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Teacher Turnover and Teacher Retirement

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Abstract

Teachers have an important impact on students in the short- and long-term, but only teachers' experience consistently predicts high teacher quality. This dissertation, divided into three chapters, investigates two topics that are related to teachers' experience levels: turnover and retirement.

The first chapter studies the relationship between voluntary beginning teacher turnover and teachers' levels of conscientiousness. It uses the data from the Beginning Teacher Longitudinal Study and the effort that teachers put on a survey taken during their first year in the profession as a proxy for teachers' levels of conscientiousness. The results of this chapter indicate that teachers putting less effort on their surveys (i.e. the less conscientious teachers) are more likely to be retained. While higher quality principals can reduce the likelihood of teacher turnover, these principals more effective at retaining less conscientious teachers.

The second chapter conceptually evaluates policies that try to induce teacher turnover in an attempt to reduce mounting pension costs. Using data from Massachusetts, this chapter calculates the required deviations from actuarially assumed teacher exit rates that would hold the uniform normal cost rate (the average cost of prefunding all currently accruing benefits for teachers as a percent of salary) constant when the lowering the discount rate from the expected investment return rate to a less risky rate. It finds that the probability that each teacher exits would have to increase substantially. This chapter also evaluates two targeted policies that would only increase teacher exit rates among the teachers that earn individual normal cost rates above the uniform normal cost rate and among the teachers that are eligible to retire. Even when all teachers in the targeted populations exit the Massachusetts Teachers' Retirement System, savings to the fund are not enough to prevent a rise in the uniform normal cost rate.

The final chapter of this dissertation calculates teachers' willingness-to-pay for several job conditions using a nationally representative sample of teachers from RAND's American Teacher Panel. Results indicate that respondents value their final average salary defined benefit plans at under 3 percent of salary relative to switching to an alternative retirement plan, but experience and cognitive ability, used to proxy for teacher quality, mediate this preference. Early-career and lower quality teachers, measuring through lower levels of cognitive ability, are indifferent to the type of retirement plan they are enrolled in. Respondents also valued their retirement plans less than they valued their replacement rates, retirement ages, salary growth, health insurance, and whether they are enrolled in Social Security.

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Dedication

To Kevin Kennedy and my grandparents, Dorothy Stoehr, Bob Stoehr, Dorothy Fuchsman, and Paul Fuchsman. I will always work to make you proud.

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Fuchsman, D. & Zamarro, G. (2019). Conscientiousness, Principals' Leadership, and Beginning Teacher Turnover. *EDRE Working Paper No. 2019-01*. Published on Social Science Research Network (Chapter 1 of this dissertation).

Introduction

Perhaps the most foundational insight from education research is the basic notion that high quality instruction matters. Teachers can impact students in at least three important ways. First, teachers have large impacts on student achievement (Aaronson et al., 2007; Rivkin et al., 2005; Rockoff, 2004). The average effect of a one standard deviation improvement in teacher quality is estimated to be 0.13 standard deviations in reading achievement and 0.17 standard deviations in math achievement (Hanushek & Rivkin, 2010). Second, teachers influence students' social-emotional skills, effort in class, and behavior (Jackson, 2018; Kraft, 2017). Third, teachers have meaningful effects on students in the long-run, affecting students' earnings, college quality, neighborhood quality, the likelihood that students save for retirement, and lowering teen birth rates (Chetty et al., 2014).

Given the important roles that teachers play in the lives of their students, it becomes important to understand what predicts high-quality teaching. Unfortunately, teachers' experience is the only consistent predictor of teacher quality (Clotfelter et al., 2006; Harris & Sass, 2011; Papay & Kraft, 2015; Rivkin et al., 2005; Rockoff, 2004; Wiswall, 2013). Teachers improve in quality as they gain experience. While there have been other promising conceivable predictors, they typically do not bear fruit. For example, teachers that enter the profession through the Teach for America have larger positive effects on student achievement traditionally certified teachers, but only in certain grades and subjects while there is more variation within the set of Teach for America teachers and traditionally certified teachers than there is across pathways to these profession (Henry et al., 2014).

The assumption that experience is the most important predictor of high-quality teaching means that a vital goal for policymakers is retaining teachers. However, many potentially

impactful educators exit the profession long before they reach their potential. Ten percent of teachers will exit the classroom after their first year and 17 percent will not survive 5 years as teachers in their initial schools (Gray & Taie, 2015). This teacher turnover poses significant problems for students, schools, and districts. Teacher turnover has significant negative effects on student achievement (Ronfeldt et al., 2013) and forces schools to engage in costly searches for replacement teachers (Barnes et al., 2007; Birkeland & Curtis, 2006; Milanowski & Odden, 2007) who are often rookie teachers of low-quality.

The first chapter of this dissertation digs deeper into the teacher turnover question. Prior research has documented that the teachers that make contributions to students' test scores are less likely to leave the profession (Boyd et al., 2007; Goldhaber et al., 2007; Hanushek et al., 2005; Henry et al., 2011; Krieg, 2006), but has yet to consider non-cognitive quality of retained teachers. Growing evidence suggests that teachers affect the non-cognitive skills of students and that the teachers that impact non-cognitive skills are not the same teachers that impact test scores (Cheng & Zamarro, 2018; Jackson, 2018; Papay & Kraft, 2015). This chapter uses teachers' item non-response rates on a survey to proxy for conscientiousness. Item non-response is the number of questions on a survey that respondents leave blank divided by the number of questions respondents were supposed to answer. Several recent studies demonstrate the potential of item non-response as a proxy for conscientiousness (Soland et al., 2019 reviews these studies). Using data from the Beginning Teacher Longitudinal Study, this chapter investigates the relationship between conscientiousness and voluntary beginning teacher turnover. Results indicate that teachers exerting less effort on their surveys (i.e. less conscientious teachers) are more likely to be retained. Furthermore, even though principals that are higher quality based on teachers'

evaluations of principals appear to be more effective at retaining teachers, these high-quality principals are more effective at retaining the less conscientious teachers.

A common proposal to improve teacher retention is to increase teacher pay since teachers earning higher salaries are more likely to remain in the profession (Borman & Dowling, 2008; Imazeki, 2005). The problem with increasing salaries is that there is not as much money available in state and district budgets to spend on raises since costs associated with teacher pension have risen substantially since 2004 (Costrell, 2019; Kim et al., 2020; McGee, 2016). Pension expenditures have ballooned to combat the $600 billion in unfunded accrued liabilities (McGee, 2019; Novy-Marx & Rauh, 2011). However, that figure may actually understate the underfunding problem in public pensions.

Actuarial assumptions, which may be incorrect, shape the fiscal health of teacher pensions. Typically, retirement funds discount teachers' future benefits at the expected investment return rate, but the true rate of return is usually lower. When the actual rate falls short of the expected rate, unfunded accrued liabilities rise (Costrell, 2018). When the discount rate decreases, the cost to prefund all currently accruing benefits, the normal cost, rises (Costrell, 2020). The second chapter of this dissertation conceptually evaluates one policy proposal that attempts to reduce pension costs. Chicago, Kansas, and California have had or currently have voluntary retirement incentive programs, which induce teacher turnover to rein in pension costs. This chapter describes a methodology that would change actuarially assumed teacher exit rates, thereby inducing teacher turnover, all while holding normal costs constant when lowering the discount rate. In Massachusetts, an assumed 7.5 percent discount rate corresponds with a uniform normal cost rate, the normal cost as a percent of salary, of nearly 12 percent. Teachers' turnover probabilities would have to increase drastically for all teachers in order to hold the uniform

normal cost rate constant at close to 12 percent when the discount rate is allowed to decline. This chapter models two policies that would target teacher turnover among the set of teachers whose individual normal cost rates exceed the uniform normal cost rate and teachers who are eligible to retire. The latter targeted policy mirrors voluntary retirement incentive programs in Chicago, Kansas, and California. When the discount rate is cut to 6 percent or lower, all teacher that earns a normal cost rate above the uniform normal cost rate and all teachers that are eligible to retire would be forced to exit teaching is Massachusetts public schools. Even when all of these teacher exit, the cumulative savings to the retirement system fail to hold the uniform normal cost rate constant at 12 percent. This means either that the state would have to raise contributions to the retirement system or that unfunded accrued liabilities would rise.

Teachers in many states, including Massachusetts, enroll in the state's Final Average Salary Defined Benefit (FAS DB) retirement plan. Some have argued that these plans serve as teacher recruitment and retention tools (Boivie, 2011, 2017), but there are serious drawbacks to these plans including that these plans are highly susceptible underfunding (Aldeman & Johnson, 2015; Backes et al., 2016; Costrell & Podgursky, 2009). Alternative retirement plans, such as Defined Contribution (DC) and Cash Balance (CB) plans, can be cost equivalent to states, given key plan assumptions, and generate comparable benefits while reducing government cost uncertainty (Costrell & Podgursky, 2009; McGee & Winters, 2018).

The third chapter of this dissertation investigates teachers' preferences for retirement plans and other components of their compensation. Using a discrete choice stated preferences experiment embedded in a 15-minute survey for a nationally representative sample of teachers, this chapter calculates teachers' willingness-to-pay for retirement plans, replacement rates (annual retirement benefits as a percent of salary), retirement ages, salary growth, class sizes,

health insurance, and Social Security. Respondents to this survey associate switching from FAS DB plans to DC and CB plans with a 2.8 and 2.6 percent salary decrease, respectively. Early-career teachers are indifferent between FAS DB plans and alternative plans, while late-career teachers value switching out of FAS DB plans at a 6.5 percent salary cut. Teachers with high levels of cognitive ability, a proxy measure for teacher quality that is associated with student achievement (Hanushek et al., 2018), would have to be compensated with a 5.2 percent raise to switch from an FAS DB plan to a DC plan but would only require 4.4 percent raises to switch to CB plans. Respondents with low levels of cognitive ability have no preferences among retirement plan types. However, teachers' willingness-to-pay for retirement plans is lower than their willingness-to-pay for job conditions. Teachers value a 2-percentage point increase in their replacement rates, a one-year decrease in the retirement age, or a half percentage point increase in annual salary growth rates equivalently to their willingness-to-pay to keep their FAS DB plans.

The evidence in the three chapters of this dissertation significantly advances knowledge of the determinants of teacher turnover and teacher retirement. Chapter 1 shows that retained teachers are not always the highest quality teachers as the retained teachers appear to be less conscientious. Policymakers need to do more to retain conscientious teachers and may task school principals to do more to keep these teachers in their schools. Results from this chapter indicate that high-quality principals are actually less effective at retaining conscientious teachers and that high-quality principals may need to rethink their strategies for retaining high-quality teachers.

Chapter 2 serves as a warning to policymakers that programs designed to induce teacher turnover to relieve teacher pensions are unlikely to be successful. Policies that can generate

enough turnover to hold pension costs at current levels when lowering the discount rate are unlikely to be feasible as they would require substantial increases in teacher turnover. Targeted policies fail to hold pension costs constant and would either need to accompany increased contributions to pension systems or unfunded liabilities would have to rise. Policies that would seek to create teacher turnover are misguided since they also ignore that the only consistent predictor of teacher quality is experience. Voluntary retirement incentive programs may sacrifice student learning in a cost-cutting effort.

The final chapter builds on prior literature which shows that alternative retirement plans may be less fiscally distressing than traditional FAS DB plans. The results show that pension reform may be possible, but only if teachers receive something in return. Teachers are willing to pay to keep their FAS DB plans, but the value they place on these plans is not substantial. The potential savings to retirement systems from giving teachers raises as compensation for switching to alternative plans would likely dwarf the salary increases. When states reform their pension plans, new retirement plans are usually only available to newly hired teachers, but the results from this chapter suggest that states may be able to switch current teachers into alternative plans. Late-career teachers who have already accrued substantial benefits had a significantly higher willingness-to-pay than early- and mid-career teachers. States may opt to leave their highly experienced teachers in FAS DB plans and give out modest raises to early- and mid-career teachers to convert a large proportion of their teacher populations into DC or CB plans.

The three chapters of this dissertation contributes to the education research community by giving it a better understanding of why high-quality teachers might leave the profession and what policymakers could consider trying to retain them.

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Chapter 1: Conscientiousness, Principals' Leadership, and Beginning Teacher Turnover[1]

Introduction

Voluntary teacher turnover is concerning for schools and students. Costly searches to replace teachers are a drain on school resources[2] (Barnes et al., 2007; Birkeland & Curtis, 2006; Milanowski & Odden, 2007) and teacher turnover negatively affects students' achievement on standardized tests (Ronfeldt et al., 2013). The effect of teacher turnover compounds when considering that replacement teachers appear to be, on average, less effective than exiting teachers (Harris & Sass, 2011; Papay & Kraft, 2015; Rockoff, 2004).

In response to the policy concerns that teacher turnover poses, there exists ample academic literature documenting the important role of principal quality (Boyd et al., 2011; Grissom, 2011; Kraft et al., 2016; Ladd, 2011) and teacher and student body characteristics (Allensworth et al., 2009; Borman & Dowling, 2008; Boyd et al., 2011; Johnson et al., 2012; Kraft et al., 2016; Ladd, 2011; Loeb et al., 2005; Marinell & Coca, 2013) on teacher turnover decisions. However, this teacher turnover literature has yet to consider in depth the non-cognitive characteristics of teachers who might be retained.

Teachers make an impact on a wide variety of student outcomes. The teacher quality literature has long known about the important role that teachers can have on students' test scores (Rivkin et al., 2005; Rockoff, 2004), but teachers can also affect students' social-emotional skills, effort in class, and behavior (Jackson, 2018; Kraft, 2017). However, those teachers who are effective at increasing students' test scores are not necessarily the same as those who are effective at supporting student socio-emotional outcomes (Kraft, 2017). Teachers' personality

[1] This paper was coauthored with Gema Zamarro.

[2] These costs on school resources are those associated with separation, recruiting, hiring, and training new teachers. Milanowski and Odden (2007) show the only large benefit of teacher turnover would be in net replacement pay, since new teachers are lower on the salary schedule than exiting teachers, but other costs dwarf these gains.

skills related to conscientiousness appear to be important determinants of teacher quality not well measured by teachers' contributions to their students' test scores (Cheng & Zamarro, 2018). Due to the influences that teachers can have on students beyond test score gains, principals and policymakers should be concerned with the quality of the teaching workforce on a variety of measures. This deference to teachers' non-cognitive skills raises the question of which teachers are more likely to be retained.

In this paper, we study the relationship between teacher turnover and teachers' levels of conscientiousness. Specifically, we follow a developing literature that proposes that individuals' effort on surveys can capture meaningful non-cognitive skills related to conscientiousness (Hedengren & Stratmann, 2012; Hitt et al., 2016), that is diligence and desire to do a task well. To our knowledge, only three other studies have looked at the role of conscientiousness in teacher turnover decisions finding either null effects (Rockoff et al., 2010) or finding that conscientious teachers have lower teacher turnover rates (Bastian et al., 2017; Robertson-Kraft & Duckworth, 2014). However, none of this previous work on conscientiousness and teacher turnover uses a national sample of teachers.

While this paper's focus is on the effects of conscientiousness on voluntary beginning teacher turnover, our data were collected during a time of economic instability: the Great Recession. We are wary that the Great Recession may impact teacher turnover[3]. Teachers demonstrating higher levels of conscientiousness may be less likely than non-conscientious teachers test their local labor markets during recessions. In order to take Great Recession induced economic instability into account, we merge the national Beginning Teacher Longitudinal Study

[3] There is a pre-existing link between teacher turnover and recessions in the literature already. In Florida, teachers with higher contributions to their students' test scores (i.e. higher value-added teachers) were more likely to be hired during recessions but were also more likely to leave the profession years after (Nagler et al., 2015).

(BTLS) dataset with unemployment data from the USC Great Recession Indicators Database (GRID) to control for differences in local labor markets and study differential effects depending on the local economic conditions.

Our results indicate that teachers with lower levels of conscientiousness, i.e. lower levels of effort on the baseline BTLS survey, present lower probabilities of teacher turnover and are less likely to switch schools during their first years of teaching. We also find that, as with prior literature, higher quality principals help retain teachers in their current schools. However, they seem to be more effective at retaining those teachers who show lower levels of conscientiousness on their baseline surveys than those who exert more effort. Highly conscientious teachers (i.e. teachers with higher levels of effort on the baseline survey) appear to be better retained when there are unstable local labor market conditions.

These results have important policy implications. To the extent that teacher survey effort captures meaningful dimensions of teacher quality (Cheng & Zamarro, 2018), our results suggest that we need better strategies to retain highly conscientious teachers in the profession. While principals are generally effective at improving teacher retention (Boyd et al., 2011; Grissom, 2011; Kraft et al., 2016; Ladd, 2011), they appear less effective at retaining those who show higher levels of conscientiousness by putting forward more effort on the baseline survey.

The rest of this paper is organized as follows. The next section provides background concerning teacher turnover and teacher conscientiousness. In the following section, we describe the data and specific measures that are part of our analysis. The next section describes our empirical approach to study the determinants of beginning teacher turnover. Next, we present the results of our analysis. The following section includes 2 sets of robustness checks: altering the information included in our measure of principal quality and controlling for teachers' reported

job satisfaction. Finally, we conclude the paper with a discussion of the results and policy implications.

Background

A 2015 National Center for Education Statistics report pegs the annual rate of teacher turnover after the first year of a teacher's career at 10 percent and 17 percent within the first five years (Gray & Taie, 2015). A considerable literature has aimed to shed light on which factors determine teacher turnover (see, e.g., Borman & Dowling, 2008; Guarino, Santibañez, & Daley, 2006). Several teacher characteristics are found to predict teacher turnover including demographic characteristics and type of certification (Boyd et al., 2006; Kane et al., 2008). Student body characteristics also factor into teacher turnover decisions (Allensworth et al., 2009; Borman & Dowling, 2008; Boyd et al., 2011; Ladd, 2011; Loeb et al., 2005). Overall, organizational factors such as school leadership, school safety and discipline, academic expectations for students, teachers' collaboration and support with each other appear to be stronger predictors of teacher turnover than teacher's demographics, preparation, or average characteristics of students in the school (Allensworth et al., 2009; Boyd et al., 2011; Johnson et al., 2012; Kraft et al., 2016; Ladd, 2011; Loeb et al., 2005; Marinell & Coca, 2013).

Researchers have also looked at how teacher quality, measured using teachers' contributions to test scores through value-added models, relates to teacher turnover. High-quality teachers, on average, were found to be less likely to leave the teaching profession in Washington State (Krieg, 2006); Texas (Hanushek et al., 2005); New York City (Boyd et al., 2007); and North Carolina (Goldhaber et al., 2007). On average, teachers in Florida with high value-added tend to change schools less often, but teachers at the high and low ends of the quality distribution tend to leave the profession more (Feng & Sass, 2017). To our knowledge, only one study

includes data from the Great Recession, finding that the beginning teachers in the first 5 years of their careers who left the classroom in North Carolina during this time were less effective on average (Henry et al., 2011). Furthermore, when high-quality teachers exit the profession, they earn more in other fields (Chingos & West, 2011).

A consistent finding in the literature is that principals' effectiveness and leadership reduce the likelihood of teacher turnover (Boyd et al., 2011; Grissom, 2011; Kraft et al., 2016; Ladd, 2011). In this respect, Grissom and Bartanen (2018) specifically connect principal quality to retaining high-quality teachers relative to low-quality teachers, or "strategic teacher retention." Whereas previous work relied solely on teacher survey responses to measure principal quality, the authors combined these teacher surveys with principal evaluations that district leaders in Tennessee conducted for their analysis; the authors use classroom observations of teachers that principals often perform as well as student achievement and growth to measure teacher quality. They corroborate the previous finding that high-quality principals can reduce the probability of teacher turnover. The authors also find that effective principals seem to be better at retaining high-quality teachers based on classroom observations, but not based on student growth or achievement.

Teacher Conscientiousness and Turnover

In general, individuals' level of conscientiousness appear to be an important determinant of job performance, retention, and job satisfaction (Barrick & Mount, 1991; Barrick & Zimmerman, 2009; Dalal, 2005; Hurtz & Donovan, 2000; Roberts et al., 2007). Importantly, among teachers, self-reported higher conscientiousness corresponds with lower levels of burnout and higher morale, which may affect turnover decisions (Kokkinos, 2007; Teven, 2007).

Only 3 prior studies have looked at the relationship between teacher conscientiousness and teacher turnover. Rockoff, Jacob, Kane, and Staiger (2010) find that, among beginning teachers in New York City in the 2006-07 school year, self-reported conscientiousness does not predict teacher turnover the following year. In contrast, Robertson-Kraft and Duckworth (2014) use a convenience sample of Teach for America beginning teachers from low-income districts and find that teachers with higher levels of self-reported grit, a non-cognitive skill associated with conscientiousness, are more likely to be retained throughout the first year than their less gritty counterparts.[4] Similarly, Bastian et al. (2017) uses a sample of first year teachers in the 2013-14 academic year in North Carolina to study the effect of personality traits on teacher retention. The authors find that more self-reported conscientious teachers have lower rates of attrition. Additionally, a meta-analysis finds that teacher self-reported conscientiousness is negatively related to burnout, which is likely to be associated with turnover (Kim et al., 2019).

In this paper, we use measures of survey effort through teachers' item non-response rates on their baseline BTLS survey as a performance-task proxy measure of conscientiousness. Self-reported non-cognitive skills measures, like the prior literature uses, are susceptible to multiple types of bias such as reference group bias and social desirability bias (Duckworth & Yeager, 2015). Because of these limitations, Duckworth and Yeager (2015) advise to exercise caution when using existing self-reported measures of non-cognitive skills and highlight the importance of developing novel performance-task based measures. In this respect, several recent studies demonstrate the potential of item non-response as a performance-task based measure to proxy for non-cognitive skills related to conscientiousness (Cheng, 2015; Cheng & Zamarro, 2018;

[4] Robertson-Kraft and Duckworth (2014) only evaluate within-year teacher turnover decisions rather than between years.

Hedengren & Stratmann, 2012; Hitt et al., 2016; Kassenboehmer & Schurer, 2018; Marcus & Schütz, 2005; Zamarro, Cheng, et al., 2018; Zamarro, Nichols, et al., 2018)[5].

Hedengren and Stratmann (2012), taking advantage of longitudinal nationally representative samples of adolescents and adults from Germany and the U.S., find item non-response to be correlated with self-reported measures of conscientiousness and a strong predictor of earnings and mortality risks later in life. Kassenboehmer and Schurer (2018) and Zamarro, Cheng, Shakeel, & Hitt (2018) find similar correlations with self-reported conscientiousness. Hitt, Trivitt, and Cheng (2016) utilize six nationally representative, longitudinal datasets of American adolescents to show that the number of questions skipped on a paper and pencil survey is a significant predictor of educational attainment and labor outcomes later in life, even after controlling for cognitive ability. Lastly, Cheng and Zamarro (2018), using data from the Measures of Effective Teaching (MET) longitudinal database, find that teacher item non-response rates on a baseline survey captures important dimensions of teacher quality as they are found to be correlated with performance in classroom observation protocols and with student ratings of their teachers. Teacher survey effort measures are also found to be related to students' cognitive and non-cognitive skills like math test scores and student self-reported effort in class.

Data

We use the Beginning Teacher Longitudinal Study (BTLS), a 5 year nationally representative panel dataset comprised of beginning teachers. Data collection began with the Schools and Staffing Survey (SASS) in the 2007-08 school year (*year 1*) and the Teacher Follow-up Survey (TFS) in 2008-09 (*year 2*). Responses to the initial SASS survey were accepted between August 2007 and June 2008. BTLS extracted the subsample of first-year

[5] See, Soland, Zamarro, Cheng, & Hitt (2019) for a detailed review of this literature.

teachers in public schools from SASS and continued to interview those beginning teachers for 3 more school years after the TFS (2009-10 through 2011-12 school years, *data years 3 to 5*). BTLS contains responses from almost 2,000 beginning teachers in the first year. These data are unique in that the BTLS continued to collect data for teachers who decided to leave the profession.

The 2007-08 iteration of SASS contained 5 questionnaires collecting information about the school district, the school, the principal, the teacher, and the library media center. It is possible to match the information of these 5 questionnaires through a unique school identifier. Since the BTLS started as a subsample of SASS, we are able to match the first year teachers in BTLS to the information collected through the other four questionnaires. In particular, we utilize information collected from the school, principal, and teacher surveys.

Our analyses focus on full-time teachers[6] in regular public schools[7]. We also only look at teachers who moved out of their original schools voluntarily. Since these data are based on survey responses, involuntary teacher turnover is captured through self-reporting that their contracts had not been renewed. About 5.6 percent of teachers self-reported they were terminated and about 0.8 percent of teachers reported their contract was not renewed due to a layoff. With these restrictions in place, and excluding incomplete records[8], our analytical sample size starts with about 1,160 teachers.

[6] Approximately 9.5 percent of teachers in our data are not full time teachers.
[7] Restricting to teachers in regular schools excludes teachers in charter schools as charter school principals have more discretion in the recruitment and firing policies of their teachers Only about 4.5 percent of teachers in our data work in a charter school.
[8] Approximately 22.6 percent of teacher in the data are excluded due to incomplete records.

Measures of Teacher Turnover

We categorize teachers in a given year into 3 groups: stayers, school changers, and leavers. Stayers are teachers who remain in the same school they taught in during year 1. Changers are those who switch schools but continue to teach at some point during year 2 through 5. Leavers are teachers who attrite from the teaching profession anytime during years 2 through 5. For part of our analysis, we follow the convention in the literature of grouping school changers and leavers in the same category, henceforth movers. The intuition behind the creation of a combined mover category is that the costs for schools to fill a vacancy are the same regardless of whether a teacher changes schools or quits teaching altogether; the school lacks one teacher and may face pressure to fill the now vacant position. We also separate changers and leavers from the mover group as part of our analysis to determine different effects on these 2 types of teacher movements.

Figure 1 shows the rates of voluntary teacher turnover based on the leaver-changer definition described above. Calculations of teacher turnover type are made based on the surviving population who remained in their original school in a given year. After the first year of teaching in our sample, about 21 percent of teachers exit their original schools voluntarily. The percentage of teachers leaving the profession is highest after the first and second year of teaching at 15 and 10 percent, respectively. The leaver rate then declines to 6 percent in year 4 and 5 percent in year 5. Except for year 4, the percentage of changers is less than half the percentage of leavers. The proportion of changers is 6 percent in year 2, 3 percent in year 3, 5 percent prior to year 4, and fell to 2 percent in year 5.

Survey Effort as a Performance-Task Based Proxy Measure for Teacher Conscientiousness

We follow the work of Hitt, Trivitt, and Cheng (2016) and build a performance-task based proxy measure for teacher conscientiousness based on a beginning teacher's item non-response rate on the BTLS baseline survey (year 1). We divide the total number of questions a teacher leaves blank by the number of answerable questions to which a teacher should have responded, allowing legitimate skips. For ease of interpretation, we standardize this measure to have mean 0 and standard deviation 1 in our empirical analysis.

The year 1 baseline survey was a long paper and pencil survey asking teachers to complete up to 339 questions. On average, respondents were asked to answer approximately 175 questions. Figure 2 depicts the average item non-response for the baseline survey for all teachers in their original schools for each year of the BTLS. The item non-response rate for the surviving population of teachers who remain in their original school in a given year ranges from 2.2 to 2.5 percent in our sample. Due to teacher turnover, the sample appears to become slightly less conscientious between years 1 and 2, since the average item non-response rate rises between these years. The average item non-response rate then increases again between years 2 and 3. Average item non-response falls very slightly by year 4, and rises to its highest point in year 5. In other words, with the exception of year 4, the sample of teachers surviving in their orginal schools appears less conscientious since they have higher rates of item non-response on the baseline survey.

In a long survey such as the BTLS, it could be that teachers who are unsatisfied with their jobs and are more likely to exit their schools will be less likely to fill out their surveys. Item non-response could then be capturing teachers' satisfaction with their jobs and not just their levels of conscientiousness. We constructed a measure of teachers' job satisfaction using two different

sets of questions on the baseline BTLS survey. The first set of questions uses teachers' responses to 4 questions regarding their satisfaction with salary, parent support, shared values with colleagues in the school, and general satisfaction in the school. The second set of questions uses responses to 7 questions about if the stress from teaching at the school are not "worth it," if other teachers at the school are satisfied, reported satisfaction with how the school is run, whether or not they would exit for a better paying job, desire to transfer to another school, if their enthusiasm is waning, and if they have considered staying home because they are "too tired to go" to school. This scale consisting of these 11 questions together presents a Cronbach's alpha of 0.77. Responses to each question are averaged to generate a single scale where lower average responses correspond with teachers displaying higher job satisfaction. The correlation between item non-response rates and our job satisfaction scale is 0.51. The positive correlation means that lower item non-response rates are associated with higher levels of job satisfaction. This correlation is moderate and may indicate that item non-response is measuring something similar to job satisfaction in this context. Due to this correlation, we will control for job satisfaction in a robustness check to study the independent effect of item non-response as a proxy for teachers' conscientiousness levels.

Item non-response rates may also capture the opportunity cost of time to fill out the survey, and teachers that have more time on their hands would have more time to fill out the survey conscientiously. We would expect the opportunity cost of taking a long survey to decrease with experience, but as our sample only contains information on beginning teachers, they likely all have similar opportunity costs since they share the same amount of experience. Based on current literature (see Soland et al., 2019, for a review), we argue that item non-response can be interpreted as a proxy for teachers' conscientiousness and related skills.

Measures of Principal Effectiveness and Other Determinants of Teacher Turnover

We follow previous literature and construct a measure of principal quality using a factor analysis (see, Boyd et al., 2011; Grissom, 2011; Kraft et al., 2016; Loeb, et al. 2005). We use responses to five questions on the baseline (year 1) teacher survey concerning principals' administrative support, rules enforcement, principals' communication, staff recognition, and satisfaction towards the school. We expect principals earning high marks from teachers on these questions to be high-quality principals. We use responses from all teachers in the school, not only beginning teachers, who answer the questionnaire for any given principal. Using all surveyed teachers in the school in the full SASS sample increases the amount of information available to capture principal quality and limits bias in principal evaluations from the surveyed beginning teachers who already decided to leave the profession or change schools prior to taking the survey. We combine teachers' principal evaluations using a principal components analysis with a varimax (orthogonal) rotation to construct an index of principals' quality. We retain a unique factor with an eigenvalue greater than 1. All variables contribute almost equally to this factor based on their similar factor loadings[9]. We average the principal' quality values predicted from our factor analysis for all teachers in the same school. We assign these overall average values of principals' quality to each BTLS teacher in that same school to use as his/her principal's quality levels in the analysis of beginning teachers' turnover. The principals' quality variable is then standardized to have mean 0 and standard deviation 1 to ease interpretation in our analysis. A principal with a higher standardized quality factor than another principal is considered a higher quality principal.

[9] Appendix A contains the questions that are part of the principal's effectiveness index and the factor loadings derived from this factor analysis.

In addition to the measure of principals' quality, our empirical models also include information derived from the baseline teacher survey on a teacher's gender, race/ethnicity, type of certification, educational attainment, whether or not the teacher reported having a mentor in the school, and whether or not the teacher had passed the certification Praxis test in reading, math, and writing as control variables in our analysis[10].

Using the baseline school survey from SASS, we also constructed variables for school characteristics such as proportion of students who are black, Hispanic, and those who are eligible free and reduced-price lunch (FRL), as well as school enrollment, school type (elementary, middle, high, and combined[11]), magnet school status, and level of urbanicity in the school location. Finally, we used baseline SASS principal surveys to obtain information on a principal's gender, race/ethnicity, experience as a principal, and prior experience as a teacher.

Since the BTLS data collection occurred during the Great Recession, we believe it can be important to control for induced differences in local labor market conditions. Local labor market conditions might also affect teachers differently depending on their conscientiousness levels. Since conscientiousness is related to job performance, retention, and job satisfaction (Barrick & Mount, 1991; Barrick & Zimmerman, 2009; Dalal, 2005; Hurtz & Donovan, 2000; Roberts et al., 2007) and since item non-response rates are related to earnings and other labor outcomes (Hedengren & Stratmann, 2012; Hitt et al., 2016), we believe that conscientious teachers will be

[10] Praxis tests are widely used tests that attempt to measure what potential teachers know about their content area as well as general teaching skills. Several states require passing these tests before a teacher may obtain a license. We use indicator variables for a teacher passing the Praxis test for reading, math, or writing as a proxy for a teacher's cognitive ability. However, not all states require teachers to pass Praxis exams for certification, but our analysis includes either state or region fixed effects which would take state differences in required Praxis testing into account.

[11] Combined schools are those that serve students in grades that cross over what would traditionally be considered elementary, middle, or high schools.

less likely than non-conscientious teachers to pursue outside labor market opportunities since the Great Recession contracted the economy altogether.

If teachers' relevant local labor markets are regions of the country themselves, then the inclusion of region fixed effects should control for the effects of the Great Recession. However, if relevant teachers' local labor markets are smaller than their regions, then the effects of the Great Recession on teacher turnover will vary within region. In order to control for the influence of local labor market conditions in this case, we match BTLS data with the University of Southern California's Great Recession Indicators Database (GRID)[12] (Angrisani et al., 2014). Researchers at the USC Dornsife Center for Economic and Social Research collected this detailed dataset containing labor market indicators either monthly or yearly at the county level. In this paper, we use information on monthly county-level unemployment rates. Since teachers must make a decision regarding whether or not to return to their original school during the school year, we used lagged average unemployment rates corresponding to each year. We average monthly county-level unemployment rates for each school year. We difference the county-level average unemployment rate for a school year relative to the county-level average unemployment rate in the 2005-06 school year, before the Great Recession started, and include this measure of unemployment rate shocks as control variable in our analysis[13]. This measure captures the percentage point change in the unemployment rate relative to when the national economy was seemingly stable. We also include an interaction term between our measure of unemployment shocks in the local labor market and teachers' item non-response rates to allow for the possibility

[12] Additional information about GRID can be found at this address: https://cesr.usc.edu/prc/archived_pilot_proposals.

[13] We also build a measure of recession intensity following Shores and Steinberg (2017). Our results are largely unchanged based on the local labor market variable we include. We prefer to present results with our measure of local labor market shocks because of its ease of interpretation. These results are available upon request.

that labor market conditions affect teachers differently depending on their levels of conscientiousness.

Empirical Strategy

We use two types of discrete duration models to study the determinants of teacher turnover. First, we study the dynamics of teacher turnover decisions year by year using discrete choice duration models for the probability of a teacher moving schools in a given year. In particular, we estimate models with the following base specification:

$$\Pr\left(Mover_{i,t} = 1 \middle| X\right) = \Lambda\left(\beta_0 + \beta_1 INR_{i,1} + \beta_2 PQ_{i,1} + \boldsymbol{T_{i,1}}\beta_3 + \boldsymbol{S_{i,1}}\beta_4 + \boldsymbol{P_{i,1}}\beta_5\right) \quad (1)$$

$t = 2,3,4,5$

$Mover_{i,t}$ denotes a teacher i leaving his/her original school in year t, either because the teacher left the profession or changed schools, and $\Lambda(\ )$ denotes the cumulative logistic distribution function. Then, the models estimated in (1) predict the probability that teacher i's employment spell, in a given school, ends at year t conditional on the teacher surviving in the original school up to that year. Since we are interested in the determinants of why a teaching spell in a school would end, our sample for a given year includes all surviving teachers whose spells in the original school have not ended, either because of leaving the profession or changing schools. As updated characteristics of schools, such as the characteristics and quality of a new school's principal, are not available to us for those teachers changing schools, teachers who leave their original schools only contribute to the analysis sample up to their last duration spell in their original schools.

$INR_{i,1}$ is the teacher's standardized item non-response rate measured on the baseline survey during year 1 and is a proxy for the teacher's conscientiousness. $PQ_{i,1}$ represents our measure of a principal's quality for the teacher's principal at baseline. $\boldsymbol{T_{i,1}}$ includes teacher

characteristics measured at baseline year 1: gender, race/ethnicity, if the teacher is alternatively certified, if the teacher has a master's degree or higher education, and if the teacher has passed the Praxis exam in math, reading, or writing. $\boldsymbol{S_{i,1}}$ includes school demographics and characteristics also measured at baseline: racial/ethnic composition of the school, proportion of students eligible for free or reduced-price lunch, enrollment, and school urbanicity. $\boldsymbol{P_{i,1}}$ includes characteristics of a teacher's principal at baseline: gender, race/ethnicity, experience as a principal, and experience teaching. Finally, we also include region fixed effects to account for any remaining geographic unobserved factors.[14]

We use three additional specifications to equation (1). First, we add in the interaction of item non-response and our principals' quality factor to test for differences in principals' ability to retain conscientious teachers. Second, we reestimate (1) but include the difference in contemporary county-level unemployment rate and the 2006 county-level unemployment rate to control for Great Recession indued changes in local labor market conditions. Finally, we estimate a fully specified model including the interaction between item non-response and principals' quality, difference in county-level unemployment rates, and the interaction between item non-response and the difference in county-level unemployment rates. We include the second interaction term to test if unstable labor market conditions affects teachers differently based on their levels of conscientiousness.

Our second set of analyses use competing-risk discrete choice duration models with a multinomial logit specification, analogous to the model in (1) and the three additional

[14] We also estimate this logit specification using state fixed effects in lieu of region fixed effects. We report region fixed effects since we find that state perfectly predicts teacher turnover in several states. Our results, however, do not substantively change based on the type of geographic fixed effects that we include.

specifications described above[15], but allowing for differential effects for the decisions of changing schools or leaving the profession altogether.

Results

Descriptive Statistics

Table 1 presents the descriptive statistics for our entire sample of beginning teachers, as well as dividing the sample into teachers who stayed in the same school for all 5 years of our data and those who have ever moved from their original schools during years 2 to 5. Panel A provides the descriptive statistics for teacher characteristics. On average, teachers leave 2 percent of questions blank, but this rate is quite variable across teachers with a standard deviation of 4 percentage points (approximately 7 answerable questions). On average and over the course of all five years, we do not find a statistically significant difference in item non-response rates between teachers who ever move out of their original schools and those who stay in their original schools all five years.[16] Three-fourths of teachers in the sample are female and 90 percent are white. Just over 25 percent of teachers are alternatively certified[17] and 16 percent have completed some graduate-level coursework. Movers are statistically significantly more likely to be alternatively certified. Nearly 90 percent of teachers reported they have a mentor. Less than half of teachers have passed their Praxis tests in reading, math, or writing.

Panel B displays the summary statistics for school characteristics. Teachers are in schools with, on average, 17 percent black students, 21 percent Hispanic students, and 46 percent Free

[15] We had to use region fixed effects in our multinomial logit models because of problems of convergence in our maximization algorithm due to the fact that state perfectly predicted teacher turnover in some states. Our results from the binary logit models do not change significantly when we include region fixed effects instead of state fixed effects, which makes us believe that most of the omitted factors that state fixed effects are capturing are probably also fixed within region.

[16] Figure 2 documents an overall increase in item non-response rate over the five years, but the difference in item non-response rates among movers and stayers is not statistically significant.

[17] The BTLS survey does not ask about which specific alternative certification program a teacher entered the classroom through.

and Reduced price Lunch (FRL) eligible students. Teachers leave schools with higher proportions of black and FRL students at a statistically significantly higher rate. Average enrollment is 847 students. Elementary schools constitute 46 percent of the sample, middle schools are 19 percent, 29 percent are high schools, and the rest are schools that combined grades. Magnet schools comprise 8 percent of the sample. Finally, suburban schools comprise almost 30 percent of schools, towns make up 16 percent, rural schools are 32 percent, and the remaining 25 percent are city schools.

Panel C contains descriptive statistics for principal variables. Average principal quality does not differ significantly between teachers in the stayer and mover groups. Female principals make up half of the sample, while black and Hispanic principals make up only 11 percent and 9 percent of the sample, respectively. Principals have an average of 12 years of experience as principals, but only 0.21 years of experience as a teacher. The average principal experience as a teacher for teachers who move out of their original schools within the first five years is higher than the average principal experience as a teacher for the stayer group.

Determinants of Teacher Turnover

We present the results of our discrete choice duration models in Tables 2 through 5. The first column estimates the specification in equation (1) while the second column includes the interaction between item non-response rates and principals' quality. We include this interaction to study principals' ability to retain more conscientious teachers (i.e. those who put more effort on their baseline survey). Column 3 controls for shocks to the local labor market using changes in unemployment rates as compared to the pre-Great Recession levels and Column 4 adds in interactions between item non-response rates and both principals' quality and the change in unemployment rates. We add in the interaction effect between our proxy measure of

conscientiousness and changes in unemployment rates because we would expect that more conscientious teachers would be less likely to test volatile labor markets. All tables present average marginal effects.

Item non-response rate is negatively related to the likelihood of teacher turnover for teachers' second year in the profession in all models in Table 2. In the fully specified model, a 1 standard deviation increase in item non-response rate is associated with a 4 percentage point reduction in the probability of teacher turnover, but it is only significant at the 10 percent significance level. In other words, those teachers who show higher levels of conscientiousnesss while completing the baseline survey are more likely to exit their schools prior to their second year as a teacher. This effect represents nearly a fifth of the overall first-year teacher turnover rate of approximately 20 percent of teachers in our sample. Teachers with higher quality principals were more likely to be retained, with a 3 percentage point reduction in the probability of teacher turnover in the fully specified model. None of the interaction terms were statistically significant predictors of teacher turnover after teachers' first year. It is worth noting the direction of these interaction effects: teacher turnover has a negative association the interaction of item non-response rate and principal quality and a positive relationship with the interaction of item non-response rate and changes in the county-level unemployment rate. Including the measure of outside labor market volatility did not change the effects of item non-response rates or principal quality on teacher turnover very drastically.

Tables 3 through 5 present our results for the determinants of teacher turnover prior to teachers' third, fourth, or fifth year in their schools. To be included in these results, teachers must have survived the first 2, 3, or 4 years in their original schools, respectively.

For year 3 (Table 3), we fail to find a significant relationship between item non-response rates and teacher turnover in the any of our models, though we do find that the relationship is still negative. We find that teachers in schools with higher quality principals are more likely to exit at a statistically insignificant rate, but we do find that there is a significant interaction effect with item non-response for year 3. Teachers with 1 standard deviation higher item non-response rates (less conscientious teachers) who are in schools with 1 standard deviation higher quality principals are 4.3 percentage points less likely to exit their schools. In other words, high-quality principals appear more effective at retaining teachers who showed lower levels of conscientiousness on their baseline survey in this case. Similarly to year 2, we find no evidence that local labor market conditions have a relationship with teacher turnover, but the coefficient is still greater than zero.

For year 4 (Table 4), like we found for year 2, we find that there is a significant negative relationship between conscientiousness and teacher turnover in our fully specified model. Teachers with a 1 standard deviation higher item non-response rate (less conscientious teachers) are 14.4 percentage points less likely to move out of their schools. While statistically insignificant in 3 out of 4 specifications, the sign on item non-response is negative, which mirrors the sign in year 2. However, changes in county-level unemployment rates mediate this large item non-response effect; teachers with lower levels of consciousness, measured as leaving more questions blank on their baseline surveys, and living in counties with higher unemployment rates relative to 2006 were more likely to exit their schools. In other words, it appears that instability in local labor market might have helped retain more conscientious teachers. Also, changes in county-level unemployment rates relative to 2006 are a statistically significant predictor of teacher turnover in this case. A 1 percentage point increase in the county-level

unemployment rate relative to 2006 is associated with a 1.6 percentage point reduction in the probability of teacher turnover in the fully specified year 3 model. Finally, aligning with the results in year 2, higher quality principals are more likely to retain teachers. Teachers in schools with 1 standard deviation higher quality principals are between 3.1 and 3.8 percentage points less likely to exit their schools. However, we do not find differences on quality principal's ability of retaining teachers of difference levels of conscientiousness in this case as the interaction between item non-response rates and principals' quality is statistically insignificant.

Results for year 5 (Table 5) show that there is a significant positive relationship between item non-response rates and teacher turnover in the full model. This is the only year for which lower rates of item non-response correspond with lower rates of teacher turnover. Principals' quality is also related to a decrease in the likelihood of teacher turnover. The interaction term for item non-response rates and principals' quality is negative and statistically significant compensating the overall effect of teacher's conscientousness; 1 standard deviation gains in both item non-response and principals' quality corresponds with a nearly 6 percentage point decline in the probability that teachers exit their schools. Just as for year 3, this effect reveals that high quality principals are more effective at retaining less conscientious teachers. There was no effect of local labor market volatility on teacher turnover. The interaction term for item non-response and local labor market volatility, however, was negative and significant. This interaction effect for year 5 differs from the effect in year 4; conscientious teachers are more likely to be retained when local labor markts are less stable prior to their fourth year in their schools, but these labor market conditions decrease the likelihood of retention by the fifth year.

Taken together, the results in Tables 2 through 5 demonstrate a four clear patterns. Teacher turnover is less likely among teachers displaying lower levels of conscientiousness (i.e.

higher item non-response rates) for the first four years of teachers' careers. Higher quality principals were always reduce the probability of teacher turnover and these principals were more effective at retaining the teachers that leave more questions blank on the baseline survey. Finally, teacher with higher item non-response rates in counties with comparatively higher unemployment rates are less likely to be retained through year four in the profession.

Tables 6 through 9 display the results for our competing-risk discrete duration models[18]. Panel A includes determinants of the probability of leaving the profession and Panel B includes the determinants of the probability of changing schools. These Tables are set up in the same way as Tables 2 through 5 described above.

Table 6 has the results for the likelihood of leaving the profession and changing schools for year 2. None of our variables of interest predict the probability of leaving the profession after teachers' first year in the profession. However, item non-response rates are significantly related to the probability of changing schools after teachers' first year in the profession. Teachers with 1 standard deviation higher item non-response rates than other comparable teachers are 4.7 percentage points less likely to change schools. This means that less conscientious teachers on the baseline survey are less likely to change schools while still remaining in the profession. Principals' quality, both interaction terms, and local labor market volatility are not associated with changing schools in the second year.

In year 3 (Table 7), our results indicate that higher item non-response rates, principals' quality, and local labor market conditions are not related to the probability of exiting the profession. However, the interaction between item non-response and principals' quality is associated with the likelihood of leaving the profession in the fully specified model; the

[18] Results for the probability of teachers staying in their original schools are very similar to the results contained in Tables 3 through 6 as it would be expected.

interacation is negative suggesting that high quality principals retain teachers leaving more questions blank (lower conscientiousness) in the profession. Item non-response is statistically insignificant in all of the year 3 specifications for changing schools. Higher quality principals are associated with decreases in the probability that teachers' switch schools. A one standard deviation increase in principal quality is associated with a 2 percentage point decrease in the probability of a teacher changing schools.

Item non-response rates predict the probability of exiting the profession in the fully specified model for year 4 (Table 8) and this effect is large in size at a 9.9 percentage point reduction in the probability of leaving the profession for a 1 standard deviation increase in item non-response rate, indicating that less conscientious teachers are better retained in the profession. Exiting the profession is also related to principals' quality and changes in unemployment rates relative to 2006. Higher quality principals help retain teachers in the profession while greater instability in the labor market seems to be pushing teachers out of the profession, more so for less conscientious teachers (higher item non-reponse rates on their baseline survey). Finally, none of our main explanatory variable are associated with the probability of changing schools in this case.

For year 5 (Table 9), teachers with higher item non-response rates (lower conscientiousness teachers) and similar quality principals are more likely to exit the profession. High quality principals are again associated with decreases in teachers' likelihood of exiting the profession. High quality principals also appear to be better at retaining their less conscientious teachers in the profession and their school in year 5. Item non-response itself is not a significant predictor of changing schools in the final year, nor is principals' quality. However, similarly to leaving the profession, teachers answering fewer questions on their baseline surveys (higher item

non-response) that are also in schools with higher quality principals are less likely to change schools in year 5. Increases in unemployment rates relative to 2006 are related to decreases in the probability of changing schools.

General patterns are less obvious in our multinomial analysis. There is a suggestively negative association between item non-response and the likelihood teachers leave the profession in the first four years. Higher quality principals reduce the probabity that teachers leave the profession or switch to a different school, but these principals are more effective at retaining teachers displaying lower levels of conscientiousness on their baseline surveys in the profession and schools. Higher county level unemployment rates relative to pre-Great Recession rates is predictive of teachers leaving the profession, but negatively related to teachers switching schools. Both effects are magnified for teachers leaving more questions blank on the baseline survey.

Robustness Checks

We conduct two sets of robustness checks for our results. The first check tests our measure of principals' quality. As described in the Data section, we perform a factor analysis for all teachers in the 2007-08 SASS dataset and create an index for all teachers in the same school. We average the index for all teachers in the same school. This robustness check removes beginning teachers' responses in the factor analysis altogether. The results of this first check are available in Tables 10 and 11. Table 10 contains results for the probability of teachers moving out of their schools and Table 11 contains results from the multinomial logit models for the proability of leaving the profession (Panel A) and changing schools (Panel B). Both tables include results from our fully specified model.

Results for all four years and for both the logit and multinomial logit models do not change our overall conclusions. Item non-response remains significant in all models and becomes significant at higher confidence levels in four cases. We do find that year 2 and year 5 principals' quality effects become insignificant as predictors of teacher turnover (Table 10) and leaving the profession (Table 11, Panel A). Beginning teachers' responses to the questions included in the factor analysis may be driving these principal effects, but significant findings in years 3 and 4 are consistent regardless of who is included in the factor analysis.

Our second robustness check formally controls for job satisfaction using the scale described in the Data section. Given the moderate correlation between item non-response rates and the job satisfaction measure (0.51), it is likely that teachers' job satisfaction affects their propensity to answer a long paper and pencil survey. Teachers answering more questions (lower item non-response) tend to have higher job satisfaction (lower values on the job satisfaction scale). Controlling for job satisfaction in our models would lend credence to item non-response as a proxy of conscientiousness. Results for this check are available in Tables 12 and 13. Table 12 includes the results for the probability that teachers exit their schools and Table 13 includes the results for the probability that teachers leave the profession (Panel A) and change schools (Panel B). Tables 12 and 13 include fully specified models.

Item non-response effects are not only robust in all cases but increase in magnitude for years 2, 3, and 4 (Table 12). Controlling for job satisfaction, teachers with a 1 standard deviation higher item non-response rate than other teachers, where the teachers have comparable principals, are 12.3 percentage points less likely to exit their schools prior to year 2; the effect is 4 percentage points when not controlling for job satisfaction (Table 2, Column 4). Principals' quality is a no longer a significant predictor of teacher turnover in year 2 when controlling for

job satisfaction, but the effect remains for years 4 and 5. Higher job satisfaction is associated with reductions in the probability of teacher turnover in all years except for year 5. The interaction between item non-response rates and principals' quality is negative and significant for years 2, 3, and 4 suggesting that principals are more effective at retaining the teachers who leave more questions blank on their baseline survey. Results related to changes in the unemployment rate and the interaction between item non-response rate and changes in the unemployment rate are robust to the inclusion of job satisfaction.

Results for the probability of leaving the profession are also generally robust to the inclusion of job satisfaction (Table 13, Panel A). Controlling for job satisfaction, item non-response rates are statistically significant predictors of the probability of leaving the profession in years 2 and 3, with teachers showing lower levels of conscientiousness in the baseline survey showing lower probabilities of leaving the profession; item non-response rates are not significant for these years in our main results. Item non-response rates and principals' quality remain significant in years 4 and 5. The only effect that is not robust when including job satisfaction is the interaction between item non-response rates and principals' quality in year 5, but these interaction effects are now negative and significant in years 2 and 3. Indicating, as before, that higher quality teachers appear more effective at retaining teachers who show lower levels of conscientiousness in their baseline survey. Changes in county-level unemployment rates relative to 2006 and the interaction effect of changes in county-level unemployment rates and item non-response rates remain significant in year 4 while this interaction effect also becomes significant in year 3. Higher levels of unemployment lead to a higher probability of teachers leaving the profession in year 4 but more conscientious teachers appear to be better retain in unstable labor conditions in years 3 and 4.

Once again, results for the probability of changing schools are robust when controlling for job satisfaction (Table 13, Panel B); but in line with the results from Table 12 and Table 13, Panel A, we even find more significant effects in this case.

Conclusion

Teacher turnover is an important policy concern, given its adverse consequences for student achievement and the large financial costs it imposes on schools. Teacher turnover is especially problematic among beginning teachers. While a breadth of literature has studied the determinants of teacher turnover, we evaluate how teachers' levels of conscientiousness might affect the likelihood of teacher turnover. Since teacher conscientiousness is a predictor of teacher quality and burnout (Kim et al., 2019), understanding these patterns of teacher turnover can help stakeholders to better design retention policies to use their resources as efficiently as possible.

We use the national Beginning Teacher Longitudinal Study to study the determinants of teacher turnover. We proxy for teachers' levels of conscientiousness with a performance-task based measure of survey effort: baseline survey item non-response rate. We rely on previous literature which shows that item non-response can be a valid performance-task proxy measure for non-cognitive skills related to conscientiousness (Hitt et al., 2016) and that teachers' item non-response rates may capture important teacher quality dimensions that value-added test score based measures miss (Cheng & Zamarro, 2018).

We observe that teachers presenting higher levels of conscientiousness through their effort on their baseline surveys were more likely to exit their schools immediately after their first year in the profession. Teachers that switch to different schools appear to drive this effect of survey effort. We also show that survey effort is weakly related to teacher turnover prior to teachers' fourth year in the profession. We corroborate the important role principals can play in

reducing the probability of teacher exits. However, our results also show that principals might be less effective at retaining teachers with higher levels of conscientiousness on their baseline survey. Unstable local labor markets, on the other hand, might help retain teachers with higher levels of conscientiousness.

Our finding that beginning teachers with higher item non-response on the baseline survey, displaying lower levels of conscientiousness, are more likely to stay falls in line with findings from Wiswall (2013). In North Carolina, beginning retained teachers have lower math value-added than the beginning teachers that leave. This concurrence of our two results provides additional reason to believe that item non-response is capturing meaningful dimensions of teacher quality that are important for schools and students.

However, our results appear to come in conflict two previous studies that find conscientious teachers are more likely to be retained (Bastian et al., 2017; Robertson-Kraft & Duckworth, 2014). We offer two explanations for this divergence. First, we use a national sample of beginning teachers whereas the other studies use only a sample of first-year teachers from North Carolina (Bastian et al., 2017) or a convenience sample of Teach for America teachers (Robertson-Kraft & Duckworth, 2014). Second, we measure conscientiousness using a behavioral measure. Bastian et al. (2017) use self-reported measures of conscientiousness and Robertson-Kraft and Duckworth (2014) use grit. For our sample, item non-response rates may be measuring conscientiousness differently than grit or a self-report of conscientiousness.

Our results have two important implications for policy. First, these results suggest the need for better strategies to retain highly conscientious teachers in general. To the extent our survey effort measures capture teachers' conscientiousness (Hedengren & Stratmann, 2012; Hitt et al., 2016) and meaningful dimensions of teacher quality (Cheng & Zamarro, 2018), our

finding that teachers with lower item non-response rates are more likely to exit their schools implies that district policymakers should do more to retain more conscientious teachers.

Second, principals' current efforts may not be completely successful at retaining more conscientious teachers. We find that high-quality principals seem to be more effective at retaining teachers who are lower quality using survey effort as a proxy for conscientiousness as our measure of teacher quality. Grissom and Bartanen (2018) find that high-quality principals strategically retain high-quality teachers when teacher quality is measured with principals' classroom observations of teachers. Our results may differ from Grissom and Bartanen because we define both teacher and principal quality differently and use different measures of these constructs. They find evidence of strategic retention when measuring teacher quality with classroom observation scores that principals typically conduct and when using superintendents' evaluations of principals as their measure of principal quality. The principals' observations of teachers in Grissom and Bartanen's study likely captures teacher quality dimensions different from teachers' levels of conscientiousness.

Our results are limited since the BTLS survey does not contain any direct measure of conscientiousness and our proxy measure, item non-response, is a noisy measure that could be capturing other unobserved factors along with teachers' conscientiousness. It should be stressed, however, that our results are robust and become bigger in magnitude and more significant when including self-reported measures of job satisfaction in the model. More research is needed to fully understand the role of teachers' conscientiousness on turnover decisions, but our paper provides evidence that local labor market conditions and principal quality can have a role to play in affecting the characteristics of teachers who are retained.

Additionally, we study the determinants of voluntary teacher turnover. Teachers may not want to admit on a survey if they exited the profession or switched to another school involuntarily. Since we rely on teachers to self-report if they were terminated or laid off, we may be including teachers that did not choose to leave their schools in our analyses.

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Figures

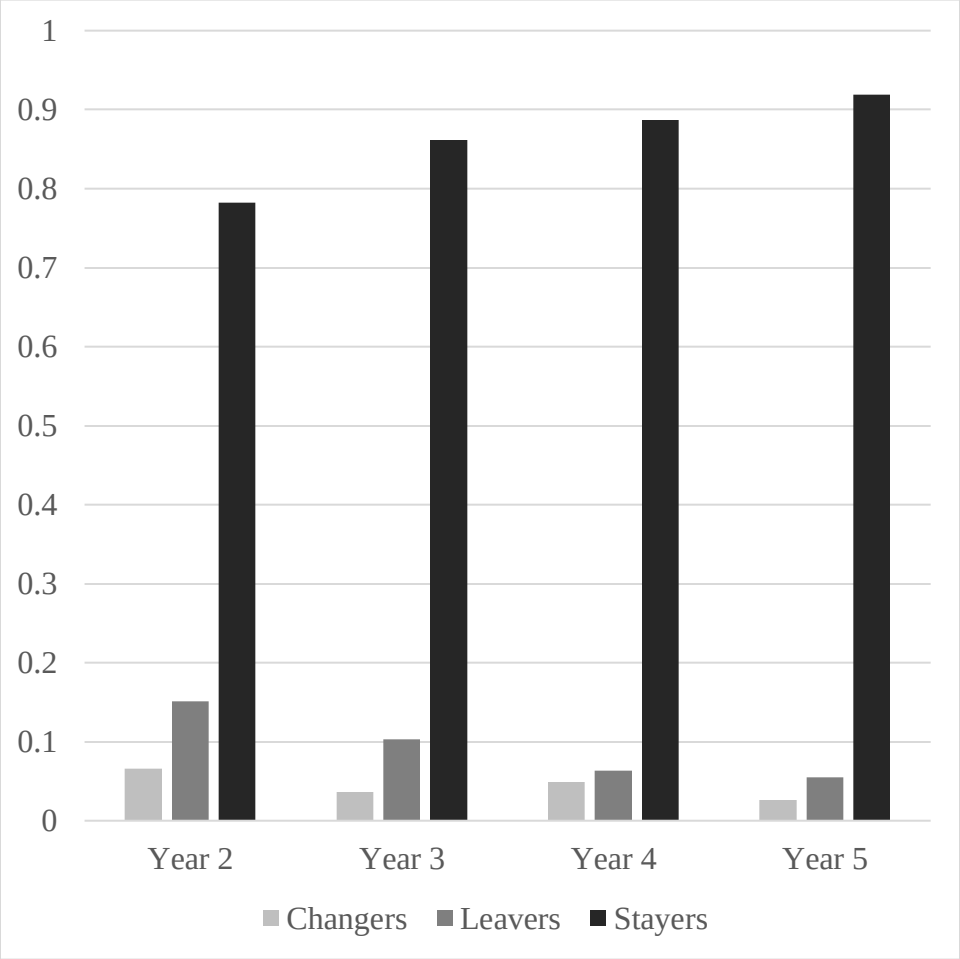

Figure 1: Proportions of Teachers who Change Schools or Leave the Profession by Year
Note: Calculations based on the surviving sample of teachers remaining in their original school in a given year. Changers switch to a new school, leavers exit the profession, and stayers remain in their original schools. Approximately 1,290 teachers in year 1, 1,160 teachers in year 2, 940 in year 3, 700 in year 4 and 560 in year 5. Year 1 is the 2007-08 school year, year 2 is the 2008-09 school year, year 3 is the 2009-10 school year, year 4 is the 2010-11 school year, and year 5 is the 2011-12 school year. Provided calculations using sampling weights.
Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

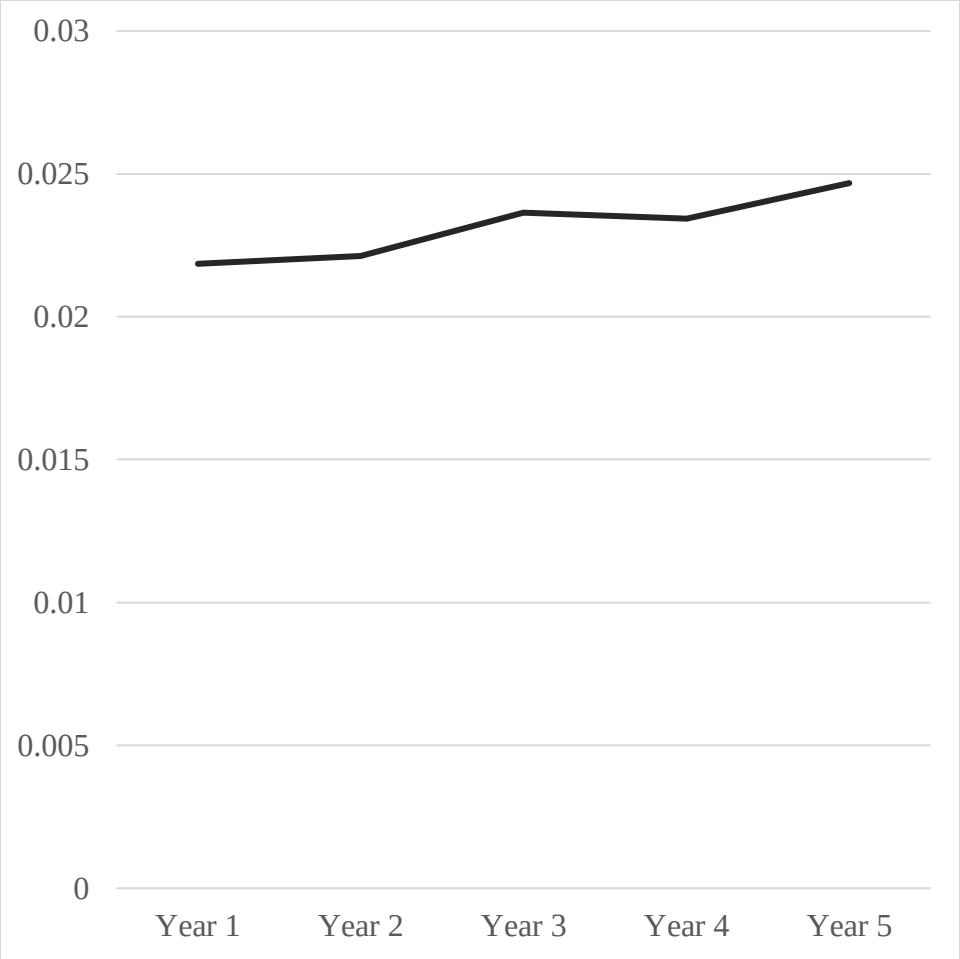

Figure 2: Average Item Non-Response based on Surviving Teacher Population
Note: Calculations based on the surviving sample of teachers remaining in their original school in a given year. Approximately 1,290 teachers in year 1, 910 teachers in year 2, 810 in year 3, 620 in year 4 and 520 in year 5. Year 1 is the 2007-08 school year, year 2 is the 2008-09 school year, year 3 is the 2009-10 school year, year 4 is the 2010-11 school year, and year 5 is the 2011-12 school year. Provided calculations using sampling weights.
Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Tables

Table 1: Descriptive Statistics for Teacher, School, and Principal Characteristics – Overall and by Moving Status

Variable	Mean	SD	Mean Stayers	Mean Movers
Panel A: Teacher Characteristics				
Item Non-Response	0.02	0.04	0.02	0.02
Answerable Questions	175.33	12.73	175.09	175.65
Female	0.73		0.72	0.75
Hispanic	0.11		0.11	0.10
White	0.90		0.92	0.88
Black	0.08		0.07	0.11
Alt. Cert.	0.26		**0.19**	**0.34**
≥ Master's Degree	0.16		0.16	0.16
Had a Mentor	0.85		0.84	0.86
Pass Read. Praxis	0.39		0.41	0.37
Pass Math Praxis	0.38		0.40	0.36
Pass Writing Praxis	0.49		0.52	0.46
Panel B: School Characteristics				
Proportion Black	0.17	0.23	**0.15**	**0.20**
Proportion Hispanic	0.21	0.29	0.19	0.24
Proportion FRL	0.46	0.28	**0.42**	**0.51**
Enrollment	847.25	599.16	862.52	827.50
Elementary School	0.46		0.48	0.44
Middle School	0.19		0.17	0.22
Combined School	0.06		0.05	0.06
Magnet School	0.08		0.08	0.08
Suburb	0.28		0.30	0.26
Town	0.16		0.19	0.13
Rural	0.32		0.30	0.35

Table 1 (Cont.)

Variable	Mean	SD	Mean Stayers	Mean Movers
Panel C: Principal Characteristics				
Principal Factor	0.13	0.95	0.20	0.05
Female	0.50		0.52	0.46
Black	0.11		0.10	0.14
Hispanic	0.09		0.07	0.11
Experience	12.47	7.03	12.33	12.65
Teaching Exp.	0.21	1.42	**0.09**	**0.36**

Note: Sample size approx. 1,230 for all teachers, 650 for stayers, and 570 for movers. Bolded sample means are statistically significant at $p<0.1$. Provided calculations using sampling weights.
Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 2: Determinants of Teacher Turnover prior to Year 2 (2008-09), Average Marginal Effects

	Base Specification	With Interaction	With Labor Market Control	Fully Specified
	(1)	(2)	(3)	(4)
Item Non-Response Rate	-0.039*	-0.044**	-0.039*	-0.040*
	(0.021)	(0.022)	(0.020)	(0.023)
Principal Quality	-0.023*	-0.030**	-0.023*	-0.030**
	(0.013)	(0.013)	(0.013)	(0.013)
Non-Response * Principal Quality		-0.029		-0.031
		(0.022)		(0.022)
Change Unemp. Rate			-0.017	-0.012
			(0.012)	(0.013)
Non-Response * Change Unemp. Rate				0.023
				(0.027)
School Characteristics	X	X	X	X
Teacher Characteristics	X	X	X	X
Principal Characteristics	X	X	X	X
Region Fixed Effects	X	X	X	X

Note: Sample size approx. 1,160 teachers Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects.

Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 3: Determinants of Teacher Turnover prior to Year 3 (2009-10), Average Marginal Effects

	Base Specification	With Interaction	With Labor Market Control	Fully Specified
	(1)	(2)	(3)	(4)
Item Non-Response Rate	0.013	0.008	0.013	-0.019
	(0.011)	(0.011)	(0.011)	(0.029)
Principal Quality	-0.007	-0.012	-0.007	-0.013
	(0.013)	(0.013)	(0.013)	(0.013)
Non-Response * Principal Quality		-0.040**		-0.043**
		(0.017)		(0.018)
Change Unemp. Rate			0.002	0.003
			(0.007)	(0.007)
Non-Response * Change Unemp. Rate				0.010
				(0.009)
School Characteristics	X	X	X	X
Teacher Characteristics	X	X	X	X
Principal Characteristics	X	X	X	X
Region Fixed Effects	X	X	X	X

Note: Sample size approx. 940 teachers Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects.
Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 4: Determinants of Teacher Turnover prior to Year 4 (2010-11), Average Marginal Effects

	Base Specification	With Interaction	With Labor Market Control	Fully Specified
	(1)	(2)	(3)	(4)
Item Non-Response Rate	-0.019	-0.022	-0.021	-0.144**
	(0.017)	(0.017)	(0.016)	(0.060)
Principal Quality	-0.032**	-0.036***	-0.031**	-0.038***
	(0.013)	(0.014)	(0.012)	(0.014)
Non-Response * Principal Quality		-0.019		-0.024
		(0.023)		(0.023)
Change Unemp. Rate			0.013**	0.016**
			(0.006)	(0.006)
Non-Response * Change Unemp. Rate				0.021**
				(0.009)
School Characteristics	X	X	X	X
Teacher Characteristics	X	X	X	X
Principal Characteristics	X	X	X	X
Region Fixed Effects	X	X	X	X

Note: Sample size approx. 700 teachers Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects.

Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 5: Determinants of Teacher Turnover prior to Year 5 (2011-12), Average Marginal Effects

	Base Specification	With Interaction	With Labor Market Control	Fully Specified
	(1)	(2)	(3)	(4)
Item Non-Response Rate	0.013	0.011	0.013	0.054**
	(0.016)	(0.014)	(0.016)	(0.026)
Principal Quality	-0.017	-0.028**	-0.018	-0.029**
	(0.011)	(0.013)	(0.011)	(0.013)
Non-Response * Principal Quality		-0.059***		-0.057***
		(0.021)		(0.021)
Change Unemp. Rate			-0.006	-0.007
			(0.007)	(0.007)
Non-Response * Change Unemp. Rate				-0.011*
				(0.006)
School Characteristics	X	X	X	X
Teacher Characteristics	X	X	X	X
Principal Characteristics	X	X	X	X
Region Fixed Effects	X	X	X	X

Note: Sample size approx. 560 teachers Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects.

Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 6: Determinants of Leaving and Changing prior to Year 2 (2008-09), Average Marginal Effects

	Base Specification (1)	With Interaction (2)	With Labor Market Control (3)	Fully Specified (4)
Panel A: Probability of Leaving				
Item Non-Response Rate	-0.005	-0.009	-0.005	-0.005
	(0.014)	(0.016)	(0.014)	(0.016)
Principal Quality	-0.011	-0.016	-0.011	-0.017
	(0.011)	(0.012)	(0.011)	(0.012)
Non-Response * Principal Quality		-0.025		-0.028
		(0.017)		(0.018)
Change Unemp. Rate			-0.008	-0.003
			(0.011)	(0.012)
Non-Response * Change Unemp. Rate				0.024
				(0.023)
Panel B: Probability of Changing				
Item Non-Response Rate	-0.048**	-0.048**	-0.047**	-0.047**
	(0.020)	(0.020)	(0.020)	(0.019)
Principal Quality	-0.012	-0.011	-0.011	-0.011
	(0.007)	(0.011)	(0.007)	(0.011)
Non-Response * Principal Quality		0.001		0.001
		(0.022)		(0.022)
Change Unemp. Rate			-0.009	-0.010
			(0.007)	(0.006)
Non-Response * Change Unemp. Rate				-0.003
				(0.014)

Note: Sample size approx. 1,160 teachers. Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects.

Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 7: Determinants of Leaving and Changing prior to Year 3 (2009-10), Average Marginal Effects

	Base Specification (1)	With Interaction (2)	With Labor Market Control (3)	Fully Specified (4)
Panel A: Probability of Leaving				
Item Non-Response Rate	0.010	0.010	0.010	-0.020
	(0.008)	(0.009)	(0.009)	(0.026)
Principal Quality	0.014	0.011	0.014	0.011
	(0.012)	(0.012)	(0.012)	(0.012)
Non-Response * Principal Quality		-0.024		-0.028*
		(0.015)		(0.015)
Change Unemp. Rate			0.001	0.002
			(0.006)	(0.006)
Non-Response * Change Unemp. Rate				0.012
				(0.008)
Panel B: Probability of Changing				
Item Non-Response Rate	0.003	-0.005	0.003	0.000
	(0.009)	(0.009)	(0.009)	(0.015)
Principal Quality	-0.019***	-0.022***	-0.019***	-0.022***
	(0.007)	(0.008)	(0.007)	(0.007)
Non-Response * Principal Quality		-0.018		-0.016
		(0.015)		(0.014)
Change Unemp. Rate			0.003	0.002
			(0.003)	(0.003)
Non-Response * Change Unemp. Rate				-0.002
				(0.005)

Note: Sample size approx. 940 teachers. Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects.

Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 8: Determinants of Leaving and Changing prior to Year 4 (2010-11), Average Marginal Effects

	Base Specification (1)	With Interaction (2)	With Labor Market Control (3)	Fully Specified (4)
Panel A: Probability of Leaving				
Item Non-Response Rate	-0.020	-0.023	-0.025	-0.099**
	(0.016)	(0.018)	(0.016)	(0.042)
Principal Quality	-0.024**	-0.026**	-0.025**	-0.027**
	(0.010)	(0.012)	(0.010)	(0.012)
Non-Response * Principal Quality		-0.010		-0.011
		(0.019)		(0.019)
Change Unemp. Rate			0.014***	0.016***
			(0.004)	(0.004)
Non-Response * Change Unemp. Rate				0.013*
				(0.007)
Panel B: Probability of Changing				
Item Non-Response Rate	-0.008	-0.009	-0.008	-0.056
	(0.009)	(0.009)	(0.009)	(0.041)
Principal Quality	-0.008	-0.010	-0.008	-0.012
	(0.007)	(0.007)	(0.007)	(0.008)
Non-Response * Principal Quality		-0.010		-0.013
		(0.011)		(0.013)
Change Unemp. Rate			-0.002	-0.001
			(0.004)	(0.004)
Non-Response * Change Unemp. Rate				0.008
				(0.007)

Note: Sample size approx. 700. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects.
Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 9: Determinants of Leaving and Changing prior to Year 5 (2011-12), Average Marginal Effects

	Base Specification (1)	With Interaction (2)	With Labor Market Control (3)	Fully Specified (4)
Panel A: Probability of Leaving				
Item Non-Response Rate	0.011	0.011	0.011	0.041*
	(0.012)	(0.011)	(0.012)	(0.022)
Principal Quality	-0.014	-0.020**	-0.014	-0.020**
	(0.009)	(0.010)	(0.009)	(0.010)
Non-Response * Principal Quality		-0.029*		-0.028*
		(0.016)		(0.015)
Change Unemp. Rate			0.001	0.000
			(0.005)	(0.005)
Non-Response * Change Unemp. Rate				-0.007
				(0.005)
Panel B: Probability of Changing				
Item Non-Response Rate	-0.001	-0.004	-0.000	0.023
	(0.009)	(0.011)	(0.011)	(0.016)
Principal Quality	-0.002	-0.008	-0.003	-0.010
	(0.007)	(0.006)	(0.007)	(0.008)
Non-Response * Principal Quality		-0.037**		-0.039**
		(0.014)		(0.017)
Change Unemp. Rate			-0.008*	-0.010**
			(0.004)	(0.004)
Non-Response * Change Unemp. Rate				-0.011
				(0.007)

Note: Sample size approx. 560 teachers. Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects.

Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 10: Determinants of Teacher Turnover Excluding Beginning Teachers from Principals' Quality Factor Analysis for All Years, Average Marginal Effects

	Year 2	Year 3	Year 4	Year 5
	(1)	(2)	(3)	(4)
Item Non-Response Rate	-0.043**	-0.023	-0.142**	0.069***
	(0.022)	(0.028)	(0.062)	(0.026)
Principal Quality	-0.005	-0.002	-0.027**	-0.013
	(0.013)	(0.014)	(0.012)	(0.013)
Non-Response * Principal Quality	-0.028	-0.045***	-0.008	-0.044***
	(0.017)	(0.016)	(0.018)	(0.015)
Change Unemp. Rate	-0.011	0.003	0.016**	-0.007
	(0.013)	(0.007)	(0.006)	(0.007)
Non-Response * Change Unemp. Rate	0.028	0.008	0.021**	-0.014***
	(0.027)	(0.009)	(0.010)	(0.005)
School Characteristics	X	X	X	X
Teacher Characteristics	X	X	X	X
Principal Characteristics	X	X	X	X
Region Fixed Effects	X	X	X	X

Note: Sample size approx. 1,150 teachers in year 2, 940 teachers in year 3, 700 teachers in year 4, and 560 teachers in year 5. Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects. Presents fully specified models analogous to Column (4) in Tables 2 through 5.
Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 11: Determinants of Leaving and Changing Excluding Beginning Teachers from Principals' Quality Factor Analysis for All Years, Average Marginal Effects

	Year 2	Year 3	Year 4	Year 5
	(1)	(2)	(3)	(4)
Panel A: Probability of Leaving				
Item Non-Response Rate	-0.005	-0.036	-0.096**	0.049**
	(0.015)	(0.029)	(0.042)	(0.022)
Principal Quality	0.001	0.013	-0.022**	-0.012
	(0.012)	(0.014)	(0.010)	(0.009)
Non-Response * Principal Quality	-0.020	-0.042***	-0.003	-0.025**
	(0.014)	(0.013)	(0.013)	(0.010)
Change Unemp. Rate	-0.004	0.002	0.016***	0.000
	(0.011)	(0.006)	(0.005)	(0.005)
Non-Response * Change Unemp. Rate	0.027	0.013	0.013*	-0.009**
	(0.022)	(0.008)	(0.007)	(0.004)
Panel B: Probability of Changing				
Item Non-Response Rate	-0.050**	0.010	-0.055	0.028*
	(0.020)	(0.020)	(0.044)	(0.017)
Principal Quality	-0.004	-0.012**	-0.006	-0.001
	(0.010)	(0.006)	(0.007)	(0.011)
Non-Response * Principal Quality	-0.005	-0.005	-0.001	-0.025
	(0.020)	(0.008)	(0.011)	(0.015)
Change Unemp. Rate	-0.008	0.001	-0.001	-0.010**
	(0.007)	(0.003)	(0.004)	(0.004)
Non-Response * Change Unemp. Rate	-0.002	-0.004	0.008	-0.010
	(0.014)	(0.006)	(0.007)	(0.006)

Note: Sample size approx. 1,150 teachers in year 2, 940 teachers in year 3, 700 teachers in year 4, and 560 teachers in year 5. Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects. Presents fully specified models analogous to Column (4) in Tables 6 through 9.
Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 12: Determinants of Teacher Turnover Controlling for Teachers' Job Satisfaction for All Years, Average Marginal Effects

	Year 2	Year 3	Year 4	Year 5
	(1)	(2)	(3)	(4)
Item Non-Response Rate	-0.123***	-0.059*	-0.156***	0.050*
	(0.031)	(0.035)	(0.058)	(0.028)
Principal Quality	-0.013	-0.010	-0.031**	-0.029**
	(0.014)	(0.014)	(0.014)	(0.013)
Job Disatisfaction	0.123***	0.044***	0.047***	0.012
	(0.022)	(0.015)	(0.017)	(0.021)
Non-Response * Principal Quality	-0.051**	-0.056***	-0.034	-0.063**
	(0.025)	(0.020)	(0.025)	(0.025)
Change Unemp. Rate	-0.019	0.004	0.015**	-0.007
	(0.015)	(0.007)	(0.006)	(0.007)
Non-Response * Change Unemp. Rate	0.001	0.014	0.021**	-0.012*
	(0.032)	(0.010)	(0.009)	(0.007)
School Characteristics	X	X	X	X
Teacher Characteristics	X	X	X	X
Principal Characteristics	X	X	X	X
Region Fixed Effects	X	X	X	X

Note: Sample size approx. 1,160 teachers in year 2, 940 teachers in year 3, 700 teachers in year 4, and 560 teachers in year 5. Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects. Presents fully specified models analogous to Column (4) in Tables 2 through 5.
Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Table 13: Determinants of Leaving and Changing Controlling for Teachers' Job Satisfaction for All Years, Average Marginal Effects

	Year 2	Year 3	Year 4	Year 5
	(1)	(2)	(3)	(4)
Panel A: Probability of Leaving				
Item Non-Response Rate	-0.049*	-0.065*	-0.098**	0.043*
	(0.026)	(0.033)	(0.040)	(0.024)
Principal Quality	-0.010	0.013	-0.023*	-0.020**
	(0.012)	(0.013)	(0.012)	(0.010)
Job Disatisfaction	0.059***	0.039***	0.024*	-0.005
	(0.019)	(0.014)	(0.014)	(0.015)
Non-Response * Principal Quality	-0.041**	-0.042**	-0.013	-0.025
	(0.019)	(0.017)	(0.020)	(0.017)
Change Unemp. Rate	-0.006	0.003	0.015***	0.001
	(0.013)	(0.007)	(0.004)	(0.005)
Non-Response * Change Unemp. Rate	0.012	0.017*	0.012*	-0.007
	(0.027)	(0.009)	(0.007)	(0.005)
Panel B: Probability of Changing				
Item Non-Response Rate	-0.079***	0.001	-0.058	0.024*
	(0.016)	(0.014)	(0.044)	(0.014)
Principal Quality	-0.001	-0.021***	-0.010	-0.009
	(0.010)	(0.007)	(0.008)	(0.007)
Job Disatisfaction	0.066***	0.007	0.023*	0.027*
	(0.011)	(0.009)	(0.012)	(0.015)
Non-Response * Principal Quality	-0.006	-0.016	-0.019	-0.046**
	(0.016)	(0.013)	(0.014)	(0.019)
Change Unemp. Rate	-0.013**	0.002	-0.001	-0.011**
	(0.007)	(0.003)	(0.004)	(0.004)
Non-Response * Change Unemp. Rate	-0.012	-0.003	0.007	-0.014**
	(0.013)	(0.005)	(0.007)	(0.007)

Note: Sample size approx. 1,160 teachers in year 2, 940 teachers in year 3, 700 teachers in year 4, and 560 teachers in year 5. Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Controls for teacher's gender, ethnicity, if teacher is alternatively certified, if teacher has greater than or equal to a Master's degree, if the teacher has passed the Praxis exam in math, reading, or writing, ethnic composition of school, proportion of students eligible for free or reduced price lunch in school, school enrollment, school urbanicity, principal's gender, principal's ethnicity, principal's experience, principal's experience teaching, and region fixed effects. Presents fully specified models analogous to Column (4) in Tables 6 through 9.

Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) “First Through Fifth Waves Data File,” 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Appendix A: Factor Loadings for Teacher Evaluations of Principal Quality Factor

Appendix Table A.1: Factor Loadings for Teacher Evaluations of Principal's Quality Factor

Variable	Factor Loadings
Principal Effectiveness Factor (Eigenvalue = 3.12, Cronbach's alpha = 0.85)	
"The school administration's behavior toward the staff is supportive and encouraging."	0.83
"My principal enforces school rules for student conduct and backs me up when I need it."	0.82
"The principal knows what kind of school he or she wants and has communicated it to the staff."	0.80
"In this school, staff members are recognized for a job well done."	0.78
"I am generally satisfied with being a teacher at this school."	0.72

Source: U.S. Department of Education, National Center for Education Statistics, Beginning Teacher Longitudinal Study (BTLS) "First Through Fifth Waves Data File," 2007-08, 2008-09, 2009-10, 2010-11, and 2012-12.

Chapter 2: Teacher Attrition and Teacher Pension Costs

Introduction

Actuarial assumptions have a broad impact on the measured financial health of teacher retirement systems. These assumptions include the expected rate of investment return, inflation, wage growth, mortality, and teacher attrition. Retirement funds often discount employees' future benefits at the assumed rate of investment return. When the actual investment return rate falls short of the expected rate, unfunded accrued liabilities will rise (Costrell, 2018). Teacher pensions are underfunded by approximately $600 billion nationally (McGee, 2019; Novy-Marx & Rauh, 2011).

As state and local governments continue to underfund their employees' public pensions, they search for ways to manage pension expenditures. To do so, state and local governments may cut funding away from other programs and redirect those funds to pensions. Pension expenditures are already cutting into "social services to the elderly, blind, disabled and other children and adults, and licensing and regulating foster homes, group homes, residential care facilities, day care facilities, and preschools" (Nation, 2018, p. 17). This crowd-out also creeps into school funding, as contributions to retirement benefits as a proportion of per pupil funding rose from 4.8 percent in 2004 to 11 percent in 2019 (Costrell, 2019). Crowd-out is suppressing teachers' wages (Kim et al., 2020; McGee, 2016). State and local governments may also try to increase funding in their pensions by raising employee contributions to the pension funds or by increasing employer contributions by increasing tax revenues.

Some state and local governments have even considered inducing teacher turnover as a potential solution.[1] For example, Chicago Public Schools negotiated the Voluntary Retirement Incentive (VRI) with the Chicago Teachers Union in 2017. This deal was simple: teachers eligible for retirement would receive a bonus equal to years of service in Chicago Public Schools times $1,500. For example, a teacher with 30 years of service would receive a lump sum payment of $45,000.[2] The only caveat was that a minimum of 1,500 teachers would have to accept the offer and retire. Of the approximately 2,700 teachers eligible, 27 percent took the deal, far below the required minimum for the bonuses to be paid out (Knapp et al., 2019). The problem with Chicago's efforts was that there were two competing incentives at play. There was the "push" out of teaching in the form of a bonus, but there was a "pull" to stay in the classroom in the form of annual salary and the continued accrual of pension benefits. Knapp et al. (2019) estimated that approximately 590 total teachers would have taken the deal but that 430 would have retired regardless of the VRI. The remaining 160 were induced to retire as a result of the VRI.[3] These findings suggest that inducing enough teacher turnover to rein in costs may be a challenge. Accruing benefits and salary likely represented too large of a pecuniary hump to induce retirement for non-VRI takers.

While unevaluated, both Kansas and California have offered or are currently offering similar programs. Kansas offered a VRI in Fall 2011 where retirement eligible public employees in its Tier 1 or Tier 2 final average salary plans would be allowed to remain in the state's group

[1] Policies designed to create teacher turnover not only prevent pension benefits from accruing as teachers exit the profession but can generate additional savings since highly experienced teachers also earn some of the highest salaries.

[2] An entering teacher with a bachelor's degree earned $50,653 in the 2014-2015 school year (Dabrowski & Klingner, 2016). This means that the teacher with 30 years of experience would actually receive a VRI bonus that is less than the example entry level teacher's salary.

[3] The projection in Knapp et al. (2019) turned out to be incorrect. They expected 22 percent of teachers to take the VRI when 27 percent actually did. Assuming that the researchers were able to correctly calculate the number of teachers who would have retired regardless, their estimate of the induced teachers would represent a lower bound.

health insurance plan or receive a single payment of $6,500 (Kansas Department of Administration, n.d.).[4] California's ongoing program offers retirement eligible teachers two years of additional service credit, which would result in more generous retirement benefits for teachers accepting the incentive (CalSTRS, n.d.).

This paper conceptually evaluates policies like voluntary retirement incentive programs. Using Massachusetts as a model, I consider how changing teacher exit rates could offset rising normal costs when lowering the discount rate. The normal cost is the amount of money required to prefund all currently accruing benefits in a year. I construct the uniform normal cost rate, a weighted average of the cost to prefund individual teachers' accruing pension benefits as a percent of salary, based on the actuarially assumed discount rate. The assumed discount rate is the expected rate of investment return. Using this assumed rate, the pension fund will be able pay all retirement benefits if total contributions to the fund are equal to the uniform normal cost rate. Since teacher retirement systems discount at an overestimated rate of investment return, changes in the discount rate would require changes in other pension assumptions if the uniform normal cost rate is expected to hold constant.

I vary the assumed teacher attrition rates using additive deviations for all teachers in Massachusetts to make up for the difference in rising normal costs resulting from changes in the discount rate. In essence, if Massachusetts were to continue funding at the uniform normal cost rate and discount at the assumed rate of investment return, it would need to raise teacher attrition rates by these deviations. I also model two plausible policies that would increase teacher attrition rates for teachers earning individual normal cost rates above the uniform rate and teachers who are at the retirement age.

[4] The state of Kansas only pays the employer share of the group health insurance plan's premiums for employees choosing to retire and continue to be covered by the group health insurance plan.

The uniform normal cost rate under a discount rate of 7.5 percent is 11.87 percent of salary. My results show, as would be expected, that lower discount rates require larger deviations to assumed teacher exit rates to hold the normal cost constant. I also find that the two plausible policies that target subsets of the teaching population would have to force every teacher that satisfies the inclusion restrictions to exit, but these targeted exit strategies would be unable to cover the entirety of the rise in the uniform normal cost rate resulting from lowering the discount rate. Generally, I find that the necessary turnover rates would be unrealistic or would not cover all currently accruing costs.

The rest of this paper is organized into four sections. The next section describes the Massachusetts Teachers' Retirement System and lays out the normal cost rate methodology. The following section describes how I model the teacher population in Massachusetts. The next explains how I will deviate exit rates from the actuarially assumed teacher exit rates and shows the impacts of increasing teacher exit rates in Massachusetts. The final section concludes with a discussion of the strategies to induce teacher attrition, other unintended consequences of these policies, limitations, and policy implications.

The Massachusetts Teachers' Retirement Systems and Normal Cost Rates

In this paper, I use the Massachusetts Teachers' Retirement System as a model (MTRS). MTRS assumes that all teachers exit by age 70, thus I consider all entry ages $e = 21, \ldots, 60$ and all exit ages $s = 21, \ldots, 70$. I use four data sources on MTRS to calculate normal cost rates in Massachusetts from MTRS and the Massachusetts Public Employee Retirement Administration Commission (PERAC). I use the actuarial assumptions for the discount rate/investment return, interest on refunds for non-vested members, cost of living adjustments, mortality, wage growth, and entry age cohort sizes from the 2016 MTRS actuarial valuation report (Massachusetts Public

Employee Retirement Administration Commission, 2016). I use the 2014 MTRS experience study (Massachusetts Public Employee Retirement Administration Commission, 2014) for female turnover rates. I obtain the interest on refunds for vested members from the 2016 financial condition statement (Massachusetts Teachers' Retirement System, 2016). Finally, the 2017 benefit guide (Massachusetts Teachers' Retirement System, 2017) provides the benefit formulas.

MTRS assumes investment returns equal to 7.5 percent and discounts at this rate (Massachusetts Public Employee Retirement Administration Commission, 2016). Costrell and McGee (2019) define the present value of an individual's wages as

$$W_{es} = \sum_{a=e}^{s}(1+d)^{e-a}\prod_{\alpha=e}^{a}(1+g_{e,\alpha-e}^{w}). \quad (1)$$

Here, $g_{e,\alpha-e}^{w}$ is the assumed wage growth rate including merit and inflationary components from PERAC (2016). The discount rate is d which MTRS assumes to be 7.5 percent.

I model the Massachusetts' Tier 2 teacher retirement plan (Massachusetts Teachers' Retirement System, 2017).[5] Tier 2 is for all teachers in Massachusetts that entered on or after April 2, 2012. This plan is a 5-year final average salary defined benefit plan with vesting at 10 years of service. Non-vested members can have their contributions refunded with 3 percent interest. Vested members can take a refund of contributions grown at a 0.1 percent interest rate or vested members can opt for a pension. Teachers with fewer than 30 years of service contribute 11 percent of earnings and teachers with 30 or more years of service contribute 8 percent.

Massachusetts uses a 5-year final average salary plan. In this plan, teachers' initial benefits are a percent of their average salary over the last 5 years of their careers. This percent of

[5] Massachusetts also has a Tier 1 plan. This plan is a 3-year final average salary with higher service factors and a retirement age of 55. Modeling only the Tier 2 plan should not bias my results substantially. If there is any bias, my results would represent lower bounds since using the Tier 1 parameters would likely increase my estimates.

final average salary, sometimes called a "replacement rate," is the product of teachers' years of service in MTRS and a service factor that varies by teachers' ages and years of service. [6] Through RetirementPlus, teachers with 30 years of overall service and 20 years of service as a teacher in MTRS can earn larger replacement rates. Replacement rates are capped at 80 percent of final average salary, even among RetirementPlus eligible teachers. MTRS includes a cost of living adjustment of 3 percent on the first $13,000 in annual retirement benefits.

I discount the value of refunds and the value of a stream of pension payments back to entry. Unlike other state retirement systems, MTRS does not provide assumptions for the take-up rate of pension or refund; accordingly, I assume teachers choose either the refund or pension based on which one has the higher present value.

Normal Cost Rates

This paper utilizes the normal cost rates from Costrell and McGee (2019) and which Costrell (2020) and Costrell and Fuchsman (2018) also use. A normal cost rate is the required contribution to prefund currently accruing pension benefits of an individual member – in this case, a teacher – in the retirement system. An individual member of the teacher retirement system is of type (e, s), where e is entry age and s is the age at separation (exit). I will refer to a cohort of teachers of type (e, s) as entry-exit age cohorts. An individual's normal cost rate is the ratio of the present value of benefits to the present value of earnings,

$$n_{es} = B_{es}/W_{es}, \tag{2}$$

where B_{es} is the present value of benefits and W_{es} is the present value of earnings defined in equation (1). Both benefits and wages are discounted back to the time of entry in the teaching workforce.

[6] See MTRS (2017) for these replacement rates.

The proportion of members in the system of type (e, s) is denoted by p_{es}.[7] The uniform normal cost rate is the weighted average of all individual normal cost rates:

$$n^* = \frac{\sum_e \sum_s n_{es}(p_{es} W_{es})}{\sum_e \sum_s p_{es} W_{es}}. \quad (3)$$

This uniform rate represents the proportion of wages required to prefund all currently accruing benefits in the retirement system. Employees and the employer partition the uniform normal cost rate in order to pay it. Typically, government statute will set the employee contribution rate and the employer will pay the portion that is left after netting out employee contributions. If this uniform normal cost rate is paid in full and assumed investment returns are actualized, then the unfunded accrued liabilities would not increase. However, even if the uniform normal cost rate is paid in full, unfunded accrued liabilities will rise if actual investment returns fall short of assumed returns.

Costrell and McGee (2019) also show that the deviations between an individual's normal cost rate and the uniform normal cost rate sum to zero. They term these deviations "cross-subsidies." Cohorts receive positive and negative cross-subsidies when their normal cost rate is greater than or less than the uniform normal cost rate. Individuals with positive cross-subsidy are sometimes referred to as the "winners," and "losers" are those who receive negative cross-subsidies.

Normal Cost Rates in MTRS

An important result that leads to underfunding of teacher pension is that higher discount rates correspond with lower normal costs. The underfunding problem can occur when discount rates are overestimated. Figure 1 plots normal cost rate surfaces corresponding with several

[7] I construct the share of members in a (e, s) cohort similarly to Costrell and McGee (2019). I summarize that methodology in the next section.

discount rates including MTRS' assumed discount rate. It shows the impact that the discount rate has on the uniform normal cost rate. In this figure, the x-axis is exit ages, the y-axis is entry ages, and the z-axis is normal cost rates. To the right of the surface plot are the uniform normal cost rates corresponding to the alternate discount rates. Colors of the mesh surfaces correspond to a single discount rate with black mesh at the bottom corresponding to the assumed rate of investment return at 7.5 percent.

I find that, in conjunction with Costrell (2020), as the discount rate is lowered, individual normal cost rates rise. Each mesh surface in figure 1 has a similar shape. There is significant heterogeneity in normal cost rates along each mesh surface indicating that normal cost rates vary significantly by entry and exit ages. For all surfaces other than the red mesh when discounting at 3 percent, the surfaces decline until members vest in MTRS.[8] After vesting, the normal cost rates fall toward zero before increasing as members begin to accrue more generous benefits. All normal cost rate surfaces decline toward zero as exit ages near 70.

More relevant for this paper than the shape of the normal cost rate surfaces are the uniform normal cost rates that correspond with the selected discount rates. The actuarially assumed discount rate is 7.5 percent and accompanies a uniform normal cost rate of 11.87 percent. Reducing the discount rate by half of a percentage point results in an increase of the uniform normal cost rate to 13.16 percent. The uniform normal cost rate rises to 20.9 percent of all earnings when the discount rate is 5 percent. When discounting at the interest rate on risk-free assets, 4 percent, the uniform normal cost rate is 27.02 percent. Under a 3 percent discount rate, the interest rate on contributions of non-vested members, the uniform normal cost rate is 35.35 percent.

[8] The red mesh surface denoting normal cost rates under a 3 percent discount rate is flat 11 percent, the employee contribution rate, since this discount rate is also the interest rate on refunds for non-vested members.

Teacher Population in Massachusetts

I adapt methodology from Costrell and McGee (2019) to model the current teacher population in Massachusetts probabilistically. They calculate the share of total members in an (e, s) of the member population by multiplying the conditional probability of exit at age s given entry at e by the probability of entry at age e,

$$p_{es} = p_{s|e} * p_e \,. \tag{4}$$

The probability of exit at age s given entry at e can be obtained using MTRS assumptions regarding mortality and turnover. I define the probability still working at age s for an entrant at age e using three components: the probability that the member was still working the prior year, the probability that the member did not exit after the prior year, and the probability that the individual did not die in the current year. Formally, the probability a member is still working at age s given entry at age e is:

$$p^{sw}_{s|e} = p^{sw}_{s-1|e} * \left(1 - \tau_{e,s-1}\right) * (1 - die_s) \tag{5}$$

where the probability still working at entry is equal to one, $\tau_{e,s-1}$ is the assumed exit rate, and die_s is the mortality rate. Subtracting the probability still working the previous year from the probability still working in the current year yields the exit hazard for this year:

$$p_{s|e} = p^{sw}_{s|e} - p^{sw}_{s-1|e}. \tag{6}$$

Costrell and McGee (2019) are able to calculate the share of members entering at age e, p_e, using data the California State Teachers' Retirement Systems provides, but MTRS does not provide this data. In order to derive the probability of entering MTRS at age e, I use a three-step procedure. MTRS provides the number of members within an age range and years of service range (Massachusetts Public Employee Retirement Administration Commission, 2016). For example, there are 2,177 members in MTRS between ages 0 and 24 with 0 and 4 years of service

and 1,575 members between ages 25 and 29 with 5 and 9 years of service. I focus on those between 0 and 4 years of service between ages 22 and 59. The lower bounds on the age ranges, L_i, can be found in the first column of appendix table 1.1. The upper bounds on the age ranges, U_i, can be found in the second column of this table.

The first step in my procedure is to determine a simple average number of entrants within each age range bin. The number of entrants between ages L_i and U_i is:

$$P_{L_i,U_i} = \frac{N_{L_i,U_i} - P_{L_{i-1},U_{i-1}} \sum_{e=L_{i-1}}^{U_{i-1}} \sum_{s=L_i}^{U_i} p_{s|e}^{sw} * 1(s-e<5)}{\sum_{e=L_i}^{U_i} \sum_{s=L_i}^{U_i} p_{s|e}^{sw}}. \quad (7)$$

Equation (7) contains three key components. First, N_{L_i,U_i} is the number of members within the age range defined by the bounds L_i and U_i with between 0 and 4 years of service. The number of entrants can be found in the third column of appendix table 1.1. Second, the number of entrants still in the retirement system that entered between the previous cell's bounds, L_{i-1} and U_{i-1}, that would be included in the current cell. For example, the cohort of 23 year old entrants with between 0 and 4 years of service would be included in the number of members between ages 22 and 24, $N_{22,24}$, as well as the number of members between ages 25 and 29, $N_{25,29}$. I subtract the number of entrants for the previous cell that would still be in the system from the total members within the current cell. The indicator function embedded in the numerator's double summation ensures that I only subtract off the members with less than 4 years of service. For ages 22 to 25, $P_{L_{i-1},U_{i-1}}$ is zero. The third key component of equation (7) is the denominator, where I sum up the probability still working for all those members. The estimated number of entrants can be found in the final column of appendix table 1.1. I divide each P_{L_i,U_i} by the total number of members between ages 22 and 59 for an initial estimate of the probability of entry, p_e^1.

The second step in my procedure is to weight the initial probability of entry estimates in a five-year rolling average for ages 21 through 60:

$$p_e^2 = 0.1 * p_{e-2}^1 + 0.2 * p_{e-1}^1 + 0.4 * p_e^1 + 0.2 * p_{e+1}^1 + 0.1 * p_{e+2}^1. \quad (8)$$

Summing up the probability of entering at age e for all entry ages should be one. However, the sum of all p_e^2s is less than one since my rolling average for ages near the bounds includes probabilities of entering equal to zero. For example, my procedure omitted entry ages 20 and 21 in step one as I would not expect many entrants at these ages, if any at all. The rolling average for age 22 would include zero for both p_{20}^1 and p_{21}^1, which makes the sum of the weights for age 22 less than one. In the final step of my procedure, I normalize p_e^2 by dividing by the sum of the probability of entering at age e for all entry ages to get the probability of entering at age e.

Assumed Teacher Exit Rates

Figure 2 plots the survival rates of an entering cohort for all entry ages based on the 2016 MTRS assumptions regarding mortality and turnover. I use the number of beginning teachers in the system and the probability that a teacher is still working at age s given entry at age e from equation (5) to construct this stair-step graph. I sum the number of teachers surviving in the system for each year potential year of service and divide by the number of beginning teachers. The horizontal axis shows years of service and the proportion of teachers remaining in the system is on the vertical axis.

The majority of assumed teacher turnover in Massachusetts occurs prior to when teacher would vest. After one year of service, slightly more than 10 percent of teachers will have exited the system. The assumed 5-year survival rate in the profession is just below 60 percent. Half of the entry cohort will exit prior to their 8th year of service. Approximately 46 percent of teachers will remain in the system long enough to vest in the plan at 10 years of service. Only 25 percent

will survive to 25 years of service. Ten percent will remain at 36 years of service. By the 40th year of service, nearly 98 percent of the cohort will have left.

Deviations from Assumed Teacher Exit Rates

Based on figure 1, I conclude that overestimating the discount rate results in uniform normal cost rates that are less than the true uniform normal cost rate, which likely ends in rising pension costs. As state and local governments have come to terms with this result, they seek out solutions to bring down their pension costs as well as cut costs for other services (Kim et al., 2020; McGee, 2016; Nation, 2018). I evaluate potential policies similar to those tried by Chicago, Kansas, and California that aim to induce teacher turnover. Here, I describe a methodology and apply the methodology to study the impacts inducing teacher turnover. My goal is to prevent the rise in the uniform normal cost rate that results from lowering the discount rate by increasing teacher exit rates.

Deviation Methodology

Equation (3) provides a shortened expression of the full uniform normal cost rate. Expansion of equation (3) would require a full understanding of how to determine retirement benefits in a system, which can be complicated. It is helpful to think of equation (3) as a function of its assumed inputs rather than the expressions for benefits and wages,

$$n^* = n(d, \boldsymbol{\tau}_{es}). \tag{9}$$

Here, the discount rate is d and the teacher exit rates are $\boldsymbol{\tau}_{es}$ which denote the probability that an individual entering at e exits at s.[9] While many other assumptions are required in order to

[9] I describe individuals as being of type (e, s) throughout as those who enter at age e and exit at age s. The normal cost rate for an individual of this type has been n_{es}. I use similar notation when describing probabilities (i.e., p_{es} is the probability that a member is of type (e, s)). Teacher exit rates are considered to be the probability that teachers will exit, τ_{es}.

calculate n^*, the two key assumptions under evaluation in this paper are the discount rate and teacher exit rates.

Let $n^*_{d_0}$ be the uniform normal cost rate obtained when the discount rate is the actuarially assumed rate of investment returns and when using assumed teacher exit rates. As Costrell (2020) shows and I show previously in this paper, lowering the discount rate, corresponds with a new uniform normal cost rate exceeding $n^*_{d_0}$. If actual investment returns are truly lower than the discount rate, the retirement system is underfunded at $n^*_{d_0}$ and contributions would need to rise. In order to continue funding at this uniform rate, some other assumed parameter in equation (9) must change. In this paper, I study the possibility of how to alter the assumed exit rates when actual investment returns are lower than assumed,

$$n^*_{d_0} = n\big(d_1, g(\boldsymbol{\tau}_{es}, \boldsymbol{\kappa}_{es})\big)\,. \tag{10}$$

Here, the discount rate d_1 is lower than the actuarially assumed d_0 and $g(\cdot)$ is some function that deviates the assumed exit rates by a factor $\boldsymbol{\kappa}_{es}$. Identifying a set of deviation parameters, $\boldsymbol{\kappa}_{es}$ is impossible in equation (10) since it is underdetermined: there is only one equation and 1,220 unknowns.[10]

I make two simplifying assumptions to regarding equation (10). I reduce the number of unknown deviation parameters to only one and make it an additive deviation. The uniform additive deviation is used for all teachers and then for subsets of teachers in later analyses. Exit rates are allowed to change for teachers with positive cross-subsidies and teachers that are eligible for retirement. Deviations are approximated with numerical methods to be within one millionth of the uniform normal cost rate under the assumed 7.5 percent discount rate.

[10] Plausible exit ages are those that are greater than or equal to the entry age. Then, for the entry and exit ages under investigation, the number of potential exit ages is $\sum_{e=21}^{60}\sum_{s=21}^{70} 1(s \geq e) = 1{,}220$.

An additional benefit of using additive deviations is their ease in interpretation. Additive deviations represent the percentage point change in a teacher's exit probability. For example, if the additive deviation is 2 percentage points and a teacher's exit probability is 10 percent, the new exit probability is 12 percent.

Uniform Deviations

Figure 3 plots estimated survival rates that would be needed to maintain uniform normal costs for different discount rates and using a single additive deviation for all teachers. Each survival rate corresponds with altered exit rates; the deviation is added to the exit rates that MTRS actuaries assume. The uniform normal cost rate for these exit rates is the uniform normal cost rate from estimation with a discount rate of 7.5 percent. Since exit rates can be expressed as a percentage, the additive deviations can be interpreted as a percentage point increase in the proportion of exiting teachers when all else is held constant.

As I expect, lower discount rates require higher deviations to maintain the uniform normal cost rate. As a result, the survival function for the lowest discount rate is always associated with higher attrition for each year of service until the survival rates converge at zero. Overall, the proportion of teachers that would be needed to exit the first year varies between 11 percent (or 89 percent retained) under the assumed 7.5 percent discount rate and 39 percent (61 percent retained) in the 3 percent discount rate case. The 5-year attrition rate is between 40 and 90 percent. Both survival rate functions for the 3 and 4 percent discount rates converge at zero within 22 years of service; no teacher would stay in the profession long enough to collect large benefits. Convergence of all survival rates occurs within 45 years of service.

The additive deviation for the 7 percent discount rate required to hold the uniform normal cost rate constant at 11.87 percent is 2.3 percentage points. Taking a 10 percent assumed attrition

rate as an example, to make up for discounting at the assumed rate of investment return when it is underestimated by half of a percentage point would require a 12.3 percent attrition rate. Under a 7 percent discount rate and an additive deviation of 2.3 percentage points, the 5-year survival rate is 53 percent. This rate is significantly lower than the assumed 5-year survival rate of 60 percent. Half of all entering teachers will have left by year 6 rather than by their 8th year. Approximately 40 percent of teachers would vest in MTRS and 9 percent would remain long enough to qualify for RetirementPlus. In the assumed case, 19 percent of teachers would have stayed 30 years and qualified for RetirementPlus.

Lowering the discount rate by another percentage point to 6 percent increases the additive deviation to 7.2 percentage points. The proportion surviving the first year is 82 percent. The 6 percent discount rate is the first discount rate for which less than half of teachers are expected to survive at least five years with less than half making it through year 4. By the fifth year, the surviving population is 39 percent of the starting cohort. For reference, 39 percent of the starting cohort would have survived to year 14 under the 7.5 percent discount with no deviation. A fifth of teachers would vest and under 2 percent would reach RetirementPlus eligibility. Less than 10 percent of teachers would remain by their 17th year of service.

The first instance in which the additive deviation is larger than 10 percentage points occurs when the discount rate falls to 5 percent; the additive deviation is 13.2 percentage points. Nearly a quarter of teachers would exit after their first year. Less than half the entering cohort will survive to year 3 and the 5-year survival rate is approximately 27 percent. In contrast, 27 percent of the starting cohort was assumed to survive 23 years under the 7.5 percent discount. Less than 1 percent of teachers will remain to see their 23rd year of service and 0.22 percent will survive to 30 years and RetirementPlus.

The additive deviations accompanying the 3 and 4 percent discount rates are 27.7 and 20.8 percentage points, respectively. For both discount rates, the less than half of teachers will make it through their second year. The 5-year attrition rate for a 3 percent discount rate is 90 percent and the five-year attrition rate for a 4 percent discount rate is 84 percent. Discounting at 3 percent is associated with only 1.27 percent of teachers surviving long enough to vest in MTRS. The 30-year survival rate is essentially zero under both discount rates. For these risk-free discount rates, the required increases in teacher turnover are unlikely to be realistic if schools are to continue operation.

Targeted Deviations

Adjusting exit rates for all teachers uniformly from assumed exit rates is unlikely to be a strategy that state and district retirement systems choose to employ. Rather, in an attempt to offset rising pension costs, retirement systems would be more selective in electing which teachers should exit. Chicago, Kansas, and California chose targeted strategies with their voluntary retirement incentive programs. I model two plausible choices for which teachers are chosen for potential exit: those teachers earning positive cross-subsidies and teachers that are eligible for retirement. The latter is more in line with voluntary retirement incentive programs in Chicago, Kansas, and California.

Teachers with Positive Cross-Subsidies.

The first targeted policy I explore alters teacher turnover rates for teachers that earn positive cross-subsidies when discounting at 7.5 percent. Figure 4 displays which entry-exit age cohorts receive positive cross-subsidies using the actuarially assumed discount rate. The magnitudes of normal cost rates can be determined based on the color bar to the right of the plot. Entry ages can be found on the vertical axis and exit ages are on the horizontal axis. The focal

point of this graph is the intersection of the vertical and horizontal lines. White intersections indicate that teachers in the corresponding entry-exit age cohort can be considered winners; teachers in these cohorts are targeted for increased exit rates relative to their assumed exit rates. Black intersections indicate that corresponding teachers earn individual normal cost rates less than the uniform normal cost rate. The size of the cross-subsidies is variable with the largest cross-subsidies occurring for those entering at age 50 or later. I do not vary the new exit rates based on the size of the cross-subsidy.

Since winners are identified under the assumed 7.5 percent discount rate, it is possible for there to not be enough teachers that would exit to make up for the potential rise in the uniform normal cost rate. This can occur because the distribution of winners and losers changes with a decrease in the discount rate and a constant uniform normal cost rate. As shown in figure 1, normal cost rates rise when the discount rate is lowered, which means that more teachers can be considered winners when funding the pension at the uniform normal cost rate associated with the assumed discount rate. In the most extreme case of this paper, the 3 percent discount rate case, all teachers are winners as soon as they vest in the system when funding at the baseline uniform normal cost rate. This phenomenon ends up occurring for all discount rates under investigation less than 7 percent, making it impossible to choose a uniform exit rate deviation for those teachers earning positive cross-subsidies that would offset the rise in the uniform normal cost rate. Instead, the sum of the affected entry-exit age cohort's assumed exit rate and the cohort specific deviation is one. In other words, lowering the discount rate beyond 7 percent would require all teachers earning positive cross-subsidies to exit. For the 7 percent discount rate, the required uniform rise in exit rates is 45.3 percentage points.

I produce the new exit rates for the "winner" group using additive deviations with the aim of choosing a uniform exit rate for these teachers that offsets the rise in the uniform normal cost rate associated with a lowered discount rate. Figure 5 is the stair-step graph akin to figures 2 and 4. The proportion of teachers remaining is on the vertical axis and the horizontal axis maps years of service. The black line is the assumed exit rates based on MTRS assumptions. The blue and orange lines represent the new exit rates using additive deviations for all teachers with the same service record. This blue line is associated with reducing the discount rate from 7.5 percent to 7 and the orange line is for any discount rate less than 7 percent.

There are two points on figure 5 where the new exit rates diverge from the assumed exit rates. The first disconnect occurs at 10 years of service. Since the normal cost rate associated with a refund of contributions is never greater than the uniform normal cost rate, the two survival rate lines are the same for the 10-year vesting period. At the 10_{th} year of service (i.e. at vesting), the assumed teacher retention rate is 45 percent, but this declines to 43 percent for the 7 percent discount rate and 40 percent if all winners exit (discount rates less than 7 percent). Entrants at age 46 or older immediately earn normal cost rates greater than the uniform normal cost rate as soon as they qualify for retirement benefits at 10 years of service. Following this first mass exodus, the two deviated teacher retention rates connect. The altered rates nearly converge with the assumed rates prior to 30 years of service. In the assumed case, a quarter of teachers will remain prior to accumulating 25 years of service compared to 23 years of service when exit rates increase by 45 percent and when all members earning positive cross-subsidies exit.

The second divergence between the three lines in figure 5 occurs at 30 years of service, when members become eligible for RetirementPlus. Teachers that enter between ages 28 and 31 first earn retirement benefits exceeding the uniform normal cost rate at this 30-year mark. The

assumed retention rate at 30 years of service is 19 percent but this rate declines to slightly over 15 percent when the discount rates is lowered to 7 percent. The 30-year exit rate is 12 percent when all winners are forced to exit. To make up for a half point reduction in the discount rate, less than 10 percent of teachers would remain 32 years into their career and less than 1 percent would by year 38. When all winners turn over, less than 10 percent of teachers would still be in the system by 31 years of service and less than 1 percent would survive through their 37th year of service.

When choosing a discount rate of 6 percent or lower, the uniform normal cost rate will have to rise since it is impossible to hold the uniform normal cost rate constant even when all teachers earning positive cross-subsidies exit. The question then becomes how much of the potential rise in the uniform normal cost rate can be offset. Table 1 provides the discount rates, additive deviations, new uniform normal cost rates, and the differences between the uniform normal cost rate calculated using a 7.5 percent discount rate and the uniform normal cost rate for all other discount rates when taking the new exit rates into account.

Panel A of table 1 contains the differences in uniform normal cost rates when the targeted policy is for teachers earning positive cross-subsidies. As shown in figure 5, discounting at 7 percent requires a 0.45 additive deviation to hold the uniform normal cost rate constant; the difference between uniform normal cost rates is essentially zero. The minimum possible uniform normal cost rate is 13.62 percent when the discount rate is 6 percent. Relative to the assumed uniform normal cost rate of 11.87 percent, the difference is 1.75 percentage points. In other words, current employee and employer contribution rates that total 11.87 percent of salary leave an unfunded 1.75 percentage points of pay in retirement benefits that have already accrued. This unfunded portion is much higher when discounting at the relatively risk-free rates of 3 and 4

percent. The difference in uniform normal cost rates is 18.04 percentage points 10.71 percentage points for the 3 and 4 percent discount rates, respectively.

Retirement Eligible Teachers.

More in line with programs in Chicago, Kansas, and California would be a targeted policy that increases exit rates for teachers that are eligible for retirement. Changing exit rates among retirement eligible members may be a more politically palatable policy tool than the positive cross-subsidy policy described previously. Forcing or heavily incentivizing exit among those who are not eligible to receive benefits would leave those leavers without a source of income whereas those at the retirement age would be able to support themselves using retirement benefits. It is also usually the case that retirement eligible teachers earn the highest salaries, which can generate additional savings for the state in terms of compensation that it no longer has to pay. In Massachusetts, retirement eligibility occurs at age 60 for teachers that have vested in the system.

Returning to figure 4, teachers in MTRS earn positive cross-subsidies when they become eligible to collect a retirement benefit with only entry ages 20, 21, and 32 through 34 as exceptions. However, members entering between ages 23 and 28 become winners two years prior to the retirement age and several entry ages prior to 50 also become winners prior to the retirement age. This means that a policy targeting retirement eligible teachers will still allow for many teachers to earn a positive cross-subsidy.

Figure 6 shows the assumed exit rates in black and the new exit rates based on a targeted exit policy to remove retirement eligible teachers in blue. The figure only graphs one line with exit rates deviating from the assumed exit rates since, regardless of the new discount rate, all teachers at the retirement age would have to exit in an attempt to make up for the rise in the

uniform normal cost rate that results from lowering the discount rate.[11] The exit rates overlap for the first 9 years of service since retirement eligibility requires at least 10 years of service. After 10 years, 42.78 percent of teachers would remain and only 16 percent of teachers would reach RetirementPlus eligibility at 30 years of service. Less than 25 percent of teachers would survive through their 23rd year and less than 10 percent would make it to year 33. Every teacher would be forced to exit at 39 years of service.

Since there is only one set of exit rates across the selected discount rates, it is worthwhile to investigate how much of the rise in the uniform normal cost rate can be offset when forcing all retirement eligible teachers to exit. Panel B of table 1 includes the uniform normal cost rates accounting for a lower discount rate and increased exit rates among retirement eligible teachers and difference between the assumed uniform normal cost rate and these new uniform normal cost rates. Even when every teacher eligible teacher exits, the uniform normal cost rate rises by 0.23 percentage points when the discount rate is lowered one half point from 7.5 percent to 7 percent. The difference in uniform normal cost rates swells to 3.23 percentage points when the discount rate is lowered another point. The relatively risk-free discount rates of 3 and 4 percent correspond with differences in uniform normal cost rates of 21.19 and 13.17 percentage points. These differences indicate that employee and employer contributions would still have to at least double in order to make up for the rise in the uniform normal cost rate.

Discussion and Conclusion

This paper conceptually evaluates policies of voluntary retirement incentive programs similar to those in Chicago, Kansas, and California. These policies sought to induce teacher turnover in order to generate savings for their retirement systems. I use data from Massachusetts

[11] This same result holds if using multiplicative deviations from assumed exit rates.

to construct the required contributions to pay for an individual's currently accruing pension benefits relative to the individual's wages called normal cost rates. Aggregating individual normal cost rates for the entire retirement system yields a uniform normal cost rate. Under all actuarial assumptions, for the case of Massachusetts, I estimate the uniform normal cost rate to be 11.87 percent of cumulative earnings; the important assumed parameter is a 7.5 percent discount rate. I approximate a single additive deviation in teacher exit rates for all teachers in the system as well as for teachers earning individual normal cost rates above the uniform normal cost rate and teachers eligible to retire. These deviations are intended to be increases in teacher turnover rates that hold the uniform normal cost rate constant at the rate corresponding with the assumed 7.5 percent discount rate.

The policies I study vary in their ability to even accomplish the underlying goal of holding the uniform normal cost rate constant when the discount rate falls. The first policy that would increase exit rates for all teachers uniformly would offset the rise in the uniform normal cost rate, but targeting teachers earning positive cross-subsidies would only prevent the uniform normal cost rate from increasing when the discount rate is lowered from 7.5 percent to 7 percent. It is impossible to cover the increased uniform normal cost rate when lowering the discount rate below 7 percent if winners are chosen for selective attrition. Likewise, lowering the discount rate and forcing all retirement eligible teachers to exit is insufficient to cover the increase in the uniform normal cost rate. For the cases in which attrition cannot cover the rise in the normal cost rate, the portion of the uniform normal cost rate that is left unaccounted for can be quite sizable. Discounting at 3 percent accompanied with either targeted policy would necessitate at least a 150 percent increase in employee and employer contributions.

Moreover, the specific policy instrument designed to force teachers to exit may not be without cost. One potential policy is to offer teachers that voluntarily exit a bonus similar to Chicago's VRI, however, these bonuses would likely have to be substantial to induce the required amount of exit. Another potential strategy would be to offer retiring teachers a higher retirement benefit than teachers may have expected, such as in California's voluntary retirement incentive program. The problem with this strategy is that it would also raise the uniform normal cost rate. One potentially promising plan would be similar to Kansas' program, which offered retirees continued enrollment in the state's group health insurance plan. Future research should study programs that use health insurance as the retirement incentive to see if this strategy would actually induce requisite turnover. Involuntary attrition is also an option to increase exit rates, but this is likely to be politically untenable.

The other non-trivial cost associated with increasing the probability that teachers exit is that additional teacher turnover is undesirable from a student learning perspective. Teachers that choose to exit or are chosen to exit may not be uniformly distributed across schools and districts. Teacher turnover is also negatively associated with student achievement (Ronfeldt et al., 2013). The only consistent predictor of teacher quality is experience and, on average, inexperienced teachers would replace experienced teachers who are induced to exit (Clotfelter et al., 2007; Harris & Sass, 2011; Kane et al., 2008; Rivkin et al., 2005; Rockoff, 2004; Wiswall, 2013).

My results rely on two simplifying assumptions to estimate deviations from assumed exit rates. I constrain the set of deviations to be only one and I assume that all teachers are subject to this deviation. I relax the second assumption in my analysis for targeted populations. It is likely possible to estimate a uniform deviation that would hold the uniform normal cost rate constant

for different populations than the ones I evaluate. However, I selected these two populations since they would be the populations that states actually try to incentivize to exit.

These results have two important policy implications. First, I frame rising pension costs as a result of missing investment return assumptions in terms of teacher turnover. The current teacher retirement debate often frames the rising costs issue in dollar amounts. For example, despite paying an amortized portion of the unfunded accrued liabilities in 2015, unfunded accrued liabilities in Massachusetts rose by $1.8 billion in 2016 (Massachusetts Public Employee Retirement Administration Commission, 2016).[12] At least part of this increase is due to a failure to estimate the normal cost with an appropriate discount rate. My paper reframes these rising costs as changes in teacher turnover assumptions. In order to prevent the uniform normal cost rate from rising from 11.87 percent of salary to 27.02 percent when the discount rate is adjusted from 7.5 percent to 4 percent, each teachers' exit probability would have to increase by 21 percentage points. Framing the cost in this way may make the pension reform conversation more accessible for policymakers and school officials.

Second, I show that common policies that would induce teacher turnover for one set of teachers over another may not make up for all rising normal costs. Neither of the plausible policies that target subsets of the teaching population that I modeled are able to cover costs when the discount rate is lower than 7 percent. This leads me to question the utility of similar policies. If they just lead to increased teacher turnover and do not fully address the underlying underfunding issue, then it seems advisable to choose other policy prescriptions.

[12] PERAC (2016) notes that the increase in unfunded accrued liabilities was, for the most part, a result of lowering the discount rate a quarter point in 2016 from 7.75 percent to 7.5 percent.

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Figures

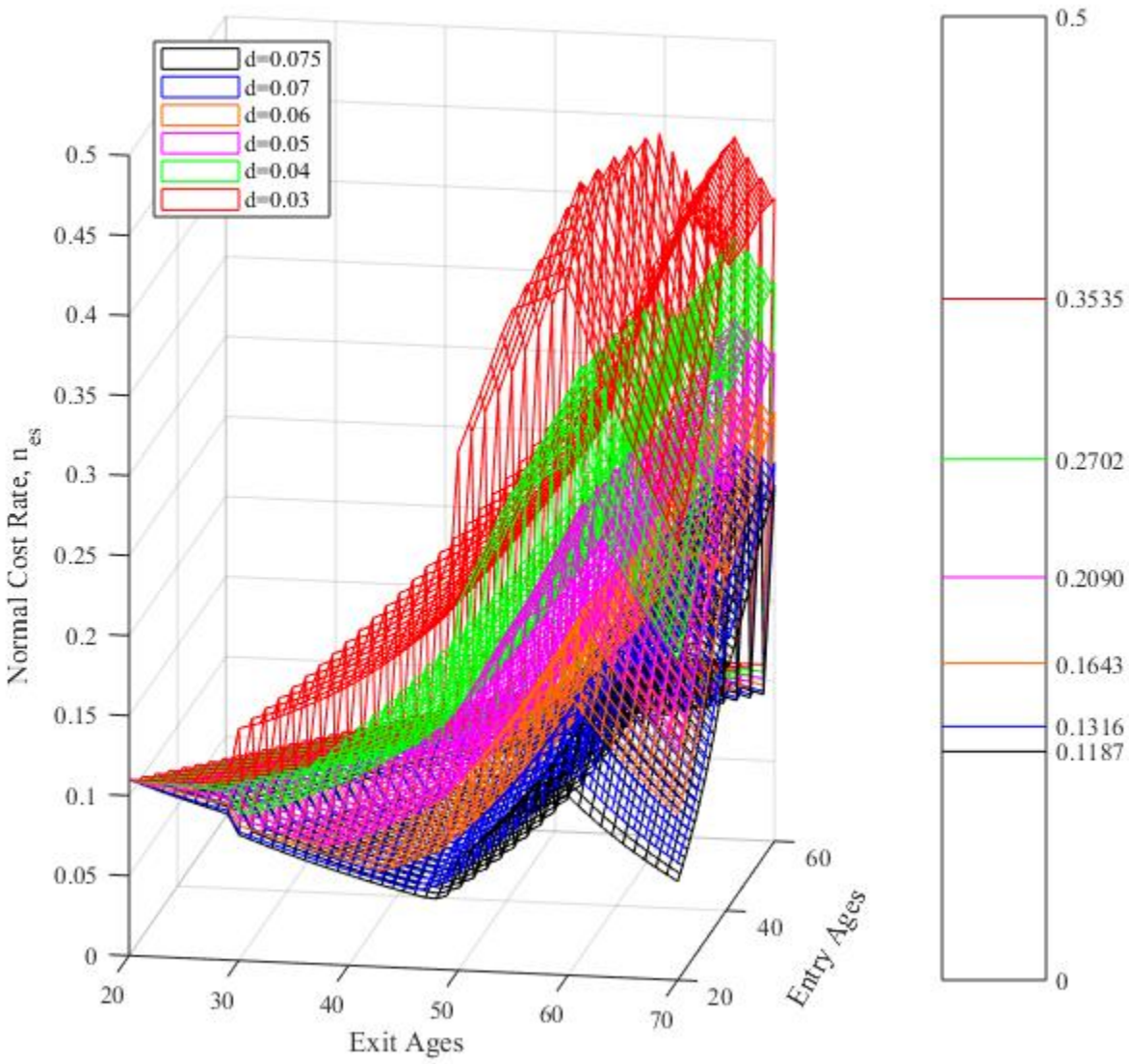

Figure 1: Normal Cost Rates, All Discount Rates
Notes: estimated using 2016 MTRS assumptions and benefit formula for new hires. The surfaces show the normal cost rates for teachers, the cost of pre-funding an individuals' currently accruing benefits as a percent of salary. Each surface uses a different discount rate. Bar on the right displays the uniform normal cost rates, the cost of pre-funding all currently accruing benefits as percent of salary, corresponding with each discount rates.

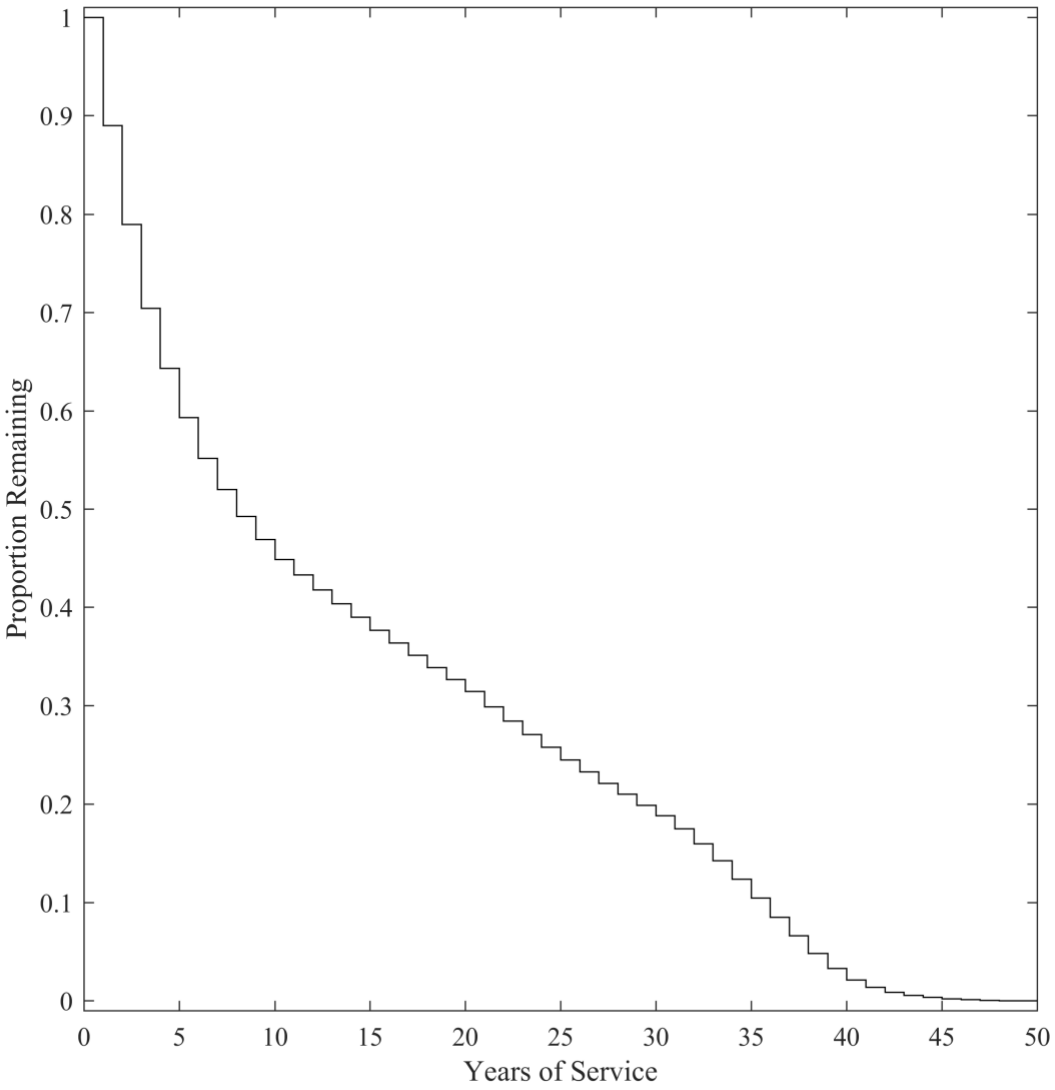

Figure 2: Actuarially Assumed Survival Rates
Notes: Estimated using 2016 MTRS assumptions. The function displays the proportion of an entering cohort (for all possible entry ages) remaining based on years of service.

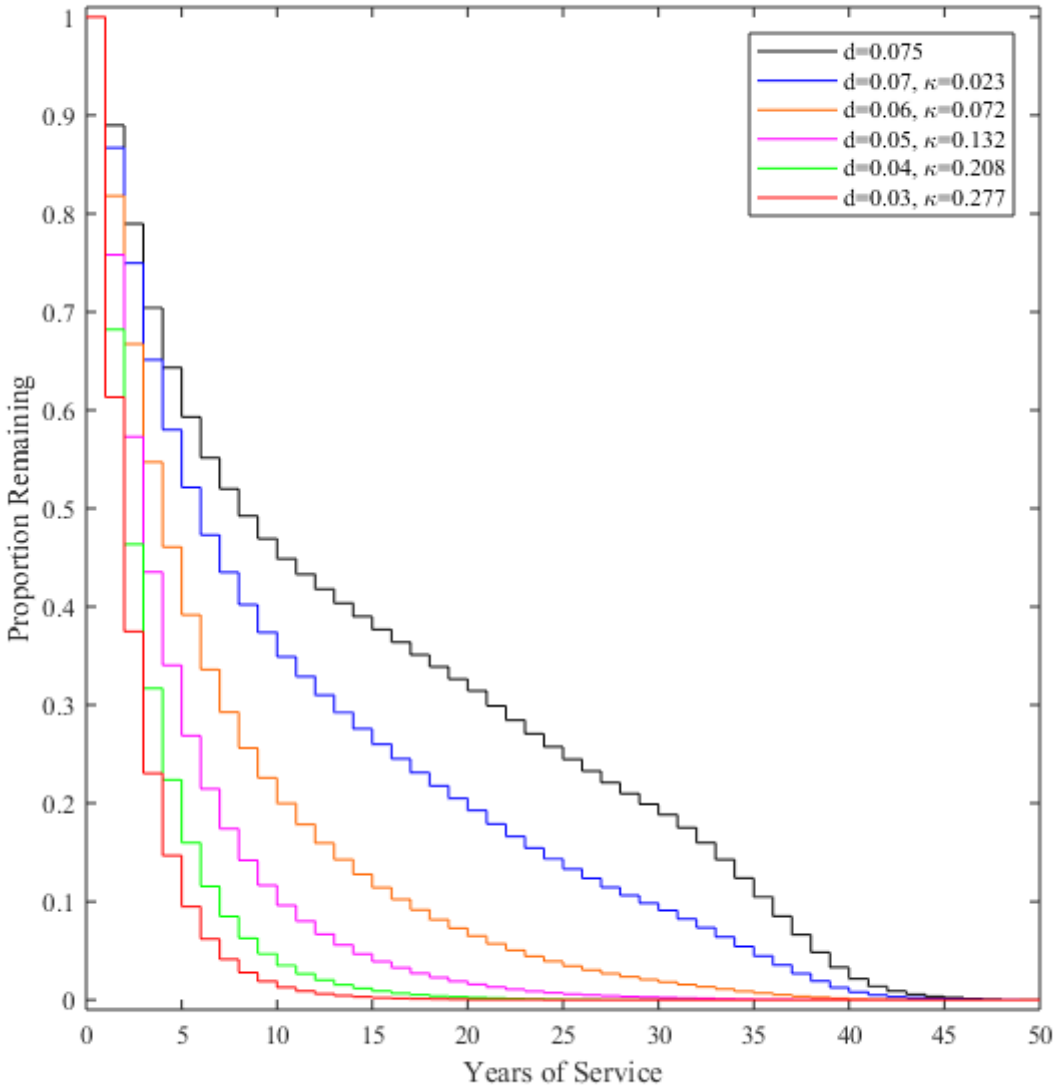

Figure 3: Survival Rates based on Constant Additive Deviations for All Teachers
Notes: Estimated using 2016 MTRS assumptions. The functions display the proportion of an entering cohort (for all possible entry ages) remaining based on years of service. Differences in lines reflect different discount rates and different additive deviations from assumed exit rates.

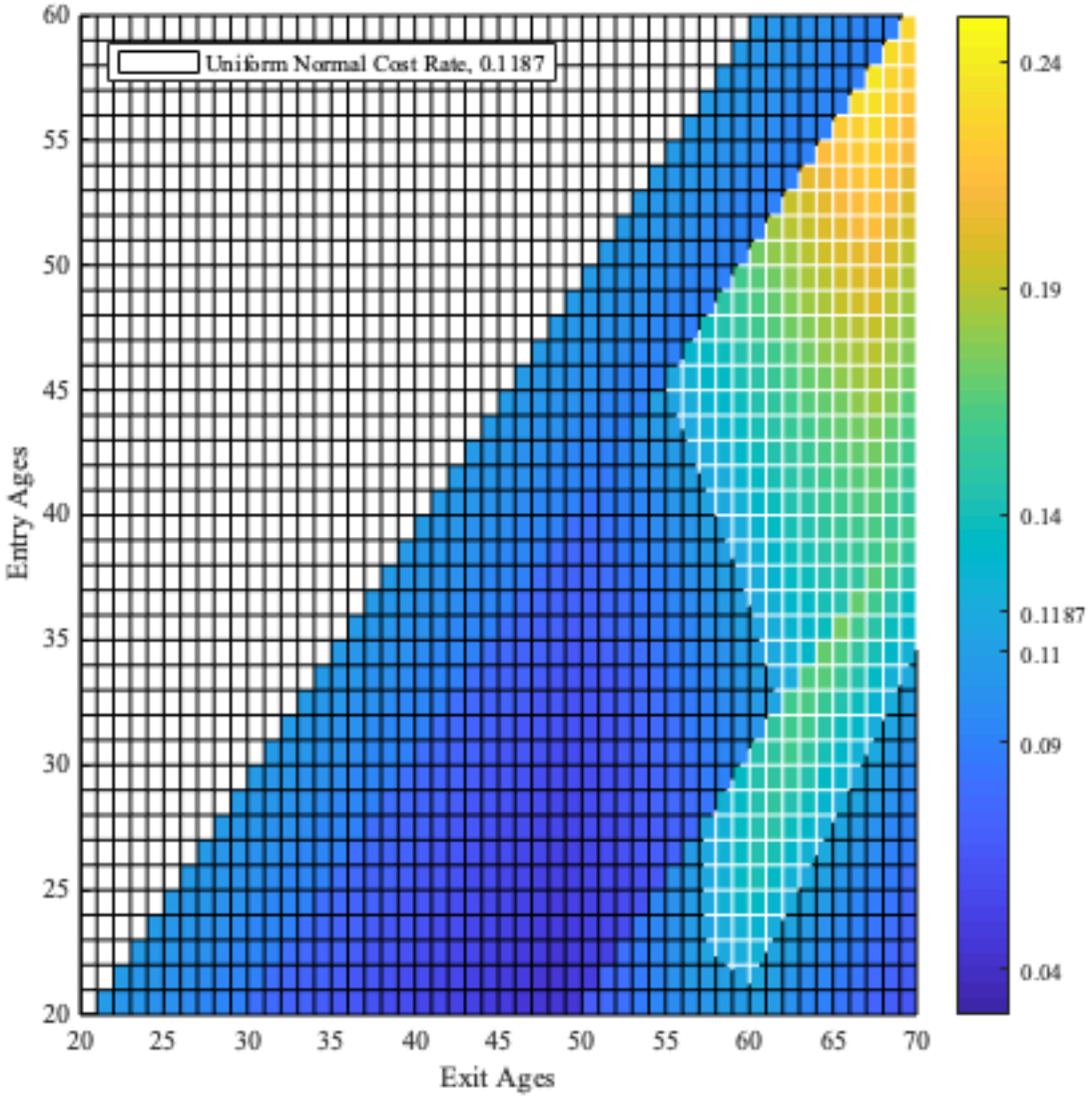

Figure 4: Entry-Age, Exit-Age Cross-Subsidies
Notes: estimated using 2016 MTRS assumptions and benefit formula for new hires. Color of the intersection between entry ages and exit ages shows if those ages correspond with teachers earning a positive cross-subsidy. Positive cross-subsidies indicate that teachers' normal cost rates, the cost of pre-funding an individuals' currently accruing benefits as a percent of salary, exceed than the uniform normal cost rate. Solid white intersections show that teachers earn positive cross-subsidies. Black intersections show that teachers' normal cost rates are less than the uniform normal cost rate. Cell color displays the size of the individual normal cost rate. Assumes a 7.5 percent discount rate.

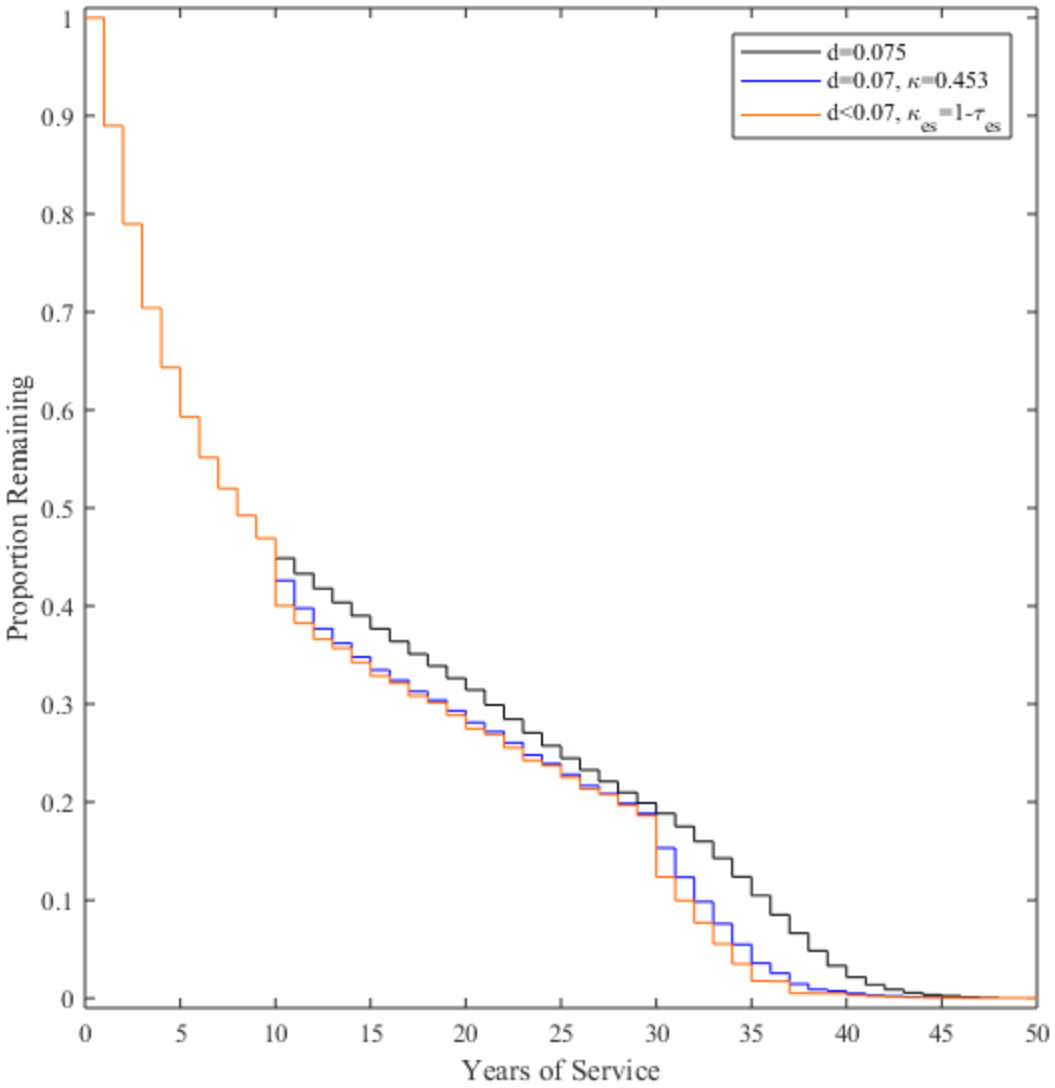

Figure 5: Survival Rates based on Limiting Positive Cross-Subsidies
Notes: Estimated using 2016 MTRS assumptions. The functions display the proportion of an entering cohort (for all possible entry ages) remaining based on years of service. Differences in lines reflect different discount rates and different additive deviations from assumed exit rates when teachers earning positive cross-subsidies are selected to leave at higher rates. All teachers earning positive cross-subsidies exit for the orange $d < 0.07$ line.

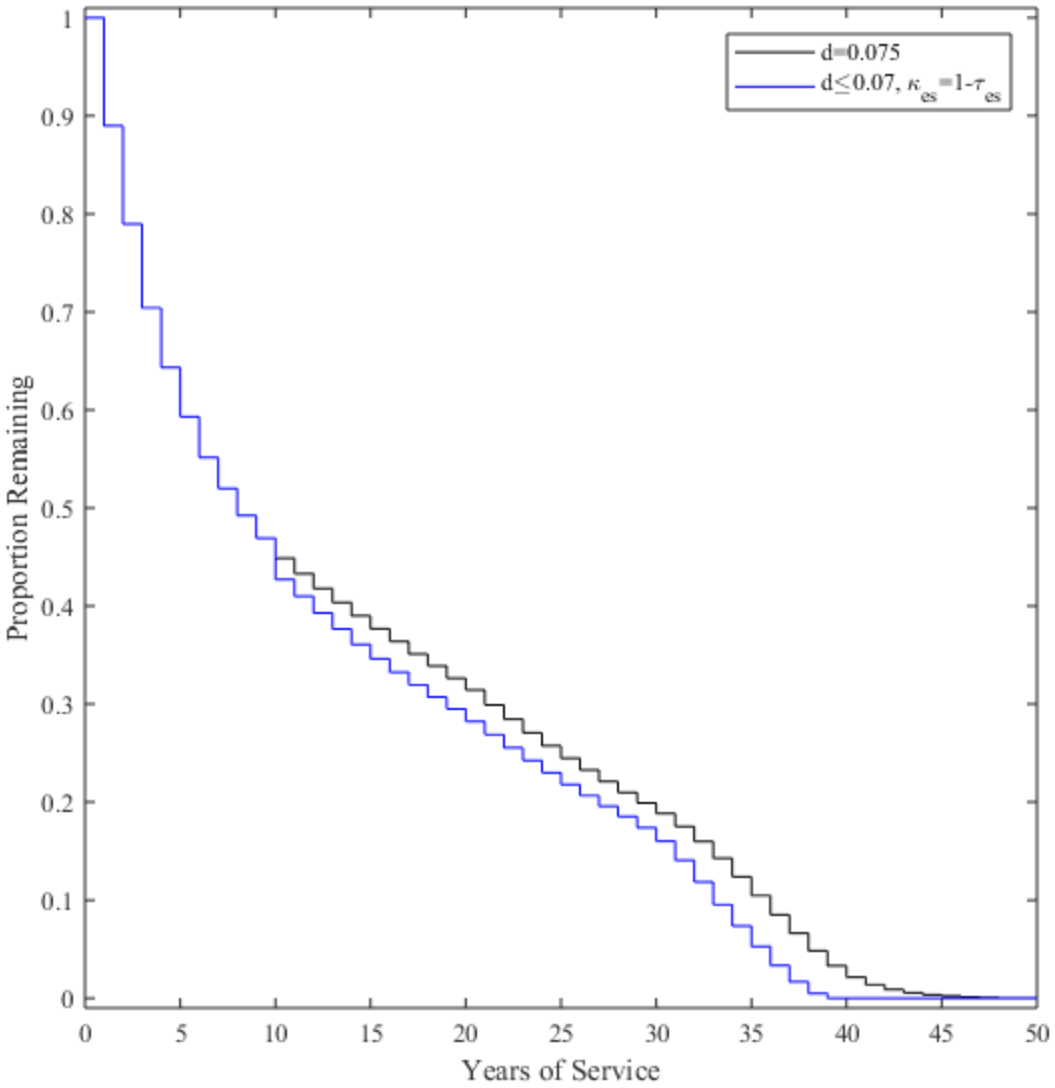

Figure 6: Survival Rates based on Retirement Eligibility
Notes: Estimated using 2016 MTRS assumptions. The functions display the proportion of an entering cohort (for all possible entry ages) remaining based on years of service. Differences in lines reflect different discount rates and different additive deviations from assumed exit rates when teachers eligible for retirement are selected to leave at higher rates. All teachers earning eligible to retire exit for the blue line.

Tables

Table 1: Deviations for Targeted Teacher Populations

d	κ	n_d^*	$n_{7.5}^* - n_d^*$	$n_{7.5,\kappa}^*$	$n_{7.5}^* - n_{7.5,\kappa}^*$
(1)	(2)	(3)	(4)	(5)	(6)
7.5%	-	11.87%	-	-	-
Panel A: Positive Cross-Subsidies					
7%	45.29	13.16%	-1.29	11.87%	0
6%	$1-\tau_{es}$	16.43%	-4.56	13.62%	-1.75
5%	$1-\tau_{es}$	20.90%	-9.03	17.33%	-5.47
4%	$1-\tau_{es}$	27.02%	-15.15	22.58%	-10.71
3%	$1-\tau_{es}$	35.35%	-23.48	29.91%	-18.04
Panel B: Retirement Eligible					
7%	$1-\tau_{es}$	13.16%	-1.29	12.10%	-0.23
6%	$1-\tau_{es}$	16.43%	-4.56	15.10%	-3.23
5%	$1-\tau_{es}$	20.90%	-9.03	19.25%	-7.38
4%	$1-\tau_{es}$	27.02%	-15.15	25.04%	-13.17
3%	$1-\tau_{es}$	35.35%	-23.48	33.05%	-21.19

Notes: Author's calculations. The uniform normal cost rate is the weighted average of all normal cost rates for all individuals in the system. The row with a discount rate of 7.5 percent shows the actuarially assumed discount rate and the corresponding uniform normal cost rate. The uniform normal cost rate is defined in equation (3). All deviations are the required additive constants that correspond with the uniform normal cost rate that is closest to the uniform normal cost rate obtained under the assumed 7.5 percent discount rate. Differences in column (4) are the differences between the uniform normal cost rate with a 7.5 percent discount rate and the uniform normal cost rate estimated under a lower discount rate. Differences in column (6) are the differences between the uniform normal cost rate with a 7.5 percent discount rate and the uniform normal cost rate estimated under a lower discount rate and the corresponding deviations. Deviations are approximated with numerical methods. Deviations equal to $1-\tau_{es}$ signify that all teachers meeting the selection criteria exit. Panel A selection criterion is if the teacher earns a positive cross-subsidy. Panel B selection criterion is if the teacher is at or above the retirement age.

Appendix A: Total Members and Entrants between ages 22 and 59

Appendix Table 1.1: Total Members and Entrants between ages 22 and 59.

Present Ages		**Members with 0-4 Years of Service**	**Estimated Entrants**
L_i	U_i	N_{L_i,U_i}	P_{L_i,U_i}
22	24	2,177	388
25	29	8,318	435
30	34	4,543	115
35	39	2,099	103
40	44	1,564	62
45	49	1,409	72
50	54	933	31
55	59	490	23

Notes: Present ages are the age range from PERAC (2016). Members with 0-4 Years of Service are the number of individuals in MTRS between the present ages. Author's calculations for estimated entrants using equation (7).

Chapter 3: Teachers' Preferences for Retirement: A National Stated Preferences Experiment[1]

Introduction

Teacher pensions in the United States are grossly underfunded with unfunded liabilities exceeding $600 billion, a total that is likely to increase in the coming years as plans use more conservative assumptions and make less risky investments (McGee, 2019; Novy-Marx & Rauh, 2011). As a result of these pension funding shortfalls, annual per pupil teacher retirement costs have nearly tripled since 2004, rising from $544 to $1,473, and now account for 11 percent of the total per pupil education expenditures (Costrell, 2019a). The soaring costs of pension benefits are straining education budgets and potentially crowding out other public expenditures including teachers' pay (Kim et al., 2020; McGee, 2016; Nation, 2018).

The vast majority of teachers participate in Final Average Salary Defined Benefit (FAS DB) retirement plans that guarantee retirement benefits at a level determined using years of service and salary at the end of teachers' careers. These plans have serious drawbacks for teachers and states' fiscal health. While FAS DB plans work well for teachers who work 30 years in a single retirement system (e.g. state), these plans often leave teachers in a retirement insecure position for much of their careers (Aldeman & Johnson, 2015). Typically embedded within these plans are strong incentives that are not always aligned with schools' labor market needs or teachers' desire to leave before or work after retirement eligibility (Costrell & Podgursky, 2009). These FAS DB plans are highly susceptible to underfunding; over 10 percent of current teachers' wages are set aside to pay for unfunded liabilities (Backes et al., 2016).[2] The

[1] This paper was coauthored with Josh McGee and Gema Zamarro.
[2] The portion of current teachers' wages being set aside is likely higher now than it was in 2016.

mounting disadvantages stemming from FAS DB plans pressure policymakers to address the retirement problem.

Defined Contribution (DC) and Cash Balance (CB) plans have become more popular as alternatives to FAS DB plans. DC plans, such as private sector 401(k) plans, rely on an employee's and an employer's contributions to the individual's retirement account and base benefits on how much money has accrued in the account. CB plans are a type of DB plan. CB plans guarantee a minimum return, but CB may exceed the minimum depending on the plan's actual return rate. Both DC and CB plans are more fiscally safe for states than FAS DB plans. Importantly, these FAS DB alternatives can be cost equivalent, given key plan assumptions, for retirement systems and generate comparable retirement benefits while reducing government cost uncertainty without exacerbating unfunded liabilities (Costrell, 2019b; Costrell & Podgursky, 2009; McGee & Winters, 2018).

Advocates of FAS DB plans argue that these plans function as recruitment and retention tools for schools to maintain a high-quality workforce (Boivie, 2011, 2017). However, FAS DB pension incentives to stay in the profession or to exit may not be aligned with teachers' true preferences (Costrell & Podgursky, 2009). In fact, recent theoretical evidence suggests that teachers might actually prefer alternative retirement plan designs that are less back-loaded and more current versus deferred compensation (McGee & Winters, 2018). Unfortunately, there is very little empirical evidence on teachers' preferences for retirement benefits to date.

For this paper, we designed and administered a 15-minute survey to a nationally representative sample of teachers from the RAND Corporation's American Teacher Panel. In this survey, we designed a discrete choice stated preferences experiment following work by Maestas et al. (2018) and Mas and Pallais (2017). Respondents were offered two jobs with

randomly selected salaries and a randomly chosen non-salary job attribute. We then model the choice between these two hypothetical jobs based on the differences between the two jobs' attributes and salaries to estimate respondents' willingness-to-pay for specific job conditions. We explore potential heterogeneity in preferences based on respondents' teaching experience, cognitive ability, and conscientiousness. Both cognitive ability and conscientiousness serve as proxies for teacher quality (Cheng & Zamarro, 2018; Hanushek et al., 2018).

This paper seeks to understand teachers' preferences for retirement and preferences for other working conditions. Although we are not the first to estimate preferences using survey methodology (e.g., DeArmond & Goldhaber, 2010; Horng, 2009; Johnson et al., 2012; Johnston, 2020; Ladd, 2011; Viano et al., 2019), the literature on teachers' preferences for retirement is severely limited; we only identified four studies. Two of these studies observed teachers' behavior to evaluate their preferences for retirement and found that teachers place a higher value on their current compensation than future compensation through retirement benefits (Biasi, 2019; Fitzpatrick, 2015).

Using a survey in Washington State, DeArmond and Goldhaber (2010) find that teachers prefer DC plans to FAS DB plans and that this preference was larger for teachers with less than 15 years of experience. Their survey question specifies that traditional pensions are DB plans and provide guaranteed benefits, while DC plans are similar to 401(k) or 403(b) plans and are more portable. Washington State uses a traditional FAS DB plan as well as a hybrid FAS DB/DC plan. It is reasonable to expect that early-career teachers may have a preference for the portability that DC plans afford. However, the preference for DC plans may be due to the fact that the state already has a DC component in its existing retirement plan, which allows teachers

to be more familiar with how DC plans operate for teachers compared to traditional FAS DB plans.

The only other survey work that estimates teachers' preferences for retirement and relates to this paper is Johnston (2020). Johnston estimates teachers' stated preferences and willingness-to-pay in a single school district outside Houston, TX, using a similar discrete choice experiment to this paper. Teachers in the school district choose between two hypothetical job offers where several job conditions randomly vary. Johnston's job conditions include salary, salary growth, retirement plan type, replacement rate, health insurance, and class size among a variety of other conditions. He finds that teachers are willing to pay for higher replacement rates, DC plans, lower health insurance premiums, and smaller class sizes. Less surprisingly, willingness-to-pay estimates for this Houston-area school district indicate that teachers would be indifferent between switching to a DC plan from a DB plan and a $900 raise. He does not find that experience mediates this preference.

Our main results indicate that teachers are willing to pay for a variety of non-salary job conditions with class size as the only exception. Teachers value FAS DB plans higher than they value alternative retirement plans. Experience explains some heterogeneity in willingness-to-pay for alternative retirement plans: early-career teachers are indifferent between FAS DB plans and either DC or CB plans. Additionally, we find that teachers with higher cognitive ability are willing to pay more for FAS DB plans. Respondents are willing to accept lower salaries if it means that they can retire with a benefit that replaces a larger portion of their final salaries or if they can retire at an earlier age. Willingness-to-pay for a higher annual salary growth rate exceeds willingness-to-pay for a higher replacement rate and this relationship is mediated by

cognitive ability. Teachers place large values on their health insurance and on enrollment in Social Security.

We make four key contributions to the literature. First, we anchor preferences in terms of changes in salary. Others have asked teachers for preferences in terms of which type of retirement plan teachers would invest in (DeArmond & Goldhaber, 2010). Second, we are the first to estimate teachers' preferences for CB plans. CB plans are growing in popularity among the United States with Kansas adopting the nation's first CB plan for new hires in 2009 (Costrell, 2019b). Third, we use a national sample of teachers rather than a sample limited to one state (DeArmond & Goldhaber, 2010) or locality (Johnston, 2020). Finally, we estimate preferences for a variety of job conditions. While Biasi (2019) and Fitzpatrick (2015) infer preferences for deferred and current compensation, they can only do so for a specific policy change. Our design is more flexible to varying several potential job conditions related to retirement.

The rest of this paper is organized into five sections. The next section characterizes our survey and RAND's American Teacher Panel. Then we develop our stated preferences experiment. The following section describes our econometric approach to estimating teachers' willingness-to-pay for job conditions. The results of our stated preferences experiment are in the following section. We conclude with implications for policy.

Data

We developed an approximately 15-minute survey focusing on teachers' knowledge of, preparation for, and preferences for retirement. We adapted questions from the 2018 Health and Retirement Study Retirement and Pension Plan module as well as the Retirement and Social Security module. The following section will go into greater detail regarding our retirement stated

preferences questions. The survey also included previously validated scales designed to measure financial literacy, personality, numeracy, and risk preferences.

We collect data from the RAND Corporation's nationally representative American Teacher Panel (ATP); survey administration was between February 10 and March 16, 2020. The ATP includes approximately 29,000 active respondents teaching in public K-12 schools. Teachers are recruited to the ATP using probabilistic sampling methods. The ATP drew a random sample of schools and purchased schools' rosters of teachers from a vendor before randomly sampling teachers within those schools to invite to participate in the panel (Robbins et al., 2018). For our study, we invited a total of 9,914 teachers and obtained a response rate of 52 percent. Our sample included both a nationally representative sample of teachers as well as samples representative of the following seven areas: Arkansas, California, Florida, Georgia, New York State, New York City, and Texas.

The final sample included 5,193 completed responses surveys. From these, we excluded respondents from our analytical sample if they reported earning salaries over $200,000, if they reported birthyears prior to 1935, if they had potential ages when entering the teaching workforce (age minus total experience) under age 20, or if they reported more experience within their current state of residence than they reported in total. Our analysis sample was 5,146 respondents. Respondents are compensated for their time at a rate of $1 per minute to complete the survey for a total of $15.

We use two validated measures for respondent's cognitive ability and level of conscientiousness, which are used to proxy for teacher quality (Cheng & Zamarro, 2018; Hanushek et al., 2018). To measure teachers' cognitive ability, we include the 8 item Lipkus Numeracy Scale (Lipkus et al., 2001) and the 5 item Cognitive Reflection Test (Frederick, 2005;

Toplak et al., 2014). Correct responses are counted to build two measures of cognitive ability, which we combine using a factor analysis with a varimax (orthogonal) rotation. We retain a single factor where both measures load equally. To measure how conscientious teachers are, our survey includes the 44 item Big 5 inventory for personality traits (John et al., 1991).[3] Responses to the Big 5 questions are on a 5-point Likert scale. We average responses to the 9 questions that capture conscientiousness to generate a single measure.

Table 1 contains descriptive statistics for our analytical sample. Over 75 percent of respondents are female. White teachers make up 83 percent of the sample while black and Hispanic teachers each comprise 8 percent of the sample. The average age of our respondents is 44 with a standard deviation of 10 and a half years. The age range of our sample is 24 to 81. On average, teachers had a total of 15.7 years of experience and 14.8 years of experience within their current state of residence. Using the average age and average total experience as benchmarks, the average teacher in our sample would have entered at age 29. Our sample has no first-year teachers but does have teachers teaching in a new state for the first time. Teachers average reported salary is approximately $63,000 and a standard deviation of approximately $22,000. We classify 44 percent of teachers as teaching in elementary schools and 56 percent in secondary schools. Respondents answered, on average, 4.5 of the 8 Lipkus Numeracy questions correctly. Respondents fared worse on the Cognitive Reflections Test with the average number of correct answers at 1.5 out of 5. On the 1 to 5 conscientiousness scale, respondents rated themselves as quite conscientious with an average value of 4.14. The standard deviation on self-reported conscientiousness is 0.55.

[3] The Big 5 inventory has been validated in a number of samples (John et al., 2008; John & Srivastava, 1999)

Stated Preferences Experiment

We use a discrete choice stated preferences experiment following Maestas et al. (2018) and Mas and Pallais (2017) to understand teachers' preferences concerning various job conditions. Stated preferences experiments, also sometimes called a conjoint analysis, originated in marketing but have spread to several other fields (Johnston, 2020). Part of the reason for their growing popularity is their success in predicting actual behavior (for example, see Hainmueller et al., 2015; Wiswall & Zafar, 2018; Wlömert & Eggers, 2016).

In our experiment, we provide teachers with two hypothetical job offers and ask them to indicate which job they prefer. Each job has eight conditions: salary, type of retirement plan, replacement rate[4], retirement age, annual salary growth, class size, health insurance coverage, and Social Security participation[5]. For each hypothetical job offer pair, salary and one other characteristic vary. Respondents are instructed to assume all other job conditions, either explicitly listed in the job offers or not included, are the same. Within each job condition, we chose baseline values that are either the midpoint of the potential values or the most common values that teachers are actually subject to. For example, the baseline value of retirement plan type is the most common teacher retirement plan: FAS DB. These baseline values make up the baseline job, which is always one of the two jobs offers and the other job contains the randomly varied condition.

We created a database of 108,000 hypothetical job offer comparisons for respondents.[6] Each respondent is presented and asked to choose between two randomly picked jobs eight

[4] A retiree's replacement rate is the ratio of the retiree's benefit to salary. It is the proportion of salary that benefits "replace." If a retiree earned $75,000 as a teacher, a 70 percent replacement rate would yield annual benefits of $52,500 (75,000*0.70).

[5] Approximately 60 percent of teachers participate in Social Security (Kan & Aldeman, 2014)

[6] We arrived at 108,000 hypothetical job comparisons by multiplying the 8 times a respondent would indicate a job preference times the 13,500 potential respondents. Since we sample from the database with replacement, we

times. Job offers presented to respondents are randomly chosen from our database with replacement, which allows for potential offers to be repeated in the sample. Respondents may be instructed to choose among the same conditions more than once and may not have to choose among other job conditions at all.

We use a four-step procedure to construct the hypothetical job offers presented to respondents by randomizing salary offers and one non-salary job conditions. We start by randomly generating two salary perturbations from a normal distribution with mean 1 and standard deviation 0.05. These perturbations are multiplied by the respondents' reported salaries to create the salary offers in our hypothetical job scenarios. Next, we randomly choose one of the seven possible non-salary job conditions where each job condition has the same likelihood of being selected. Then, we randomly pick one value corresponding with the selected job condition to vary from the job condition's baseline value. We then randomly pick whether the baseline job is offered as Job A or Job B and assign the relevant job condition values and salary perturbations. In the final step, salaries are assigned to teachers to prevent strictly dominating job offers. We assume that teachers would always select a job that corresponds with a higher salary and a larger replacement rate, earlier retirement, higher salary growth, smaller class sizes, or additional health insurance. For example, we would always expect respondents to choose the job that offers 8 percent annual salary growth and a $50,000 salary instead of the job that offers 5 percent annual salary growth and a $49,000 salary. Switching the salary offer forces a meaningful comparison about a respondent's willingness to pay for the extra 3 percentage points of salary growth. We have no prior expectation for one value for retirement plan type or for Social Security eligibility to strictly dominate in the same way that our other job condition values dominate.

increased the number of potential respondents beyond the number of teachers we sent the survey to in order to reduce the number of repeated hypothetical job comparisons.

Next, we create a table for the job offers and place the salaries in the corresponding job columns and fills in the baseline job offer column with the baseline job offer. The randomly selected job condition is filled in next with the randomly chosen condition value. The rows corresponding with the randomly selected job condition and salaries are shaded to increase visibility to respondents about how the job offers are different. Key differing text in the randomly selected job condition and the salary are bolded. The rest of the table is filled in with the baseline job offer. Figure 1 is an example of two job offers where both jobs are exactly the same other than the retirement ages and salaries.

When teachers in the sample do not provide their salary information, we use their state average teacher salary rounded to the nearest $10,000. State average teacher salaries are also used when respondents' reported salaries are under $10,000. If respondents do not indicate which state they teach in, we use the national average teacher salary instead. If class size is the job condition randomly selected, we either add or subtract 3 students from the state average school level class size rounded to the nearest integer.[7] Again, the national average school level class size is imputed if respondents do not indicate which state they teach in. Respondents leaving our question for the grades they teach blank or who indicate they teach elementary and secondary grades are assigned the average values corresponding to secondary schools. We obtain average teacher salaries and average class sizes information from the Digest of Education Statistics (Snyder et al., 2019).[8]

[7] We consider elementary teachers to be those who teach grade K-6 and secondary teachers to be those who teach grades 7-12.

[8] State average class sizes for the District of Columbia, Florida, Hawaii, Maryland, and Rhode Island are not reported due to a failure of reporting standards to be met. See Table 209.30 of the Digest of Education Statistics for additional information (Snyder et al., 2019).

Table 2 contains the wording for each job condition, the values corresponding to different job conditions, and additional notes describing which condition values are the baseline values. Bolded text in the condition wording column is the same bolded text that appears for respondents. The frequency that job conditions randomly vary between is in parentheses in the job condition column. The number of times that each job condition is randomly selected varies between 5,762 and 6,024. Baseline values for each job condition are noted in the potential values column. The frequency that each job condition value is displayed is in the fourth column. Within job condition, there is an approximately uniform distribution of the condition values.

The final column of table 2 shows the probability that respondents choose a job with a given job condition value. The most substantial threat to the validity of our experimental design is if respondents always choose jobs with the higher salaries, implying that the range of salary offers is too large, or that respondents never pick the job with the higher salary, suggesting that the range of salary offers is too small. The variation in respondents' choices across condition values indicates that the salary offers are neither too large nor too small. For job conditions with ordered condition values, we expect respondents to be more likely to choose jobs with more favorable condition values.

This choosing pattern is what we observe. Between 73 and 74 percent of respondents pick the job with a replacement rate within 3 percentage points of the 70 percent baseline value, while respondents were more hesitant to choose jobs with 60 or 62 percent replacement rates and much more likely to pick jobs with 78 or 80 percent replacement rates. About 73 of respondents choose jobs that lowered the retirement age by 3 years from the baseline retirement age at age 60 and 79 percent of respondents chose the job with a retirement age of 55. Respondents, however, were less likely to choose jobs that had retirement ages above the baseline: less than 60 percent

of respondents pick jobs with age 67 or 69 retirement ages. Between 62 and 67 percent of respondents opt for jobs that offered rates of salary growth under the 5 percent baseline value while between 82 and 86 percent of respondents select job offers with higher salary growth rates. Only 65 percent of respondents choose jobs with class sizes with three fewer expected pupils and 78 percent are willing to accept jobs with larger class sizes, suggesting that teachers do not value smaller class sizes very highly relative to salary. Jobs offering health insurance that covered 60 percent of healthcare costs are chosen over jobs that offer plans covering 80 percent of costs 62 percent of the time. 78 percent of respondents select jobs that offer dental and optical coverage instead of plans that do not offer these additional services. Jobs with retirement plans other than traditional final average salary defined benefit plans are more likely to be chosen and respondents prefer jobs without enrollment in Social Security.

Econometric Approach

The raw proportions of respondents choosing specific job conditions, presented above, gives us an overall idea of which job attributes teachers prefer, but it does not tell us how much teachers prefer those job attributes. Even though we force respondents to choose jobs at the expense of higher salaries, the simple proportions mask heterogeneity in the gap between the two salary offers. We cannot tell if teachers are picking jobs because they value the job conditions or if they pick because like the salary. Following the approach of Maestas et al. (2018), we estimate teachers' willingness-to-pay for the seven job conditions previously described.

We assume that teachers choose between a set of jobs based on a latent utility model where unobserved utility is a linear and additively separable function of the jobs' non-salary conditions and the jobs' corresponding salary:

$$U_{ijt} = \alpha + X'_{ijt}\beta + \delta \ln w_{ijt} + \varepsilon_{ijt} \quad (1)$$

where U_{ijt} is individual i's latent utility for job choice j in the individual's job choice set t. While teachers may weigh several job offers in job choice set t, our experiment restricts the set to only two jobs. Within choice sets, only one job condition and salary vary. Non-salary job conditions are X'_{ijt} and w_{ijt} is the salary. We use the natural logarithm of salary to facilitate interpretation of our effects as percent changes and since the salary offers in our experiment are tied to teachers' reported salaries and there is substantial heterogeneity in salaries across our national sample and within states due to salary schedules. We assume that ε_{ijt} is an Extreme Value Type I random variable.

We model the probability that an individual chooses job choice j over job choice k in choice set t as:

$$P(U_{ijt} > U_{ikt}) = \Lambda\left[(X'_{ijt} - X'_{ikt})\beta + \delta(\ln w_{ijt} - \ln w_{ikt})\right] \quad (2)$$

where $\Lambda[\cdot]$ denotes the cumulative logistic distribution. We should be able to identify β and δ in equation (2) since each non-salary job condition and salary is randomly selected. Despite our randomization, there could be other state level unobserved differences that are associated with the jobs that our respondents select. For example, most states use FAS DB plans, which may lead teachers to develop a preference for these plans. To account for these differences, we include state fixed effects. Preferences may also be dynamic based on how many job choices respondents have already made. For example, respondents may be willing to pay to retire at age 57, but the strength of that preference may differ if respondents have seen a previous job offer with an age 55 retirement age. To combat this type of bias, we also include question fixed effects in some models.

Consider a non-salary job condition c and the marginal utilities for this job condition, β^c, and salary, δ, identified in equation (2). For individual i, job offer j in choice set t that included

job condition c has expected utility $E(U_{ijt}) = \beta^c + \delta \ln w_{ijt}$ and job offer k in the same choice set that does not have the job condition has expected utility $E(U_{ikt}) = \delta \ln w_{ikt}$. An individual is indifferent between the two jobs when we fix the salary at w and subtract off the individual's willingness-to-pay for the job condition:

$$\delta \ln w = \beta^c + \delta \ln(w - WTP^c) \tag{3}$$

where the WTP^c is the willingness-to-pay for job condition c. We solve for WTP^c in equation (3) to derive our willingness-to-pay measure:

$$WTP^c = w\left[1 - \exp\left(-\frac{\beta^c}{\delta}\right)\right]. \tag{4}$$

We report willingness-to-pay estimates as $1 - \exp\left(-\frac{\beta^c}{\delta}\right)$ and interpret these effects as $100\left[1 - \exp\left(-\frac{\beta^c}{\delta}\right)\right]$ percent salary increases. We use the delta method to calculate standard errors in equation (4) and cluster the standard errors for each respondent. Statistical inference tests the null hypothesis that the willingness-to-pay estimates are different from zero; under this null hypothesis, respondents would be indifferent to the job condition.

We investigate heterogeneity in willingness-to-pay for job conditions based on respondents' experience, cognitive ability, and levels of conscientiousness. Cognitive ability and conscientiousness serve as proxy measures for teacher quality. To do so, we interact the differences in job conditions for a choice set with experience, cognitive ability, and conscientiousness in equation (2). Estimates of β^c these interaction terms would represent the differential effect of teachers' preferences for the job condition for teachers in the top or bottom quartile for these mediators relative to teachers in the second or third quartiles of the mediators' distributions. In order to translate this differential into a willingness-to-pay estimate, we add the interaction term to the reference group's preference in the numerator of the exponential in

equation (4). For example, the willingness-to-pay for an early-career teacher, denoted by the superscript e, for job condition c is $WTP^{ce} = w\left[1 - \exp\left(-\frac{\beta^{c}+\beta^{ce}}{\delta}\right)\right]$ where β^{ce} is the differential preference of the job condition for early-career teachers. We interpret this effect similarly to the overall effect.

Results

Table 3 contains our willingness-to-pay-estimates for the entire sample. These estimates are estimated using the non-linear transformation in equation (4) based on the estimates from the model described in equation (2). The first column is our base specification while the second column includes state fixed effect to control for any residual variation in preferences that could be correlated with respondents' state of residence retirement systems options. In column 3, we include question fixed effects to control for changes in willingness-to-pay as respondents answer more questions. Finally, column 4 includes both state and question fixed effects.

We prefer the fully specified model in column 4 since we expect heterogeneity across states and questions. In the absence of state fixed effects, we expect respondents' willingness-to-pay estimates to be larger and in favor of the state-offered plan since respondents are more accustomed to their plans. Willingness-to-pay estimates may be larger for the first stated preference questions than for the last questions while respondents are getting used to the set up and understanding the job conditions. The results when including either state or question fixed effects for plan type, health insurance and Social Security shrink toward zero relative to the results without either fixed effect, but this shrinkage is slightly larger when including state fixed effects rather than questions fixed effect. Results that include state fixed effects but exclude question fixed effects mirror results that account for the effects of states and questions. Overall results of this analysis indicate that respondents were willing to forgo current salary to remain in

their DB plans, higher replacement rates, earlier retirement ages, higher salary growth rates, smaller class sizes, more health insurance benefits, and to be enrolled in Social Security; all estimates are statistically different from zero at the 99 percent confidence level.

Respondents value their FAS DB plans more than they value alternative retirement plans. Overall, on average, respondents equate switching from a DB plan to a DC plan with a 3.7 percent pay cut in our base model (column 1) and a 2.8 percent pay cut in our fully specified model (column 4). This finding differs from previous literature that finds that teachers actually preferred DC plans to DB plans and were willing to pay for DC plans (DeArmond & Goldhaber, 2010; Johnston, 2020). Our divergence from previous literature could be partially explained by our sample's geographic diversity: DeArmond and Goldhaber (2010) use a sample of teachers in Washington State, which includes a DC component in their hybrid retirement system, while Johnston (2020) uses a sample of teachers from a single school district in Texas.

Respondents may be marginally more willing to switch to a CB plan from their FAS DB plan than they were willing to switch to a DC plan. Our results show that switching from an FAS DB plan to a CB plan is associated with a 3.5 percent decrease in salary in the base model (column 1) and a 2.6 percent decrease in salary in the fully specified model (column 4), similar to the results for changing to a DC plan described above. It is worth noting that when respondents have to pick between an FAS DB plan and an alternative plan, they are instructed that retirement benefits replace 70 percent of salary and that they can retire with full benefits at age 60 for both plans; the only differences are how the benefits are set and how risky benefits are for teachers. This means that respondents valued the way benefits accrue in an FAS DB plan more than the alternative plans or value the lower risk inherent to FAS DB plans above the riskier DC or CB plans.

Our estimates also show that teachers value higher replacement rates and earlier retirement ages. A one percentage point increase in replacement rate is equivalent to a 1.6 percent increase in salary. Since a one percentage point increase in replacement rate from the baseline of 70 percent to 71 percent is a 1.4 percent increase, teachers are indifferent between 1.4 percent increase in replacement rate and a 1.6 percent salary increase. Respondents are indifferent between lowering the retirement age by one year and a 2.5 percent salary increase. Willingness-to-pay for replacement rate and retirement age changes is not sensitive to the type of fixed effect that we include.

Teachers and teachers' unions commonly call on state and local policy makers to increase salaries and reduce class sizes (e.g., Weingarten, 2019a, 2019b), but there is a natural tradeoff here. Hiring additional teachers to reduce class sizes leaves less money in the budget to offer salary raises. We include salary growth rates and class sizes in our experiment to compare the magnitudes of teachers' preferences of these job conditions with preferences for retirement plan attributions and to quantify the tradeoff between salary growth and class sizes from teachers' perspectives. We estimate that teachers are willing to pay 5.8 percent of salary for a one percentage point increase in their annual salary growth rate and 0.4 percent of salary to decrease average class sizes by one student. Willingness-to-pay for a one percentage point increase salary growth is nearly four times as large as willingness-to-pay for a one percentage point increase replacement rate, but this preference may be unsurprising for two reasons. First, while both represent a form of deferred compensation, salary growth is less deferred than replacement rates. Second, higher salary growth rates also increase final average salary, which allows a lower replacement rate to replace a higher salary overall.

Finally, we include two health insurance components and Social Security in our experiment to compare retirement preferences with other non-salary compensation preferences. When faced with a health insurance plan that lowers the percent of health costs that insurance providers will cover from 80 percent to 60 percent, teachers require a 17.4 or 16.5 percent salary increase. Respondents are indifferent between a 10.1 percent raise in the base model and a health plan that includes dental and optical coverage. The willingness to pay in our fully specified model is 10.8 percent of salary. Respondents are also willing to pay 11.8 percent of salary in the base model and 10.9 in the fully specified model to be enrolled in Social Security. This willingness-to-pay exceeds the employer contribution to Social Security of 6.2 percent.

Willingness-to-pay Heterogeneity by Experience

We estimate willingness-to-pay distributions for teachers with differing levels of experience and present the results in table 4. These estimates are from our preferred specification and include state and question fixed effects. Column 1 shows the estimates for teachers in the first quartile of experience (less than 9 years), termed early-career teachers. Mid-career teachers are those teachers in the second and third experience quartiles with between 9 and 21 years of experience. Column 3 is for late-career teachers, which are the respondents with greater than 21 years of experience. All estimates in the table are transformed coefficients from the same logistic regression that interacts early- and late-career status with non-salary job components. We find that experience significantly mediates preferences for retirement plan type and several other job characteristics

Early- and mid-career teachers are willing to pay less than their more experienced counterparts for FAS DB plans relative to DC plans. Early-career teachers are indifferent between DB plans and DC plans and mid-career teachers value DC plans relative to DB plans at

2 percent of salary while late-career teachers are indifferent at 6.5 percent of salary. The difference in valuations between early- and late-career teachers is 6 percentage points and the difference between mid- and late career teachers is 4 percentage points; both of these differences are statistically significantly different than zero.

When it comes to CB plans, early- and mid-career teachers have weaker preferences for FAS DB plans over CB plans. Early-career teachers have no preference between CB and FAS DB plans; their statistically insignificant preference is actually for CB plans over FAS DB plans. Mid-career teachers are willing to pay 2.4 percent of salary and late-career teachers are willing to pay 6.4 percent of salary for an FAS DB plan over a CB plan. Just as was the case DC plans, late-career teachers have significantly stronger preferences than early- and mid-career teachers for FAS DB plans relative to CB; the early- late-career teacher willingness-to-pay difference is 6.7 percentage points and the mid- late-career teacher willingness-to-pay gap is 4 percentage points.

Gaps in willingness-to-pay between teachers with different experience are smaller for all other job characteristics. Early-career teachers have weaker preferences for earlier retirement ages and health insurance than mid-career teachers. Early-career teachers also display a smaller willingness-to-pay for earlier retirement ages and health insurance plans that cover larger shares of costs than late-career teachers. Respondents in the early-career category have 1.1 percentage point higher willingness-to-pay for a 1 percentage point increase in salary growth than late-career teachers We find no evidence of heterogeneity in willingness-to-pay for replacement rate, class size, and Social Security.

Willingness-to-pay Heterogeneity by Teacher Quality Proxy

Table 5 contains the willingness-to-pay estimates when cognitive ability, our proxy measure for teacher quality, is included as a mediating condition. The estimates in this table include state and question fixed effects. We group teachers by quartiles in our cognitive ability factor. Column 1 contains willingness-to-pay estimates for teachers in the first cognitive ability quartile, column 2 presents estimates for the second and third cognitive ability quartiles, and the third column has effects for the top quartile. With class size and Social Security as the only exceptions, cognitive ability significantly mediates our willingness-to-pay estimates.

We find significant heterogeneity in willingness-to-pay for retirement that cognitive ability explains. As cognitive ability increases, teachers' willingness-to-pay for alternative retirement plan types decreases. Teachers in the bottom cognitive ability quartile are indifferent between switching from FAS DB plans to either a DC or CB plan, while teachers in the top quartile value these plans at a 5.2 or 4.4 percent pay cut, respectively. Teachers displaying higher levels of cognitive ability are willing to pay for higher replacement rates and earlier retirement ages more than teachers in lower quartiles.

Cognitive ability also mediates willingness-to-pay for salary growth and health insurance. The most striking difference among any of these willingness-to-pay estimates is how much teachers in the top quartile are willing to pay for salary growth relative to teachers in the bottom cognitive ability quartile. Respondents in the top quartile are willing to pay 8.2 percent of salary for a one percentage point increase in salary growth whereas teachers in the bottom quartile are willing to pay 3.6 percent and teachers in the middle two quartiles are willing to pay 5.9 percent. Bottom quartile respondents are willing to pay less to prevent their health insurance from

covering a lower percentage of costs relative to respondents in the other three quartiles. Top quartile respondents value dental and optical coverage less than other respondents.

Table 6 presents estimates of willingness-to-pay mediated by conscientiousness, our second proxy measure for teacher quality. Again, we include state and question fixed effects. Column 1 includes estimates for the bottom quartile of self-reported conscientiousness using the Big 5 inventory. Column 2 includes estimates for the second and third quartiles of conscientiousness and column 3 is for the top quartile.

We fail to find much evidence of willingness-to-pay heterogeneity related to teachers' self-reported conscientiousness. Top quartile teachers have marginally stronger preferences for FAS DB plans relative to CB plans. Bottom quartile teachers also display weaker preferences for increases in replacement rate and lower retirement ages than teachers in the middle two quartiles, but there are no differences in willingness-to-pay for replacement rate and retirement age between bottom and top quartile teachers or between teachers in the middle two quartiles and the top quartile. Teachers in the top quartile of self-reported conscientiousness have weaker preferences for salary growth than all other teachers. High-conscientious teachers also have weaker preferences for class sizes than low-conscientious teachers. Teachers in the middle two quartiles have a stronger preference for Social Security than teachers in the bottom quartile.

Conclusion

Teacher pensions are dramatically underfunded in the aggregate (McGee, 2019; Novy-Marx & Rauh, 2011). In an effort to make up outstanding liabilities, these retirement funds are taking up larger sums of money than ever before (Costrell, 2019a), which squeezes state and local budgets (McGee, 2016; Nation, 2018). Even more, the traditional pension plans associated with underfunding do not work well for all teachers (Aldeman & Johnson, 2015; Backes et al.,

2016; Costrell & Podgursky, 2009). However, there are promising alternative retirement plans with fewer of drawbacks, but advocates for the status quo have stymied the progress of these substitute plans citing teachers' preferences for traditional final average salary defined benefit pensions.

This paper investigates teachers' preferences for retirement. We develop a stated preferences experiment that asks teachers to choose among jobs that offer different salaries and different non-salary job conditions. We embed our experiment into a nationally representative survey of public K-12 school teachers. We find that teachers are indifferent between a 2.8 and 2.6 percent pay cut and switching to an alternative retirement plan. This finding differs from other literature on teachers' retirement preferences that finds teachers prefer 401(k)-style plans to traditional pension, but the extant literature only measures preferences for a single school district or state (DeArmond & Goldhaber, 2010; Johnston, 2020). Corroborating previous literature, we find that early-career teachers place less value on traditional pensions relative to alternative plans than their more experienced counterparts.

We also show that teachers place sizable values on other job conditions. Teachers are willing to trade salary today if it means that retirement benefits will be larger or if they can retire at a younger age. They put even more importance on salary growth than on the size of their retirement benefits. Teachers are willing to pay for additional health insurance benefits and to be enrolled in Social Security. Respondents are not willing to pay very much for changes in their expected class sizes.

While our results are important for policy, there is one key limitation. Teachers stated preferences on a 15-minute survey may differ from their true or revealed preferences. There is a literature that finds that stated preferences experiments tend to match revealed preferences in

other populations (e.g., Hainmueller et al., 2015; Wiswall & Zafar, 2018; Wlömert & Eggers, 2016), but none of this previous literature has tested if teachers' stated preferences match their behavior.

The value that teachers are putting on alternative retirement plans is important for policy. Relative to FAS DB plans, teachers are willing to accept a smaller raise for a cash balance plan rather than a defined contribution plan, though this difference is not statistically significant. Teachers are indifferent between switching from a traditional pension plan to one of the alternatives and a 5 percent raise. The savings to the states if they were to switch to a defined contribution or cash balance plan would likely dwarf the salary increases. If states find it politically untenable to switch all current teachers from one retirement plan to another, we show that early-career teachers place little value on the type of retirement plan they have. States may be able to reform their retirement systems for all new hires and early-career teachers and receive less pushback.

Teachers' willingness-to-pay for other non-retirement plan job conditions is also noteworthy and generally larger than their willingness-to-pay for retirement plans. Teachers value 2 percentage point increases in their replacement rates at 3.2 percent of salary, which exceeds their willingness-to-pay for FAS DB plans over DC plans (2.8 percent) and CB plans (2.6 percent). Lowering the retirement age one year is associated with a 2.5 percent pay increase, which is just below the valuation on FAS DB plans relative to CB plans. Teachers value a half percentage point increase in their annual salary growth rate at 2.8 percent of salary, the same value that they have for FAS DB plans over DC plans. Teachers are willing to pay approximately 4 times as much for dental and optical insurance or to be enrolled in social security than they are for a specific retirement plan type. These findings indicate that teachers, while having a

preference for their retirement plan type, value other components of their compensation significantly higher.

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Figures

RAND AMERICAN TEACHER PANEL

Imagine you are offered two teaching jobs shown below. Except for the highlighted characteristic(s), please assume the jobs are the same in all other ways, including on characteristics not listed in the table.

Please review the jobs and indicate below whether you prefer Job A or Job B.

	Job A	Job B
Salary Growth	Salary grows by 5 percent annually.	Salary grows by 5 percent annually.
Type of Retirement Plan	The retirement plan bases benefits on a formula involving a person's age, years of service, and salary.	The retirement plan bases benefits on a formula involving a person's age, years of service, and salary.
Replacement Rate	A teacher who works a full career in the same retirement system earns retirement benefits that would provide a monthly check equivalent to 70 percent of their end-of-career salary.	A teacher who works a full career in the same retirement system earns retirement benefits that would provide a monthly check equivalent to 70 percent of their end-of-career salary.
Retirement Age	A teacher who works a full career in the same retirement system is eligible to receive benefits at **age 57**.	A teacher who works a full career in the same retirement system is eligible to receive benefits at **age 60**.
Class Size	Teachers have class sizes of approximately 18 students.	Teachers have class sizes of approximately 18 students.
Health Care	The health insurance plan would cover 80 percent of healthcare costs for the average person and provide catastrophic coverage.	The health insurance plan would cover 80 percent of healthcare costs for the average person and provide catastrophic coverage.
Social Security	Teachers contribute to and earn benefits in Social Security.	Teachers contribute to and earn benefits in Social Security.
Salary	**$98,279**	**$102,288**

○ Prefer Job A

○ Prefer Job B

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Figure 1: Example of Two Job Offers

Tables

Table 1: Sample Descriptive Statistics

	Mean	Std. Dev.	Minimum	Maximum
Female	0.77			
Hispanic	0.08			
White	0.83			
Black	0.08			
Asian	0.03			
Age	44.09	10.49	24	81
Total Experience	15.69	8.4	2	52
Experience in State	14.67	8.14	0	52
Salary	63377.28	22473.16	0	157000
Elementary School	0.44			
Secondary School	0.56			
Numerical Ability Score	4.48	1.76	0	8
Cognitive Reflection Test Score	1.76	1.53	0	5
Conscientiousness	4.14	0.55	1.78	5

Table 2: Job Conditions and Values

Job Condition	Condition Wording	Potential Values	Frequency Value Appears	Probability of Choosing Value
Retirement Plan Type (5,762)	The retirement plan bases benefits on **[value]**.	a formula involving a person's age, years of service, and salary	baseline	
		how much money has accumulated in a person's individual account from employee contributions, employer contributions, and investment returns	2,881	72%
		employee contributions, employer contributions, and investment returns with a minimum guarantee	2,881	70%
Replacement Rate (5,850)	A teacher who works a full career in the same retirement system earns retirement benefits that would provide a monthly check equivalent to **[X] percent** of their end-of-career salary.	60	779	64%
		62	752	64%
		65	760	71%
		67	767	73%
		70	baseline	
		73	661	74%
		75	673	79%
		78	695	85%
		80	763	83%
Retirement Age (5,780)	A teacher who works a full career in the same retirement system is eligible to receive benefits at **age [X]**.	55	992	79%
		57	938	73%
		60	Baseline	
		63	970	72%
		65	1,012	65%
		67	963	59%
		69	905	52%

Table 2 (Cont.)

Job Condition	Condition Wording	Potential Values	Frequency Value Appears	Probability of Choosing Value
Salary Growth (5,848)	Salary grows by **[X] percent** annually.	2	1,468	62%
		3.5	1,460	67%
		5	Baseline	
		6.5	1,446	82%
		8	1,474	86%
Class Size (5,962)	Teachers have class sizes of approximately **[X] students**.	-3	2,933	65%
		0	Baseline	
		+3	3,029	78%
Health Insurance (5,920)	The health insurance plan would cover **[X]** percent of healthcare costs for the average person and provide **[Y]**.	X = 60, Y = catastrophic coverage	2,961	62%
		X = 80, Y = catastrophic coverage	baseline	
		X = 80, Y = catastrophic coverage, dental, and optical	2,959	81%
Social Security (6,024)	Teachers **[value]** Social Security.	contribute to and earn benefits in	baseline	
		do not contribute to or earn benefits in	6,024	62%

Table 3: Willingness-to-Pay for Job Conditions

	WTP (1)	**WTP** (2)	**WTP** (3)	**WTP** (4)
Plan Type: DC rather than DB	-0.037*** (0.004)	-0.028*** (0.004)	-0.030*** (0.004)	-0.028*** (0.004)
Plan Type: CB rather than DB	-0.035*** (0.004)	-0.026*** (0.004)	-0.028*** (0.004)	-0.026*** (0.004)
Replacement Rate	0.016*** (0.000)	0.016*** (0.000)	0.016*** (0.000)	0.016*** (0.000)
Retirement Age	-0.025*** (0.001)	-0.025*** (0.001)	-0.025*** (0.001)	-0.025*** (0.001)
Salary Growth	0.058*** (0.001)	0.058*** (0.001)	0.058*** (0.001)	0.058*** (0.001)
Class Size	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)
Health Insurance: 60% rather than 80%	-0.174*** (0.005)	-0.165*** (0.005)	-0.166*** (0.005)	-0.165*** (0.005)
Health Insurance: add in Dental & Optical	0.101*** (0.003)	0.108*** (0.004)	0.107*** (0.004)	0.108*** (0.004)
Do not Enroll in Social Security	-0.118*** (0.004)	-0.109*** (0.004)	-0.111*** (0.004)	-0.109*** (0.004)
State FE		X		X
Question FE			X	X
N	41,522	41,490	41,522	41,490

Notes: Willingness-to-pay estimates from equation (4) based on results from logistic regression of the model in equation (2). Standard errors calculated using delta method with clustering by individual in parenthesis; *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Willingness-to-Pay for Job Conditions mediated by Experience

	Early-Career	**Mid-Career**	**Late-Career**
	(1)	(2)	(3)
Plan Type: DC rather than DB	-0.005 (0.007)	-0.020*** (0.006)	-0.065*** (0.008)
Plan Type: CB rather than DB	0.003 (0.007)	-0.024*** (0.006)	-0.064*** (0.009)
Replacement Rate	0.016*** (0.001)	0.015*** (0.001)	0.017*** (0.001)
Retirement Age	-0.023*** (0.001)	-0.025*** (0.001)	-0.027*** (0.001)
Salary Growth	0.063*** (0.003)	0.059*** (0.002)	0.052*** (0.002)
Class Size	-0.006*** (0.002)	-0.003** (0.001)	-0.004** (0.002)
Health Insurance: 60% rather than 80%	-0.146*** (0.009)	-0.170*** (0.008)	-0.175*** (0.010)
Health Insurance: add in Dental & Optical	0.100*** (0.006)	0.115*** (0.005)	0.105*** (0.006)
Do not Enroll in Social Security	-0.103*** (0.007)	-0.106*** (0.006)	-0.115*** (0.008)
Experience Range	0-8	9-21	22+

Notes: Willingness-to-pay estimates from equation (4) based on results from logistic regression of the model in equation (2). N=41,114. State and question fixed effects included. Standard errors calculated using delta method with clustering by individual in parenthesis; *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Willingness-to-Pay for Job Conditions mediated by Cognitive Ability

	Quartile 1	**Quartiles 2 & 3**	**Quartile 4**
	(1)	(2)	(3)
Plan Type: DC rather than DB	-0.011 (0.009)	-0.026*** (0.005)	-0.052*** (0.009)
Plan Type: CB rather than DB	-0.013 (0.009)	-0.023*** (0.006)	-0.044*** (0.009)
Replacement Rate	0.014*** (0.001)	0.016*** (0.001)	0.018*** (0.001)
Retirement Age	-0.020*** (0.001)	-0.026*** (0.001)	-0.025*** (0.001)
Salary Growth	0.036*** (0.002)	0.059*** (0.002)	0.082*** (0.003)
Class Size	-0.006*** (0.002)	-0.003** (0.001)	-0.005*** (0.002)
Health Insurance: 60% rather than 80%	-0.144*** (0.010)	-0.171*** (0.007)	-0.166*** (0.010)
Health Insurance: add in Dental & Optical	0.119*** (0.008)	0.111*** (0.005)	0.093*** (0.006)
Do not Enroll in Social Security	-0.105*** (0.008)	-0.112*** (0.005)	-0.104*** (0.007)

Notes: Willingness-to-pay estimates from equation (4) based on results from logistic regression of the model in equation (2). N=41,190. State and question fixed effects included. Respondents in quartile 1 are low-cognitive ability teachers, quartiles 2 and 3 are moderate-cognitive ability, quartile 4 is high-cognitive ability. Standard errors calculated using delta method with clustering by individual in parenthesis; *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Willingness-to-Pay for Job Conditions mediated by Conscientiousness

	Quartile 1	**Quartiles 2 & 3**	**Quartile 4**
	(1)	(2)	(3)
Plan Type: DC rather than DB	-0.034***	-0.024***	-0.032***
	(0.008)	(0.005)	(0.009)
Plan Type: CB rather than DB	-0.015*	-0.027***	-0.039***
	(0.008)	(0.006)	(0.009)
Replacement Rate	0.015***	0.016***	0.016***
	(0.001)	(0.001)	(0.001)
Retirement Age	-0.023***	-0.026***	-0.024***
	(0.001)	(0.001)	(0.001)
Salary Growth	0.060***	0.060***	0.053***
	(0.003)	(0.002)	(0.003)
Class Size	-0.007***	-0.003***	-0.002
	(0.002)	(0.001)	(0.002)
Health Insurance: 60% rather than 80%	-0.162***	-0.170***	-0.155***
	(0.010)	(0.007)	(0.010)
Health Insurance: add in Dental & Optical	0.114***	0.106***	0.108***
	(0.007)	(0.005)	(0.007)
Do not Enroll in Social Security	-0.097***	-0.113***	-0.113***
	(0.007)	(0.005)	(0.008)

Notes: Willingness-to-pay estimates from equation (4) based on results from logistic regression of the model in equation (2). N=41,190. State and question fixed effects included. Respondents in quartile 1 are low-conscientiousness teachers, quartiles 2 and 3 are moderate-conscientiousness, quartile 4 is high-conscientiousness. Standard errors calculated using delta method with clustering by individual in parenthesis; *** p<0.01, ** p<0.05, * p<0.1.

Conclusion

A robust body of evidence recognizes how important high-quality teachers are for students. High-quality teachers improve student achievement (Aaronson et al., 2007; Hanushek & Rivkin, 2010; Rivkin et al., 2005; Rockoff, 2004), facilitate the development of student non-cognitive skills (Jackson, 2018; Kraft, 2017), and significantly improve students' long-term outcomes (Chetty et al., 2014). The only persistent predictor of teacher quality is experience (Clotfelter et al., 2006; Harris & Sass, 2011; Papay & Kraft, 2015; Rivkin et al., 2005; Rockoff, 2004; Wiswall, 2013). Despite positive returns to experience, many teachers do not remain in the classroom long enough to reach their potential. Raising teacher salaries is one policy prescription often thought to increase teacher retention (Borman & Dowling, 2008; Imazeki, 2005). However, expenditures going to teacher pensions have risen drastically (Costrell, 2019), which has prevented teachers from receiving raises (Kim et al., 2020; McGee, 2016). The substantial rise in pension expenditures has largely been used to pay down unfunded accrued liabilities (McGee, 2019). This dissertation contributes to the knowledge of teacher turnover and teacher retirement.

In chapter 1, I explore the relationship between voluntary beginning teacher turnover and teachers' level of conscientiousness. I construct item non-response rates to proxy for conscientiousness using beginning teachers' responses on a long survey taken during their first year in the profession. A growing literature validates item non-response as a promising proxy measure for conscientiousness (Soland et al., 2019). Data from the Beginning Teacher Longitudinal Study reveals that teachers putting forward less effort on their surveys (i.e. less conscientious teachers) are less likely to leave their schools. I also show that as principal quality increases, teacher retention increases, but there is important heterogeneity related to the type of

teachers retained. Higher quality principals are less effective at retaining the teachers that put forward more effort (are more conscientious) on their surveys.

The results in this chapter are subject to two primary limitations. First, the Beginning Teacher Longitudinal Study does not include any direct measures of conscientiousness. Item non-response is only a proxy and as such it is a noisy measure and may be capturing other aspects of teachers' work unrelated to their levels of conscientiousness. It could be, for instance, that teachers who fill out their surveys are highly dissatisfied with their schools and vent their frustrations on the survey. To alleviate this concern, I construct a measure of teacher job satisfaction and find that, when controlling for this measure, teachers putting more effort on their surveys continue to be less likely to stay. Second, my aim is to study voluntary teacher turnover, which is self-reported on this survey. Teachers that were fired or transferred to another school against their desires may not want to admit this on a survey. However, conscientiousness is a skill that is associated with job performance (Barrick & Mount, 1991; Barrick & Zimmerman, 2009; Dalal, 2005; Hurtz & Donovan, 2000; Roberts et al., 2007), making it unlikely that conscientious teachers involuntarily exited their schools. If I include any teachers that did not voluntarily exit their schools, it is likely that these teachers are less conscientious and my estimates of the relationship between teacher turnover and conscientiousness would be a lower bound of the true effect.

The second chapter evaluates voluntary retirement incentive programs. It shows that teachers' exit rates from the Massachusetts Teachers' Retirement System would have to unrealistically increase in order to hold the cost of prefunding retirement benefits, termed the normal cost, constant when using a lower discount rate than the expected investment return rate. I consider two targeted policies that would only increase the probability that teachers exit if they

earn individual normal costs above the average normal cost or if teachers are eligible to retire. Both targeted policies struggle to accomplish the goal of keeping costs constant when using a discount rate of 6 percent or less. States would have to raise employee or employer contributions to make up for this difference. If states do not act, unfunded accrued liabilities will rise. I conclude this paper with a discussion about policy levers states could pull to increase teacher turnover and argue that paying out bonuses to retirees, increasing benefits, or allowing retirees to stay enrolled in the group health insurance plans would be insufficient to generate the required number of teacher exits.

This chapters' results are limited since I only model Massachusetts' Tier 2 retirement plan. Massachusetts' Tier 1 plan has slightly different plan parameters; this plan is a 3-year final average salary plan that gives teachers higher service factors than the 5-year final average salary Tier 2 plan. The Tier 1 plan has an earlier retirement age than the Tier 2 plan that I modeled. My decision to focus on the Tier 2 plan should yield a lower bound estimate of the uniform normal cost rate. Since the Tier 1 plan has a longer averaging period and larger age/service credits than the Tier 2 plan, the benefits associated with Tier 1 membership will be larger than Tier 2. Assumed teacher exit rates do not discriminate based on the plan teachers are enrolled in, thus it is unlikely that the different retirement ages among the two plans would bias my estimate of the uniform normal cost rate and my results. My estimates of deviations to assumed teacher exit rates for the targeted policies are at the greatest risk of being biased. Changes to assumed teacher turnover rates would be larger if the retirement age was the same in both plans, but it is unclear if more generous benefits in the Tier 1 plan would be offset as these teachers retire earlier and do not continue to accrue benefits. Further research should test to see how changing the retirement age affects the size of the deviations I estimate in this chapter.

Chapter 3 of this dissertation estimates teachers' willingness-to-pay for different job amenities. I find that teachers value their FAS DB plans at less than 3 percent of salary relative to DC or CB plans. Experience and teacher quality (proxied using cognitive ability measures) mediate this preference for FAS DB plans. Early-career and low-cognitive ability teachers are indifferent between FAS DB and alternative retirement plans while late-career and high-cognitive ability teachers value FAS DB plans. I find teachers have stronger preferences for the value of their retirement benefit, the age at which they are eligible for retirement, salary growth rate, health insurance, and Social Security than their employer-offered retirement plan type.

Results from the final chapter of this dissertation are limited since these preferences are revealed on survey and I lack measures of actual teacher behavior. Observing behavior may provide better information about teachers' preferences, but there is a growing literature that compares stated preferences estimates to respondents' behavioral estimates. This literature finds that stated preferences mirror revealed preferences in populations other than teachers (Hainmueller et al., 2015; Wiswall & Zafar, 2018; Wlömert & Eggers, 2016). Future research should evaluate how well the revealed preferences of teachers match their stated preferences.

Despite the limitations associated with the three chapters of this dissertation, the results presented here provide important lessons for policy. Chapter 1 concludes that retention of conscientious teachers needs to improve and that principals need to develop new strategies to improve retention of their conscientious teachers. Chapter 2 discourages policymakers from trying to reduce pension costs by inducing teacher turnover for four reasons. First, the required amount of teacher turnover would likely be damaging to the successful operation of schools. Second, increases in teacher turnover are not guaranteed to prevent the rise in unfunded liabilities. Third, mechanisms to create teacher turnover are unlikely to induce enough teachers

to leave. Fourth, inducing teacher turnover would prevent teachers from improving in quality with experience and would force experienced and effective teachers out of the classroom. Chapter 3 concludes that states would be able to reform their pensions to fiscally safer retirement plans if they compensate teachers with salary raises. States may choose to exclude experienced teachers that place sizable valuations on their FAS DB plans when moving teachers out of FAS DB plans and into new plans.

The results of all three chapters of this dissertation each provide policy implications that, at the most basic level, ask policymakers to stop and think. It encourages principals to try and retain effective teachers. It encourages state lawmakers to consider what other costs may be associated with producing teacher turnover. It encourages state lawmakers to be willing to pay teachers to enroll in alternative retirement plans. This dissertation also calls on policymakers to act before it is too late. Failure to act will only make matters worse for teachers and for their students.

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Institutional Review Board Approvals

Chapter 1

Office of Research Compliance
Institutional Review Board

September 21, 2017

MEMORANDUM

TO:	Gema Zamarro Rodriguez Kaitlin Anderson Dillon Fuchsman Elise Swanson
FROM:	Ro Windwalker IRB Coordinator
RE:	EXEMPT PROJECT CONTINUATION
IRB Protocol #:	16-10-146
Protocol Title:	*Character Assessment: New Methods of Measuring Noncognitive, Social, and Emotional Skills*
Review Type:	EXEMPT
New Approval Date:	09/21/2017

Your request to extend the referenced protocol has been approved by the IRB. We will no longer be requiring continuing reviews for exempt protocols.

If you wish to make any modifications in the approved protocol that may affect the level of risk to your participants, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 109 MLKG Building, 5-2208, or irb@uark.edu.

Chapter 3

UNIVERSITY OF ARKANSAS

To:	Gema Zamarro Rodriguez BELL 4188
From:	Douglas James Adams, Chair IRB Committee
Date:	05/20/2019
Action:	**Exemption Granted**
Action Date:	05/20/2019
Protocol #:	1904195290
Study Title:	What They Know and What They Want: A Survey of Teachers and their Retirement Systems

The above-referenced protocol has been determined to be exempt.

If you wish to make any modifications in the approved protocol that may affect the level of risk to your participants, you must seek approval prior to implementing those changes. All modifications must provide sufficient detail to assess the impact of the change.

If you have any questions or need any assistance from the IRB, please contact the IRB Coordinator at 109 MLKG Building, 5-2208, or irb@uark.edu.

cc: Joshua B McGee, Investigator
Dillon S Fuchsman, Investigator