Year Teachers (hisp)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of hisp	% of CR	freq	% of hisp	% of NYCTF	freq	% of hisp	% of TFA	freq	% of hisp	% of Other
2000	312	21	10	3	0	27	15	1	15	1133	77	19
2001	337	24	12	36	3	10	13	1	11	1023	73	19
2002	264	22	12	108	9	10	11	1	10	802	68	17
2003	295	34	10	162	19	9	16	2	9	395	46	15
2004	273	38	9	256	36	10	29	4	9	161	22	11
2005	283	43	9	233	35	12	29	4	9	114	17	10
2006	343	48	10	236	33	12	23	3	5	114	16	13
2007	380	51	11	247	33	13	30	4	6	87	12	15
2008	461	53	12	284	33	15	32	4	7	90	10	15
2009	372	54	13	219	32	15	37	5	8	61	9	15
2010	182	51	14	125	35	18	14	4	7	34	10	17

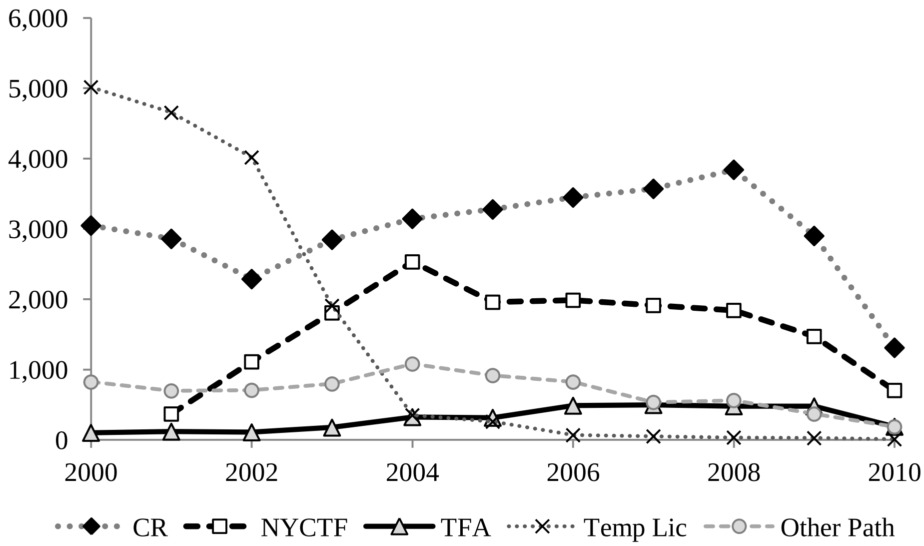
Table 3.21. Other Race First-Year Teachers (oth) (Not White, Black, or Hispanic)

Year	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
	freq	% of oth	% of CR	freq	% of oth	% of NYCTF	freq	% of oth	% of TFA	freq	% of oth	% of Other
2000	157	33	5	0	0	0	11	2	11	303	64	5
2001	145	32	5	13	3	4	11	2	9	282	63	5
2002	119	27	5	51	11	5	11	2	10	267	60	6
2003	168	37	6	109	24	6	16	3	9	167	36	6
2004	188	34	6	215	39	8	36	7	11	111	20	8
2005	226	40	7	174	30	9	39	7	12	133	23	11
2006	276	46	8	182	30	9	58	10	12	88	15	10
2007	281	46	8	214	35	11	61	10	12	51	8	9
2008	356	53	9	204	30	11	68	10	14	48	7	8
2009	287	53	10	164	30	11	65	12	14	23	4	6
2010	156	55	12	76	27	11	32	11	17	21	7	11

Table 3.22. Missing Race First-Year Teachers (miss)

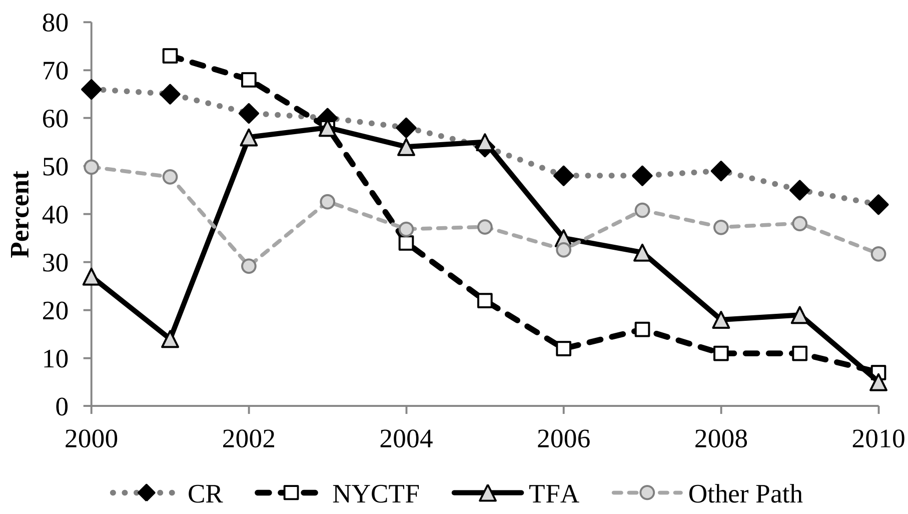
	College Recommended (CR)			NYC Teaching Fellows (NYCTF)			Teach for America (TFA)			All Other Paths		
Year	freq	% of miss	% of CR	freq	% of miss	% of NYCTF	freq	% of miss	% of TFA	freq	% of miss	% of Other
2000	86	39	3	0	0	0	2	1	2	135	61	2
2001	79	34	3	21	9	6	2	1	2	127	55	2
2002	64	25	3	100	39	9	1	0	1	89	35	2
2003	91	27	3	177	52	10	5	1	3	69	20	3
2004	100	46	3	50	23	2	7	3	2	59	27	4
2005	61	48	2	37	29	2	8	6	3	20	16	2
2006	47	46	1	35	34	2	3	3	1	17	17	2
2007	50	78	1	5	8	0	1	2	0	8	13	1
2008	30	83	1	2	6	0	0	0	0	4	11	1
2009	11	65	0	0	0	0	0	0	0	6	35	2
2010	8	80	1	0	0	0	0	0	0	2	20	1

Figure 3.1. Number of First-Year Teachers by Pathway and Year



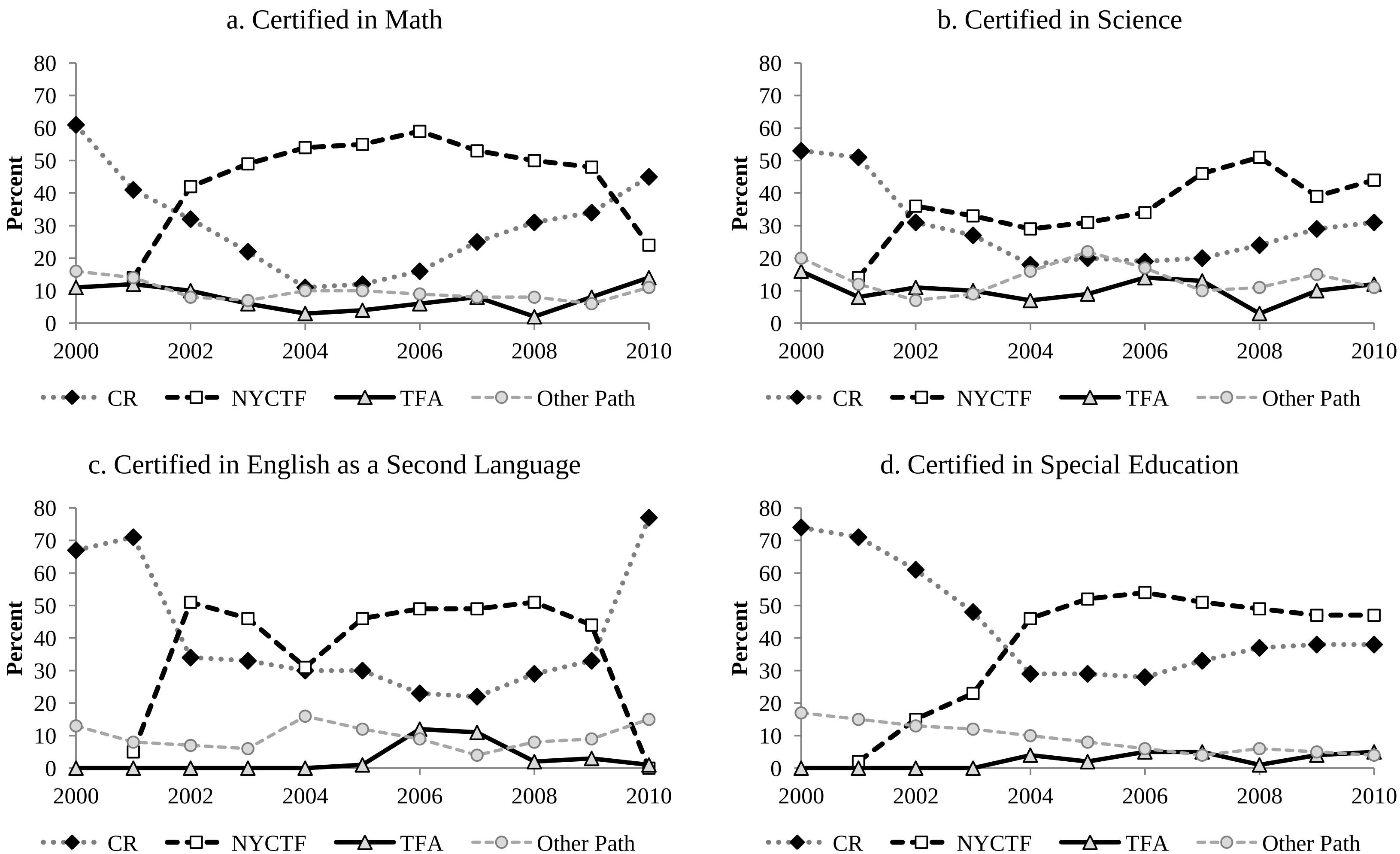
Notes: CR = College Recommended (traditional teaching pathway)
NYCTF = New York City Teaching Fellows
TFA = Teach for America
Temp Lic = Temporary Licensed (uncertified)
Other Path = Modified Teaching Licensed, Transitional B Licensed, and Individual Evaluation

Figure 3.2. Percent of Teachers Certified in Childhood by Pathway and Year



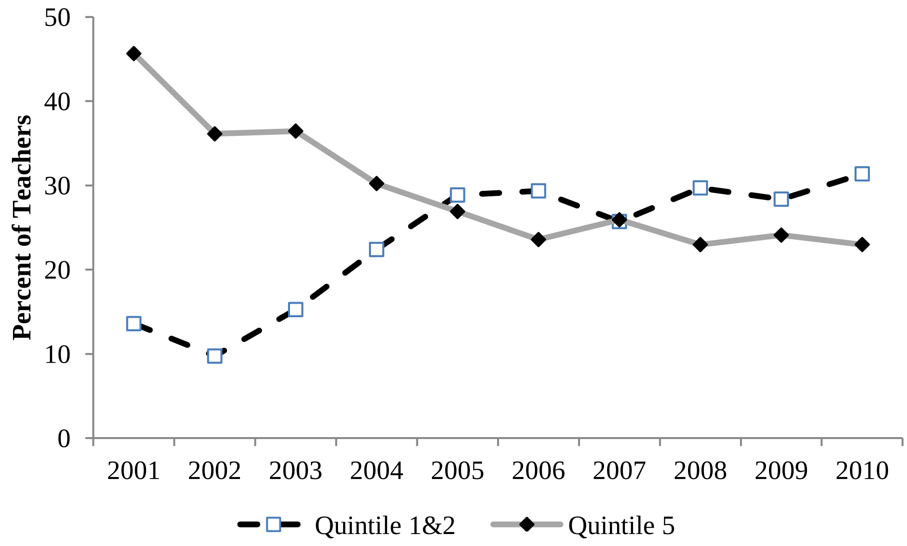
Notes: CR = College Recommended (traditional teaching pathway)
NYCTF = New York City Teaching Fellows
TFA = Teach for America
Other Path = Modified Teaching Licensed, Transitional B Licensed, Temporary Licensed, and Individual Evaluation

Figure 3.3. Percent of Teachers Certified by Area, Pathway and Year



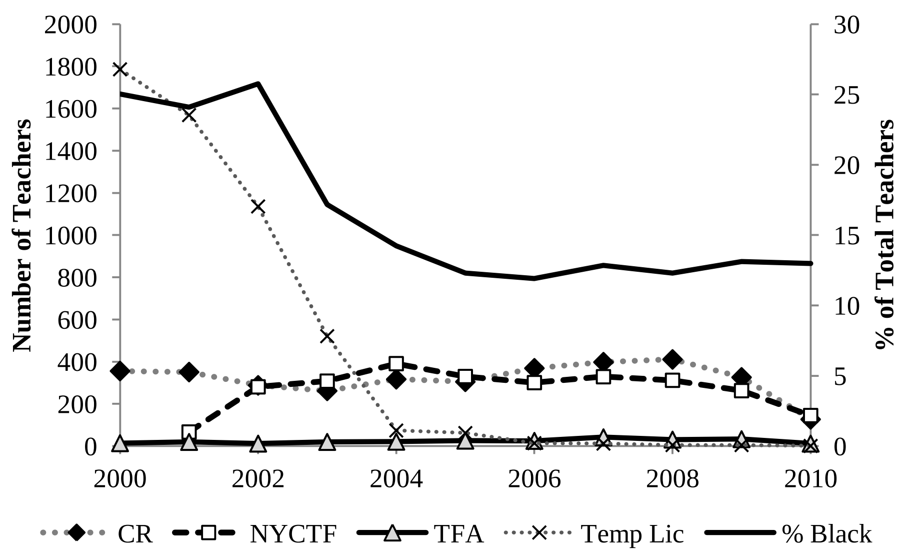
Notes: For definition of teacher pathways (CR, NYCTF, TFA, Other Path) see Figure 3.2 notes.

Figure 3.4. Percentage of Entering NYCTF Teachers by the Poverty Quintile of the School in which They Teach



Notes: Schools are put into quintiles based on the percentage of students within the school who are eligible for free/reduced price lunch (FRPL). Schools in Quintile 1 & 2 have the lowest 40 percent of FRPL students. Schools in Quintile 5 have the highest 20 percent of FRPL students.

Figure 3.5. First-Year Black Teachers by Pathway, and Percent of First-Year Teachers who are Black



Notes: See Figure 1 notes for definition of teaching pathways (CR, NYCTF, TFA, Temp Lic). % Black is the percentage of all first-year teachers who are black.

References

Alva, S., N.B. Coe, and W. Webb. 2010. The Impact of a DROP Program on the Age of Retirement and Employer Costs. CRR Working Paper 2010-11. Chestnut Hill, MA: Center for Retirement Research at Boston College.

Arias, E. 2010a. United States life tables by Hispanic origin. National Center for Health Statistics. Vital Health Stat 2(152).

Arias E., 2010b. United States life tables, 2006. National Center for Health Statistics. Vital Health Stat 58(21).

Asch, B., S.J. Haider, and J. Zissimopoulos. 2005. Financial incentives and retirement: Evidence from federal civil service workers. *Journal of Public Economics* 89(2–3): 427–40.

Boyd, D., P. Grossman, K. Hammerness, H. Lankford, S. Loeb, M. McDonald, M. Reininger, M. Ronfeldt, and J. Wyckoff. 2008. Surveying the Landscape of Teacher Education in New York City: Constrained Variation and the Challenge of Innovation. *Education Evaluation and Policy Analysis*. 30(4): 319-343.

Boyd, D., P. Grossman, K. Hammerness, H. Lankford, S. Loeb, M. Ronfeldt, and J. Wyckoff. 2012. Recruiting Effective Math Teachers: Evidence from New York City. *American Educational Research Journal* 49(6): 1008-1047.

Boyd D., P. Grossman, H. Lankford, S. Loeb and J. Wyckoff. 2006. How changes in entry requirements alter the teacher workforce and affect student achievement. *Education Finance and Policy* 1(2): 176-216.

Boyd, D., P. Grossman, H. Lankford, S. Loeb, and J. Wyckoff. 2007. Who Leaves? Teacher Attrition and Student Achievement? Working paper. Albany, NY: Teacher Policy Research.

Boyd D., P. Grossman, H. Lankford, S. Loeb and J. Wyckoff. 2009. Teacher Preparation and Student Achievement. *Educational Evaluation and Policy Analysis* 31: 416-440.

Boyd, D., H. Lankford, S. Loeb, J. Rockoff and J. Wyckoff. 2008 The Narrowing Gap in New York City Teacher Qualifications and its Implications for Student Achievement in High-Poverty Schools. *Journal of Policy Analysis and Management* 27(4): 793-818.

Boyd, D., H. Lankford, S. Loeb and J. Wyckoff. 2005. Explaining the Short Careers of High-Achieving Teachers in Schools with Low-Performing Students. *American Economic Review Proceedings* 95(2): 166-171.

Bradley P.C. and T.A. Louis. 2000. *Bayes and Empirical Bayes Methods for Data Analysis*. 2nd Edition. Chapman & Hall: London.

Brewer, D.J., 1996. Career paths and quit decisions: Evidence from teaching. *Journal of Labor Economics* 14(2): 313-339.

Chetty, R., J. Friedman, J. Rockoff. 2001. The Long-term Impacts of Teachers: Teacher Value-added and Student Outcomes in Adulthood. NBER working paper 17699. Cambridge, MA: National Bureau of Economic Research.

Clotfelter, C.T., H.F. Ladd and J.L. Vigdor. 2006. Teacher-Student Matching and the Assessment of Teacher Effectiveness. *Journal of Human Resources* 41.1: 778-820.

Clotfelter, C.T., H.F. Ladd and J.L. Vigdor. 2007. How and Why Do Teacher Credentials Matter for Student Achievement? CALDER Working Paper 2. Washington, D.C.: The Urban Institute.

Coile, C., and J. Gruber. 2000. Social Security and Retirement. NBER working paper 7830. Cambridge, Mass: National Bureau of Economic Research.

Coile, C., and J. Gruber. 2007. Future Social Security Entitlements and the Retirement Decision. *The Review of Economics and Statistics* 89(2): 234–246.

Constantine, J., D. Player, T. Silva, K. Hallgren, M. Grider, and J. Deke. 2009. An Evaluation of Teachers Trained Through Different Routes to Certification. Princeton, NJ: Mathematica Policy Research, Inc.

Costrell, R.M., and J.B. McGee. 2010. Teacher Pension Incentives, Retirement Behavior, and Potential for Reform in Arkansas. *Education Finance and Policy* 5(4): 492-518.

Costrell, R. M., and M. Podgursky. 2009. Peaks, Cliffs, and Valleys: The Peculiar Incentives in Teacher Retirement Systems and Their Consequences for School Staffing. *Education Finance and Policy* 4(2): 175–211.

Decker, P. T., D.P. Mayer, and S. Glazerman. 2004. The effects of Teach for American on students: Findings from a national evaluation. Princeton, NJ: Mathematica Policy Research, Inc.

Dee, T. 2005. A Teacher Like Me: Does Race, Ethnicity, or Gender Matter" *American Economic Review* 95(2): 158-165.

Feistritzer, E. 2008. *Alternative Routes to Teaching*. Upper Saddle River, NJ: Pearson.

Fitzpatrick, M. 2013. How Much Do Public School Teachers Value Their Pension Benefits? Working paper. Cornell University.

Fitzpatrick, M. and M. Lovenheim. Forthcoming. Early Retirement Incentives and Student Achievement. *American Economic Journal: Economic Policy*.

Friedberg, L., and S. Turner. 2010. Labor Market Effects of Pensions and Implications for Teachers. *Education Finance and Policy* 5(4): 463-491.

Friedberg, L., and S. Turner. 2011.Pensions and Public School Teacher Retirement: An Analysis Using National Teacher Data. Research Dialogue Issue no. 99. TIAA-CREF Institute.

Friedberg, L., and A. Webb. 2005. Retirement and the evolution of pension structure. *Journal of Human Resources* 40(2): 281-308.

Furgeson, J., R. P Strauss, and W. B Vogt. 2006. The effects of defined benefit pension incentives and working conditions on teacher retirement decisions. *Education Finance and Policy* 1(3): 316–348.

Gerald, D.E., and W.J. Hussar. 2003. Projections of Education Statistics to 2013. U.S. Department of Education, National Center for Education Statistics. NCES 2004-013. Washington, DC.

Goldhaber D., B. Gross, and D. Player. 2011. Teacher Career Paths, Teacher Quality, and Persistence in the Classroom: Are Public Schools Keeping Their Best? *Journal of Public Policy and Management* 30(1): 57-87.

Grossman and Loeb, eds. 2008. *Alternative Routes to Teaching***,** Mapping the New Landscape of Teacher Education. Cambridge: Harvard Education Press.

Hanushek, E., J. Kain, D. O'Brien and S. Rivkin. 2005. The Market for Teacher Quality. NBER working paper 11154. Cambridge, Mass: National Bureau of Economic Research.

Hanushek, E.A., J.F. Kain, and S.G. Rivkin. 2004. Why Public Schools Lose Teachers. *Journal of Human Resources* 39(2): 326-354.

Henry, G., C. Thompson, K. Bastian, C. Fortner, D. Kershaw, K. Purtell, and R. Zulli. 2010. Portal Report: Teacher Preparation and Student Test Scores in North Carolina. Working paper.

Hill, C. J., Bloom, H. S., Black, A. R. and Lipsey, M. W. 2008. Empirical Benchmarks for Interpreting Effect Sizes in Research. *Child Development Perspectives* 2: 172–177.

Jackson, K. 2009. Student Demographics, Teacher Sorting, and Teacher Quality: Evidence from the End of School Desegregation. *Journal of Labor Economics* 27(2): 213-256.

Kane, T. J., J. E. Rockoff and D. O. Staiger. 2008. What Does Certification Tell Us About Teacher Effectiveness? Evidence from New York City. *Economics of Education Review* 27(6): 615-631.

Koedel, C. and J.R. Betts. 2011. Does Student Sorting Invalidate Value-Added Models of Teacher Effectiveness? An Extended Analysis of the Rothstein Critique. *Education Finance and Policy* 6(1): 18-42.

Koedel, C., M. Podgurksy, and S. Shi. 2013. Teacher Pension Systems, the Composition of the Teaching Workforce, and Teacher Quality. *Journal of Policy Analysis and Management* 32(3): 574-596.

Lankford, H., Loeb, S., and J. Wyckoff. 2002. Teacher Sorting and the Plight of Urban Schools: A Descriptive Analysis. *Educational Evaluation and Policy Analysis* 24: 37-62.

McGee, J.B. (working paper) Who Leaves and Who Stays: An Analysis of Teachers' Behavioral Response to Retirement Incentives.

Murnane, R. 1984. Selection and Survival in the Teacher Labor Market. *The Review of Economics and Statistics* 66(3): 513-518.

National Association of State Retirement Administrators. 2012. Return to Work/Employment After Retirement. Retrieved November 4, 2013 from http://www.nasra.org/

National Commission on Teaching and America's Future. 2009. Learning Teams: Creating What's Next. Washington, DC. Retrieved September 29, 2011 from http://www.nctaf.org/

North Carolina General Assembly Legislation S.L. 1998-212, S.L. 1998-217, S.L. 2000-67, S.L. 2001-424, S.L. 2002-126, SL. 2004-124, S.L. 2005-144, S.L. 2005-276, S.L. 2005-345, S.L. 2007-145, S.L. 2007-326.

Pew Center on the States. 2010. The Trillion Dollar Gap: Underfunded State Retirement Systems and the Roads to Reform. Washington, DC. Retrieved October 2, 2011 from http://downloads.pewcenteronthestates.org/The_Trillion_Dollar_Gap_final.pdf

Podgursky, M., R. Monroe, and D. Watson. 2004. The Academic Quality of Public School Teachers: An Analysis of Entry and Exit Behavior. *Economics of Education Review* 23: 507-18.

Rivkin, S.G., E.A. Hanushek, and J.F. Kain. 2005. Teachers, Schools, and Academic Achievement. *Econometrica* 73(2): 417-458.

Rockoff, J. 2004. The impact of individual teachers on student achievement: Evidence from panel data, *American Economic Review* 94(2): 247-252.

Rothstein, J. 2009. Student Sorting and Bias in Value Added Estimation: Selection on Observables and Unobservables. *Education Finance and Policy* 4(4): 537-571.

Samwick, A. 1998. New Evidence on Pensions, Social Security, and the Timing of Retirement. *Jornal of Public Economics* 70(2): 207-236.

Stinebrickner, T. 2001. A Dynamic Model of Teacher Labor Supply. *Journal of Labor Economics* 19(1): 196-230.

Stinebrickner, T. 2002. An Analysis of Occupational Change and Departure from the Labor Force: Evidence of the Reasons that Teachers Leave. *The Journal of Human Resources* 37(1): 192-216.

Stock, J. H., and D.A. Wise. 1990. Pensions, the option value of work, and retirement. *Econometrica* 58(5): 1151–1180.

Wisconsin Center for Education Research. 2010. NYC Teacher Data Initiative: Technical Report on the NYC Value-Added Model. Madison, WI: University of Wisconsin System.

Xu, Z., J. Hannaway, and C. Taylor. 2008. Making a Difference? The Effects of Teach for America in High School. CALDER Working Paper 17. Washington, D.C.: The Urban Institute.