Who Leaves and Who Stays: An Analysis of Teachers' Behavioral Response to Retirement Incentives

(Preliminary do not Quote)

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Abstract
In this paper we present an empirical investigation of teacher's behavioral response to the incentives embedded in the Arkansas Teacher Retirement System (ATRS) pension plan. In previous work we described the plan parameters, discussed the sharp incentives these parameters create, and then estimated the effect of pension wealth accrual on teacher separation decisions using a longitudinal dataset of Arkansas teachers. This paper extends this previous work by investigating the differential response of teachers to the pension plan parameters. We begin by developing a value-added model for teachers in Arkansas. We estimate a multilevel mixed model with random effects at the student level. Teacher quality is estimated at the school-by-grade level thus avoiding the difficulty of student sorting within a grade at a school. We then use our value added estimates to explore, both descriptively and econometrically, the possibility that teachers of different quality differ in their response to pension incentives. Defined benefit pension plans for teachers typically create strong incentives to work until reaching one's mid-50s, and then to retire not long afterwards, due to a spike in the accrual of pension wealth. The "pull" to stay in until reaching that spike and the "push" to leave shortly thereafter applies both to teachers of high and low quality. The overall effect of the pension system on teacher quality depends on who responds to these incentives, i.e. whether the response varies by quality. In this paper we provide a first examination of this question using data from the Arkansas Teacher Retirement System. In addition to exploring the differential effects of quality, our dataset also allows us to investigate the effect of other observable teacher characteristics including subject and grades taught. To our knowledge no one has yet explored the link between teacher quality and their behavioral response to pension incentives.

Key Words: pension, teacher retirement, defined benefit, cash balance, peak value, probit

1. Introduction

The structure of retirement benefits creates large incentives for the timing of teacher retirement decisions, through the pattern of pension wealth accrual. In previous work (Costrell 2010) we examined the magnitude of the teacher's behavioral response to these pension incentives, and found strong evidence that teachers respond in a significant way. The aim of this paper is to determine if there are differential responses to the pension incentives by quality.

There is a substantial labor economics literature discussing the effect of pensions on retirement decisions, surveyed in Section 4 of Friedberg and Turner (2010). This literature, primarily on private sector employees, established a consistent link between defined benefit (DB) pension accrual and retirement behavior (representative papers include Kotlikoff and Wise, 1987; Ippolito, 1997; Stock and Wise, 1990). It also found that the rise of DB plans reduced labor force participation of older workers (Kotlikoff and Wise, 1987), and, conversely, the decline of such plans (and conversion to defined contribution or cash balance) contributed to the rise of retirement ages since the 1980s (Friedberg and Webb, 2005).

There are several reasons why it is important to extend the prior literature to the public teacher retirement systems. First, it is sometimes asserted that teachers, after entering the profession primarily for non-pecuniary reasons, may also be unresponsive to pecuniary incentives for retirement.[1] Hence, it is worth examining the data to see if this is true. The teacher retirement system is also of special interest because the incentives embedded in these pension plans (like those in other public plans) are considerably more pronounced than those in private plans previously studied.[2] Thus, the impact of the system must be large, either on the behavior of teachers (if they respond to the incentives) or on the distribution of benefits (if they do not respond, but passively accept the penalties for not timing retirement to the incentives). A third reason to examine the teacher retirement system is the public interest in the composition of the teacher workforce; for example, we can test whether teachers are more or less likely to retire early given district, school, or even school by grade quality.

We begin by explaining the current configuration of the Arkansas teacher pension plan. We then turn our attention to the incentive structure the plan creates. We follow this with a brief description of how we measure quality, and then conclude with our empirical investigation.

2. The Arkansas Teacher Retirement Plan

Arkansas public school teachers are covered by a traditional DB pension system, the ATRS. Employees contribute 6 percent of their salary while employers contribute 14 percent,[3] for a total of 20 percent.[4] There was a period when an employee could choose to be non-contributory (with lower benefits), but since 1999 all new full-time employees have been contributory by requirement. Over the school years 2000-01 to 2007-08 -- the period covered by our data -- nearly 80 percent of teachers in Arkansas were

[1] If so, they would differ not only from private employees, but also Federal workers (see Asch, Haider, and Zissimopoulos, 2005).
[2] Costrell and Podgursky (2009, p. 193) find that spikes in teacher pension wealth accrual (like that depicted in Figure 2 below) dwarf those found in Kotlikoff's and Wise's exhaustive study of private pension accrual in the 1980s, typically by an order of magnitude.

contributory. For the remainder of this paper, we will focus our attention on the pension plan parameters for this group.

An ATRS member becomes vested after 5 years, entitling her to receive an annuity -- a regular retirement check for life -- upon reaching a certain age or length of service. She is eligible for "normal" retirement upon reaching age 60 or 28 years of service, drawing a pension equal to:

$$Standard\ Annuity = \$900 + 2.15\% * YOS * FAS, \tag{1}$$

where *YOS* denotes years of service and final average salary *(FAS)* is an average of the last 3 years. Thus, a teacher with 28 years of service would earn 60.2 percent of her final average salary plus $900. She can start drawing the pension earlier, after 25, 26, or 27 years of service, but with an adjustment of 85%, 90% or 95%, respectively. If a vested teacher were to separate from service prior to being eligible to receive the pension, the first draw would be deferred until she reached age 60. Once the pension draw begins, a 3 percent simple COLA applies.[5]

3. Accumulation of Pension Wealth

To demonstrate the powerful incentive effects of this system, we use the plan parameters to examine the way in which teachers accumulate pension wealth with each year of employment. Pension wealth is the expected present value of the stream of annual payments to which an individual is entitled upon retirement, a measure that can be readily determined using standard actuarial methods. Pension wealth not only reflects the size of annual payments -- a common, but incomplete measure of benefits. It also reflects how long these benefits are received, a variable of great significance.

Formally, consider an individual's pension wealth, PW, at some potential age of separation, As. The stream of expected payments may begin immediately, or may (perhaps must) be deferred until some later retirement age.[6] The present value of those payments is:

$$PW(A_s) = \sum_{A \geq A_s} (1+r)^{(A_s - A)} f(A \mid A_s) \cdot B(A \mid A_s), \tag{2}$$

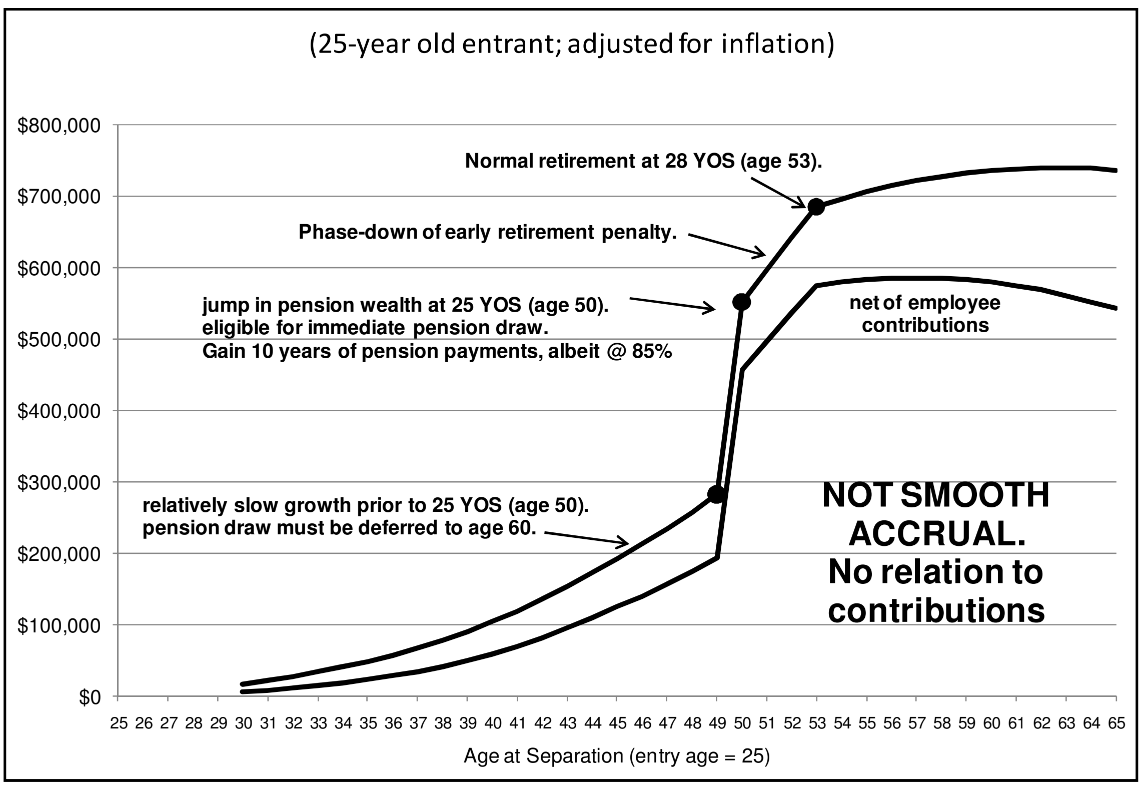
[3] This includes 5.7 percent for amortization of unfunded actuarial accrued liabilities, as of fiscal year 2009.
[4] Teachers in Arkansas are also covered by Social Security. Therefore, contributions to ATRS are in addition to the 12.4 percent combined employer-employee contribution to the Social Security system.
[5] Occasionally the legislature will enact a one-time compounding of the COLA.
[6] In Arkansas (unlike some other states), the best choice (to maximize present value) is simply to receive benefits as soon after separation as possible.

where B(A│As) is the defined benefit one will receive at age A, given that one has separated at age As, f(A│As) is the conditional probability of survival to that age, and r is the discount rate.

In principle, PW(As) represents the market value of the annuity. If, instead of providing a promise to pay annual benefits, the employer were to provide a lump sum of this magnitude upon separation, the employee could buy the same annuity on the market. Equivalently, one may think of the teacher's pension wealth, PW(As), as the size of the 401(k) balance that could be annuitized to match the pension she is due upon separation at age As.

Figure 1 depicts the pension wealth, in inflation-adjusted dollars, for a 25-year-old entrant to the Arkansas teaching force who works continuously until leaving service. The salary schedule assumed is that of the state capital (Little Rock), under which teachers receive annual step increases as well as lane increases as they move from a B.A. to a master's degree. The entire salary grid is assumed to increase at 2.5% inflation. We assume a 5% interest rate, and use the most current female mortality tables from the Centers for Disease Control and Prevention (U.S. Department of Health and Human Services (2007).

Figure 1: Pension Wealth at Age of Separation

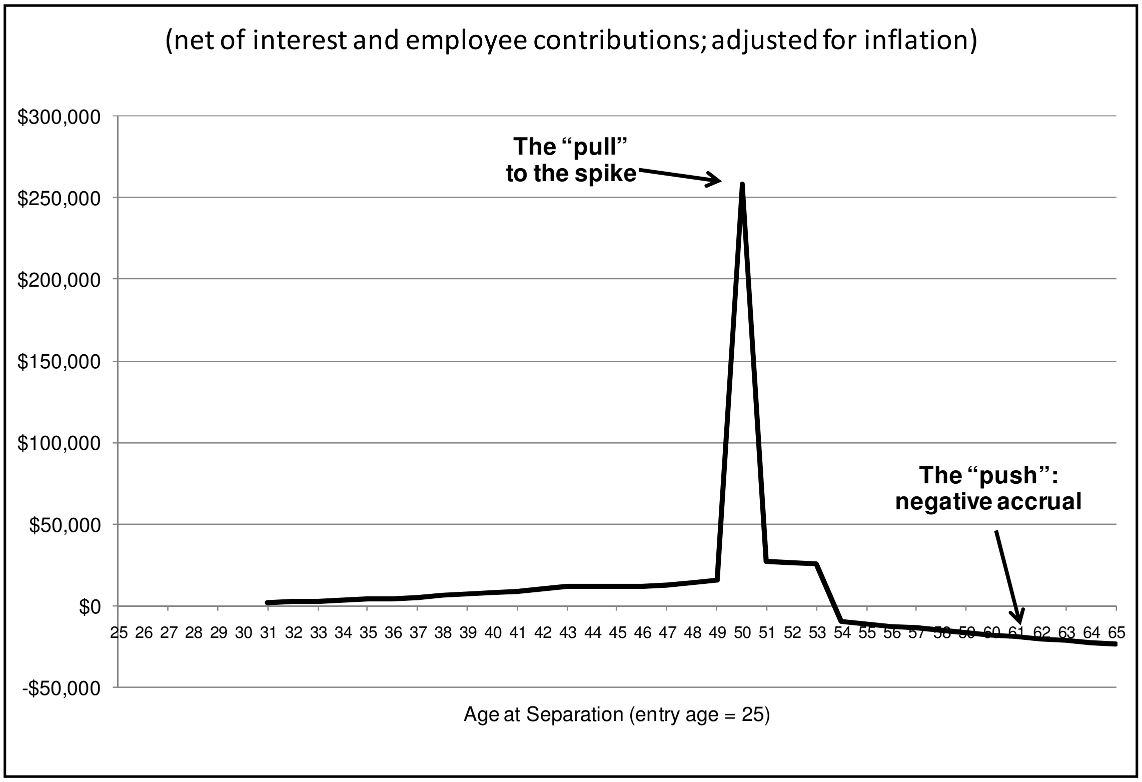


The accumulation of pension wealth is smooth and steady up to age 49, but not thereafter. During her first 24 years in the classroom, this teacher accumulates about $283,000 in pension wealth. Her pension wealth then jumps by $268,000 at age 50, upon completing her 25th YOS and becoming eligible for early retirement. The jump is due to the fact that she is now eligible for 10 extra years of pension benefits, beginning immediately, instead of deferring to age 60. Over the next three years, her pension wealth continues to grow rapidly, due to the phase-down of the early retirement penalty. After she reaches eligibility for normal retirement, at 28 YOS and age 53, the growth in her pension wealth levels off. The pattern for net pension wealth (netting out employee contributions, with interest) is similar.

A less forward-looking individual might simply look at the one-year accrual of pension wealth at each point in time. This is the difference between pension wealth one year from now, if one continues to work, and the pension wealth upon separation today, netting out the interest on current pension wealth. This is depicted in Figure 2. This is a measure of deferred income earned from an additional year of work, directly comparable to the salary earned in that year. This component of income rises gradually through the first 24 YOS, up to about $15,500 per year, net of employee contributions.[7] A particularly sharp spike occurs at age 50 (25th YOS for a 25-year-old entrant). In that year, our teacher would earn an increase in pension wealth of nearly $260,000 -- almost five times her salary -- before the rate of accrual drops off precipitously the next year. The reason, as discussed above in conjunction with Figure 1, is that she is now eligible for ten extra years of pension payments, since she qualifies for early retirement immediately after 25 YOS, instead of having to defer to age 60.

[7] The gross figures are about $3,000 higher -- they are not depicted here, since they are visually indistinguishable.

Figure 2: One Year Accrual of Pension Wealth



For service beyond this point, her first pension draw is immediate upon separation. For ages 51-53, the one-year accrual is about $27,000, effectively adding about 50% to salary. This is due to the phase-down of the penalty for early retirement over these years, from 15% to zero. Upon reaching 28 YOS, she qualifies for normal retirement, and beyond that point -- age 53 for a 25-year-old entrant -- her accrual turns negative each year, as shown in Figure 2. This is because the rise in annual pension does not outweigh the loss of a year's pension payment.

Figure 2's spike in pension wealth accrual at 25 YOS serves as a "pull" factor rewarding teachers who stay in service at least until that point. The negative accrual after 28 YOS serves as a "push" factor, discouraging those who stay longer.

4. Longitudinal Separation Data

In the previous section we discussed the incentives created by the pension parameters in Arkansas. Our empirical analysis relies on longitudinal teacher records, provided by the Arkansas Department of Education (ADE) and linked to the ATRS data discussed above. The ADE data are observations on all teachers working in the state from the 2000-01 school year through the 2007-08 school year. These data provide us with the opportunity to look at separations from teaching that may precede formal retirement (i.e. the collection of a pension), as would occur for those who separate prior to meeting the YOS requirement and must defer the pension until meeting the age requirement. These longitudinal employment records allow us to consider separation probabilities from the front end, from entry on forward, which is useful for labor market analysis. These data are well suited to regression analysis to estimate the effect of pension wealth accrual on the separation decisions of teachers.

Specifically, we used the ADE data for our eight-year panel on working teachers, linked to the ATRS data, to construct a series of person-year observations with an indicator variable for whether the teacher is working or separated from service. A teacher was considered to have separated in the year after her last working record, or if ATRS records her as retired. Table 1 provides a summary of the data. There are 36,657 teachers covered over this period, for a total of 209,721 observations, of which 8,194 were separations. The demographic composition is 80.5% female and 89.6% white, with mean age 42.4 and 12.2 YOS. (The pension accrual variables in Table 1 will be defined below.)

Table 1: Summary Statistics on Longitudinal Data Set

Variable	**All**	**Small Sample**	
Number of Teachers	36,657		
Number of Separations	8,194		
Number of Records	209,721		
Variable	**Grand Mean**	**Min**	**Max**
Female	80.5%	-	-
White	89.6%	-	-
Age	42.4	20	81
Service	12.2	0	46
One Year Accrual	$14,077	-$51,471	$379,176
5yr Peak Value	$72,376	$0	$535,713
Pension Wealth	$182,634	$0	$1,094,521
Earnings	$47,301	$32,385	$57,202

In addition to data on teachers we also have access to a rich dataset containing information on districts, schools, and individual students. This dataset, provided by the ADE, contains both achievement and demographic information for the universe of students in Arkansas and extends from the 2001-02 school year through the 2008-09 school year. Arkansas testing regiment tests all students in the third through eighth grades in both English Language Arts (ELA) and Mathematics. The full testing regiment was in place by the 2004-05 school year, so we have the ability to generate estimates of quality from 2005 forward.

5. Estimating Quality

This section presents our empirical methodology for estimating district, school, and school-by-grade quality. Since Hanushek(1971) provided evidence that none of the readily observable characteristics of teachers (experience, degrees, certification, etc...) explain much of the variation in educational outcomes, social scientists have been focused on educational output and the estimation of education production functions. These value added models attempt to estimate the contribution of individual districts schools and teachers to student achievement. While many value added specifications have been employed in the literature, we follow the model presented by Todd and Wolpin(2003) and subsequently used by Sass(2006). In the standard education production function student achievement, *Y*, of student i with teacher *j* in school *k* at time *t* is expressed as a function of cumulative own/family inputs, *X*, cumulative schooling inputs, *S*, individual time invariant characteristics (i.e. ability), μ, and an error term:

$$Y_{ijkt} = Y_i[X_i(t), S_i(t), \mu_i, \varepsilon_{it}]. \quad (3)$$

If we assume that this cumulative education production function is additively separable and that the impact of an input does not vary with age, this function can be expanded as follows:

$$Y_{ijkt} = \beta \sum_t X_{it} + \gamma \sum_t S_{ijkt} + \varepsilon_{ijkt}. \quad (4)$$

Estimating equation 2 puts an overwhelming informational burden on the researcher. The researcher would need a complete set of variables representing the student's schooling history and own inputs. In the absence of a complete set of own and school observables, the estimated coefficients would surely be biased by omitted variables. This difficulty has led researchers to seek alternative estimation strategies.

The empirical model we use for this paper is a parsimonious specification of the value added model which takes advantage of multiple test score observations for individual students. This model takes the general form:

$$Y_{ijkt} = \alpha \boldsymbol{Y}_{i,t-1} + \beta_1 \boldsymbol{X}_{it} + \beta_2 \boldsymbol{S}_{ijkt} + \theta_i + \rho_k + \tau_j + \varepsilon_{ijkt} \quad (5)$$

where $Y_{i,t-1}$ represents the students test score history, X includes individual level controls, S includes school level controls, τ represents the value added of the district/school/school-by-grade j, and θ, ρ, and ε represent the unobserved impact of individuals, schools, and random error. A model of this type has been used in the literature on several occasions including Aaronson(2007), Hanushek(2005), Rivkin(2005), and Rockoff(2004).

In the general model specification above we include a student fixed effect term θ, however we drop this term in our specific estimating equations below. If we included student fixed effects, it would greatly decrease the statistical power of our quality estimates, and lead to bias by identifying the quality estimates on the performance of switchers. Ballou(2004) provides evidence that the inclusion of previous test performance sufficiently controls for the omitted own and school histories.

The specific model we estimate includes a two year test score history in both ELA and Mathematics on the right-hand-side of both subject's regression equations. The appendix contains tables that detail the coefficient estimates and significance levels from our value added regressions. The models take the following form (for concision I drop some subscripts):

$$\boldsymbol{Y_{Math,t} = \beta_1 Y_{Math,t-1} + \beta_2 Y_{Math,t-2} + \beta_3 Y_{ELA,t-1} + \beta_4 Y_{ELA,t-2} + \rho + \gamma_{Math,j} + \varepsilon} \qquad (2)$$

$$\boldsymbol{Y_{ELA,t} = \beta_1 Y_{ELA,t-1} + \beta_2 Y_{ELA,t-2} + \beta_3 Y_{Math,t-1} + \beta_4 Y_{Math,t-2} + \rho + \gamma_{ELA,j} + \varepsilon} \qquad (3)$$

We estimate these regression equations using two years of testing data (i.e. a school's 2006 quality estimate is based on testing data from 2005 and 2006). This technique essentially averages the schools quality estimate across the two years. There are two advantages of estimating our model in this way.

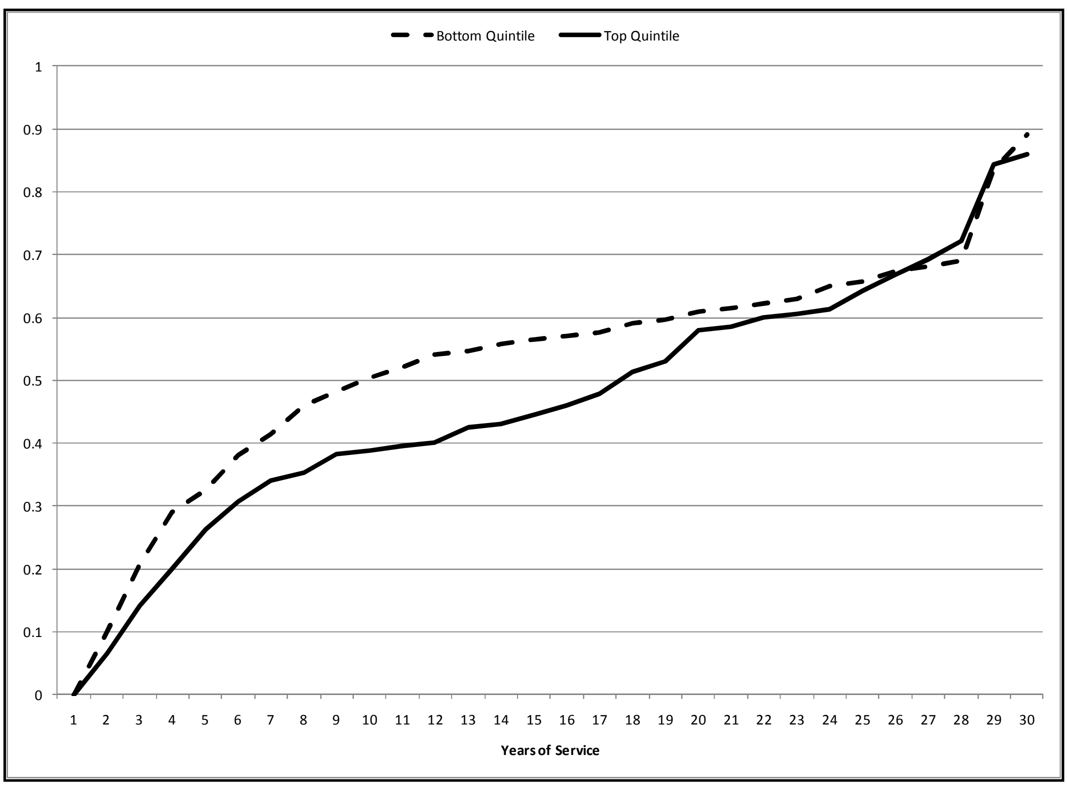
1. It will increase statistical power by increasing the number of observations per school.
2. It will increase the reliability of the estimates by focusing on the intertemporally stable portion of school value added.

One limitation of our data is that it does not allow us to place teachers and students in individual classrooms. Therefore, I will have to aggregate to the grade level within schools. While this is not ideal, aggregating to the grade level does eliminate the problems resulting from any of sorting of students between teachers within a grade based on unobservable highlighted by Rothstein(2008 and 2009).

We estimate quality using a random effects estimator in separate regressions for the district, school, and school-by-grade levels. The resulting quality estimates are distributed normally with a mean of zero, $\mathrm{N}(0, \sigma_\gamma^2)$. For the purposes of this paper we want a single estimate of quality across subjects, so we average the quality estimates from the math and ELA regressions at each level of aggregation. Further, we will concentrate our analysis on the top and bottom of the quality distribution. We divide average quality into quintiles and create a dummy variable for each quintile at the district, school, and school by grade levels.

To gain a first look at the differing separation rates by quality we use the raw separation rates observed in the data to estimate the separation rates for an entering cohort. The conditional exit rate for each YOS is estimated as the number of separations divided by working teachers. These conditional exit rates are applied sequentially to the declining cohort survivor rate to generate the frequency distribution. We disaggregate these separation rates for the top and bottom quintiles of quality. Figure 3 displays the cumulative distribution of the estimated separation probabilities for school-by-grade quality. Analogous figures for school and district quality are included in the appendix. Figure 3 clearly illustrates a difference in the separation rates of the top and bottom quintiles of quality. Similar patterns are present in the figures for school and district quality. Descriptively it appears that the bottom quintile exhibits higher separations rates in the first few years on the job, but lower separation rates mid career.

Figure 3: Separation Probabilities by School x Grade Quality



6. Empirical Methodology

In this section we present the empirical method used to estimate the impact of pension plan parameters on teacher retirement/separation decisions. Pension plan parameters affect retirement decisions through two main pathways. The first, and primary one, is through accrual effects -- the subject of our previous analysis. Individuals weigh the additional pension wealth to be gained through additional years of work against the value of additional years of retirement, so larger accrual would be expected to induce later retirement. A second possible pathway is wealth effects. Higher pension wealth will increase the ability to consume in retirement and therefore would be expected to induce individuals to retire earlier.

The model we chose is known as the "peak value" model, presented by Coile and Gruber (2000a and 2000b). It is a forward-looking approach that has been used several times in the literature including Friedberg and Webb (2005) and Coile and Gruber (2007).[8] Specifically, we focus on two main variables that model different aspects of the accrual effect.

The first variable of interest is "peak value" (PKV). Peak value is defined as the difference between current pension wealth and the maximum present value of future pension wealth across all possible future separation dates.[9] Formally, peak value is defined as follows:

Let:
PW_t $denote\ pension\ wealth\ in\ year\ t$
PW_m $denote\ the\ maximum\ present\ value\ PW\ occuring\ in\ future\ year\ m,$
$evaluated\ at\ year\ t$:

$$PW_m = \max_k \left[\frac{PW_k}{(1+r)^{k-t}}\right] \ \forall\ \mathrm{k} > t$$

$Then\ PKV_t\ denotes\ peak\ value\ in\ year\ t$:

$$PKV_t = \max\,(0, PW_m - PW_t) \qquad (3)$$

Peak value represents the incentive a worker has to continue working. It measures the maximum accrual a teacher can attain if she continues to work until her pension wealth is maximized. When a teacher has reached her maximum present value of pension wealth, peak value reaches zero.

The results we present below employ a peak value variable modified to impose a finite horizon, specifically 5 years. In practice this makes little difference to our estimates, and in fact slightly improves

[8] Asch, Haider, and Zissimopoulos (2005) point to an earlier literature on retention of military and Federal civil service workers that uses "annualized cost of leaving" models. Others have used "option value" models (Stock and Wise (1990)), which require one to specify a utility function over work and leisure.

[9] The term "peak value" is potentially confusing, since it more accurately describes the maximum future wealth than the difference between that and current wealth. However, we follow conventional usage here.

the log likelihood of our estimates, consistent with the idea that horizons may in fact be limited.[10] More importantly, for our simulations later in the paper, a constant accrual pension system does not exhibit a peak value over an unlimited horizon. Imposing a finite horizon to allow for such simulations does not distort the estimations reported here.

It is likely that workers, in addition to considering the maximum pension wealth they could attain (over a 5-year horizon), are also influenced by the immediate future. We include one year accrual (OYA) in our model to capture this single year effect. OYA is similar to peak value, but only looks forward one year. OYA was discussed above and is depicted in Figure 2 for a 25-year-old entrant. One advantage of including this variable is that it allows for a disincentive to work. In years after a teacher has reached her maximum pension wealth, peak value takes on a value of zero while OYA becomes negative. OYA captures the fact that forgoing a year of pension is costly. One can think of peak value representing a pull effect, in the years prior to the pension wealth peak, and OYA representing a push effect immediately afterwards. In addition to these two pension accrual variables, we include pension wealth itself (PW), as discussed above, and earnings to capture the direct incentive to continue working.[11]

Our dependent variable is a dichotomous indicator, valued at one for separation or retirement, and zero for continued work. As discussed in notes above, we have calculated 1-year separation rates. The 1-year separation rates accurately represent early-career attrition rates, but also include breaks in service. By focusing on 1-year separation rates, instead of say 5-year separation rates, we will be conservatively estimating the impact of pension parameters on separations.

We use a probit specification of the following form:

$$\Pr(\text{separate} = 1)_{it} = \Phi(\beta_0 + \beta_1\,\text{OYA}_{it} + \beta_2\,\text{PKV}_{it} + \beta_3\,\text{PW}_{it} + \beta_4\,\text{X}_{it} + \beta_5\text{D}_{it} + v_i) \qquad (4)$$

where $\Phi(.)$ is the cumulative normal distribution, X_{it} includes teacher level explanatory variables for teacher i at time t, including earnings, race, gender, age, service, and ultimate T-DROP status, while D_{it} denotes district level variables for that teacher, and v_i represents the individual teacher random effects which are individually and identically distributed $N(0,\sigma_v^2)$. All dollar valued variables are in millions of 2008 dollars.

We include our quality quintile dummy variables in the regression specification above to estimate the direct effect of quality on separation probabilities. Additionally, we are interested in any differential

[10] The 5-year horizon also generates a slightly better log likelihood than a 10-year horizon, which in turn is better than with an infinite horizon.

[11] Our data set does not include some other relevant variables, such as spousal earnings and non-pension wealth.

response to the pension accrual variables by quality. We model these differential effects by including the interaction between our quality quintile dummies and the pension accrual variables.

7. Pension Accrual Effects

In this section we present results from our regression analysis. Our overall sample includes all contributory teachers who worked in the state of Arkansas from 2000-01 through 2007-08. We have 209,721 observations on 36,657 individual teachers with an average of 5.7 observations per teacher over the 8 year study period. The dataset that includes quality is limited to the five years between 2003-2004 and 2007-2008 due to the availability of testing data. For this smaller dataset, we have 73,594 observations on 21,942 individual teachers with an average of 3.4 observations per teacher. The dependent variable was assigned a value of one for observations one year after a teacher's last working record. There were 8,194 separations in the larger 8 year study period,[12] and there were 3,291 separations over the smaller 5 year study period. The values of the independent variables are summarized in Table 1 for the larger 8 year period.

We estimated the model with random effects at the individual level, under various specifications. Table 2 presents the estimated coefficient values with standard errors. All regressions also include a constant, age, age^2, and a service spline variable with 5 year increments. Column (1) Presents the baseline specification estimated using the larger 8 year data set. Column (2) presents the same model estimated over the smaller 5 year period. Columns (3)-(5) present the coefficient estimates from models that include school-by-grade, school, and district effects respectively.

The two accrual variables and earnings have negative effects, as expected, and are stable in magnitude across all specifications. Current pension wealth has the unexpected sign, a result we consider spurious. Prior literature has found the effect of pension wealth to be "economically quite small" and that is the case here, too.[13]

All specifications include an intercept term indicating participation in the T-Drop program. T-Drop ("Teacher Deferred Retirement Option Plan") is a provision that allows for re-employment after retirement. Under this plan, a teacher with 28 or more YOS can keep working after "retirement" for up to ten years, with 60-70% (depending on the YOS at which she enters T-DROP) of her pension check going into an interest-bearing retirement account. When she actually leaves teaching, she receives the amount accumulated in her account and begins to collect 100% of her pension check. For pension calculation purposes, her final average salary is frozen at the time she enters T-DROP, except for the annual COLA.

[12] The number of 5-year separations was much lower, 4,580.
[13] Friedberg and Webb (2005, p. 296), who cite similar findings in Coile and Gruber (2000b) and Samwick (1998).

She makes no contributions to ATRS after entering T-DROP. For those who choose to work beyond 28 years, T-DROP is clearly advantageous and many Arkansas teachers avail themselves of this program. In larger data set, approximately 10 percent of contributory members are in T-DROP.

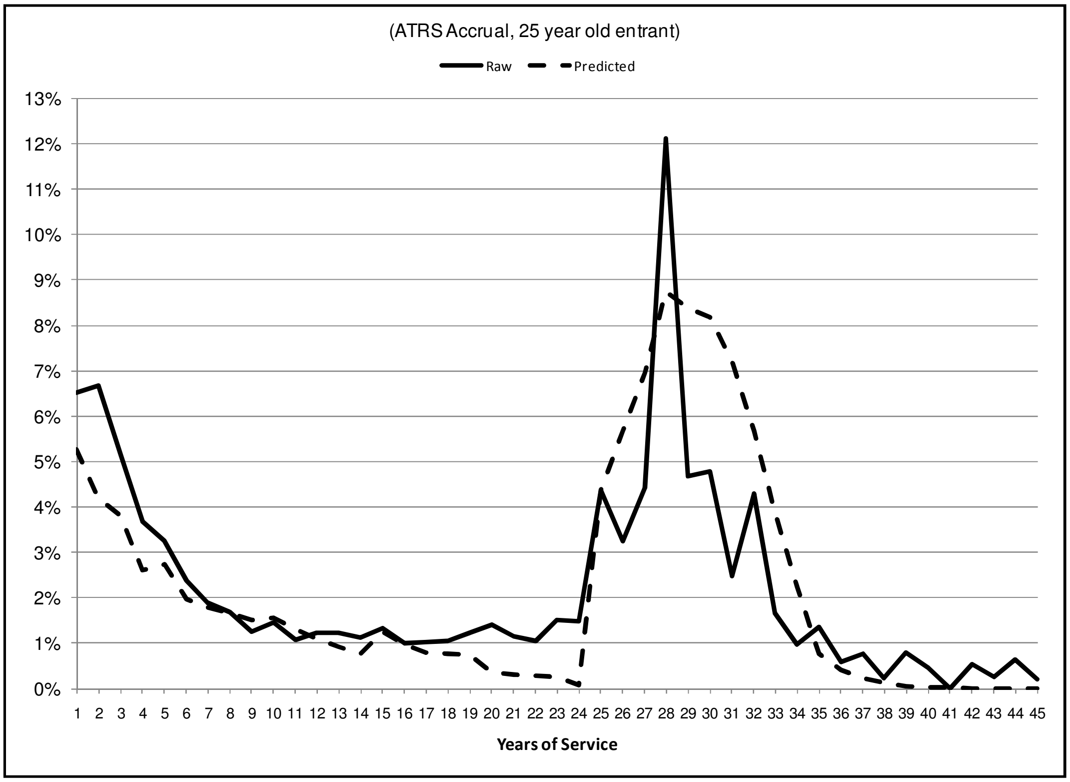
Table 2: Coefficient Estimates

Variable	(1)[14]	(2)	(3)	(4)	(5)
One Year Accrual ($10,000)	-0.0193*** (0.0043)	-0.0253*** (0.0074)	-0.1160*** (0.0370)	-0.0891*** (0.0276)	-0.0818*** (0.0266)
Peak Value ($10,000)	-0.0325*** (0.0019)	-0.0353*** (0.0030)	-0.0249*** (0.0092)	-0.0368*** (0.0080)	-0.0292*** (0.0070)
Pension Wealth ($10,000)	-0.0055*** (0.0013)	-0.0093*** (0.0020)	-0.0124*** (0.0044)	-0.0121*** (0.0032)	-0.0119*** (0.0029)
Earnings ($1,000)	-0.0636*** (0.0041)	-0.0534*** (0.0063)	-0.0689*** (0.0140)	-0.0495*** (0.0103)	-0.0479*** (0.0093)
T-Drop	-0.9803*** (0.0264)	-0.9116*** (0.0416)	-0.7250*** (0.0937)	-0.7065*** (0.0676)	-0.7132*** (0.0568)
Female	-0.0169 (0.0136)	0.0297 (0.0216)	0.0581** (0.0369)	0.0304 (0.0295)	0.0678 (0.0271)
White	0.0011 (0.0173)	0.0336 (0.0265)	-0.0077 (0.0511)	0.0082 (0.0385)	0.0316 (0.0333)
Log-Likelihood	-31,136	-13,810	-3,639	-6,766	-9,319
Observations	209,721	128,973	18,913	36,448	53,066

Do the pension variables explain the observed spike in separations? To answer this question Figure 3 compares the separation rates observed in the data to those predicted by our regression equation. The dashed line in Figure 3 depicts the estimated separation rates for an entering cohort. The solid line represents the separation rates predicted by our regression equation. We have, in effect, replaced the 40-odd YOS indicator variables in the dashed line with smoothly varying age and service variables, plus the pension accrual variables in column (1). Using these coefficients, we model the separation rates for a cohort of 25-year-old entrants. The solid line reproduces in moderately attenuated form the separation patterns depicted in the dashed line. This suggests to us that it is the pension variables, rather than service and/or age which accounts for the spiky separation pattern.

[14] * denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level

Figure 4: Predicted vs. Raw Separation Probabilities, non T-DROP



8. Differential Effect of Quality

We now turn our attention to our estimates of the interactions between the pension accrual variables and our quality estimates. Table 3 below presents the coefficient estimates for the interaction between the top and bottom quintiles of quality and the pension accrual variables. Each of these models included dummies for the first, second, fourth, and fifth quintiles, so all estimates are compared to the middle or third quintile. Column (1)-(3) detail the results for school-by-grade, school, district quality respectively. Interestingly, all but one of the first order quality effects and most of the interactions are statistically insignificant.

The only variable that appears to systematically elicit a differential effect by quality is One Year Accrual. The estimates for the interaction between one year accrual and the first and fifth quintiles of both school-by-grade and school quality are positive and significant. This indicates that those at the bottom and top of the quality distribution have a weaker response to one year pension accrual than does a teacher in the middle of the quality distribution.

Table 3: Interactions between Quality and Pension Accrual

Variable	(1)	(2)	(3)
1st Quintile of Quality	0.4380 (0.3661)	0.1315 (0.2824)	-0.1294 (0.2432)
5th Quintile of Quality	-0.4025 (0.3776)	-0.3400 (0.2712)	-0.4277* (0.2472)
1st Quintile x One Year Accrual	0.1380*** (0.0454)	0.0943*** (0.0344)	0.0601* (0.0320)
5th Quintile x One Year Accrual	0.1640*** (0.0474)	0.0968*** (0.0320)	-0.0242 (0.0357)
1st Quintile x Peak Value	-0.0224 (0.0168)	-0.0011 (0.0124)	-0.0068 (0.0093)
5th Quintile x Peak Value	-0.0505** (0.0200)	0.0001 (0.0107)	-0.0016 (0.0088)
1st Quintile x Pension Wealth	-0.0028 (0.0035)	-0.0003 (0.0027)	-0.0022 (0.0023)
5th Quintile x Pension Wealth	-0.0053 (0.0034)	-0.0023 (0.0024)	-0.0027 (0.0022)
1st Quintile x Earnings	-0.0080 (0.0098)	-0.0035 (0.0076)	0.0047 (0.0065)
5th Quintile x Earnings	0.0128 (0.0099)	0.0069 (0.0071)	0.0120* (0.0066)

We can now use our coefficient estimates to graphically look at the differences in separation rates. We estimate the separation rates for an entering cohort using our coefficient estimates and then plot the resulting probability distribution. Figure 5 presents the resulting graph for the school-by-grade quality quintiles. Analogous figures for school and district quality are included in the appendix. In figure 5 the solid red line represents the middle quintile of school-by-grade quality, the solid black line represents the bottom quintile, and the dashed black line represents the top quintile. Figure 5 clearly illustrates the lessened response of those in the top and bottom quintiles of quality. However, it is also evident that teachers in these quintiles are still quite responsive to pension accrual. The distribution for both the top and bottom quintiles still exhibit increased separation probabilities that correspond to the spike in pension accrual. We can also look back to table 2 and see that the one year accrual variable is stable and significant of across all specifications, as are all of the pension accrual variables.

Figure 5: Estimated Separation Probabilities for School-by-Grade Quality Quintiles

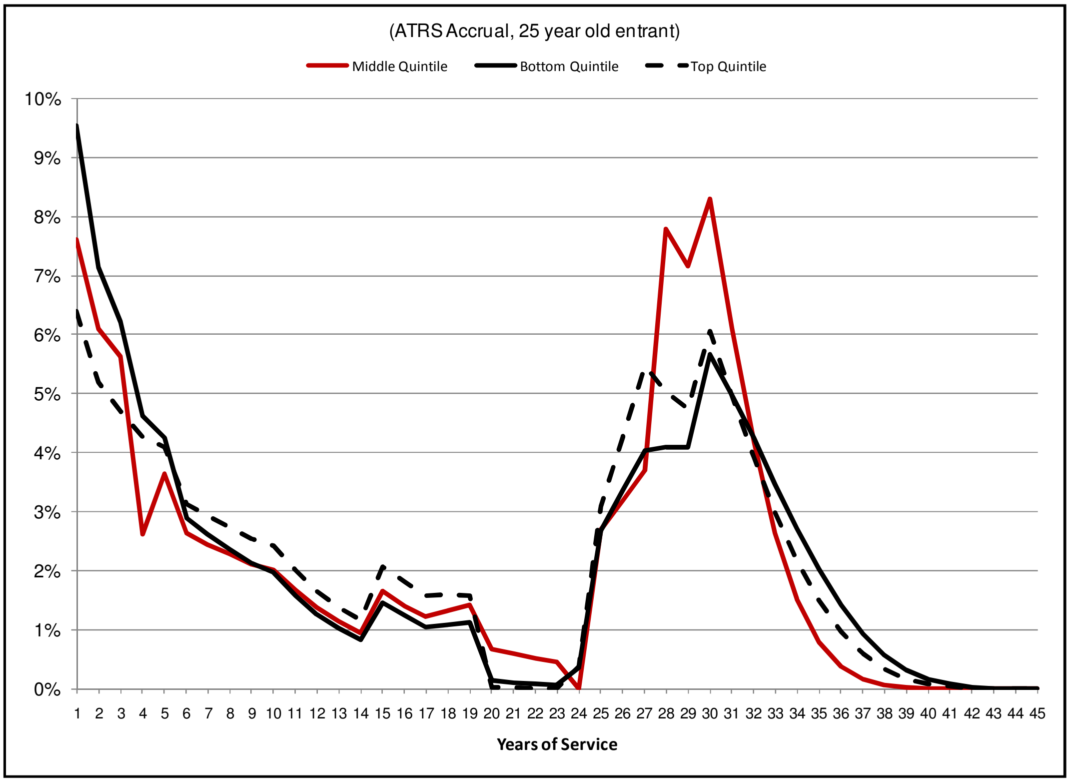
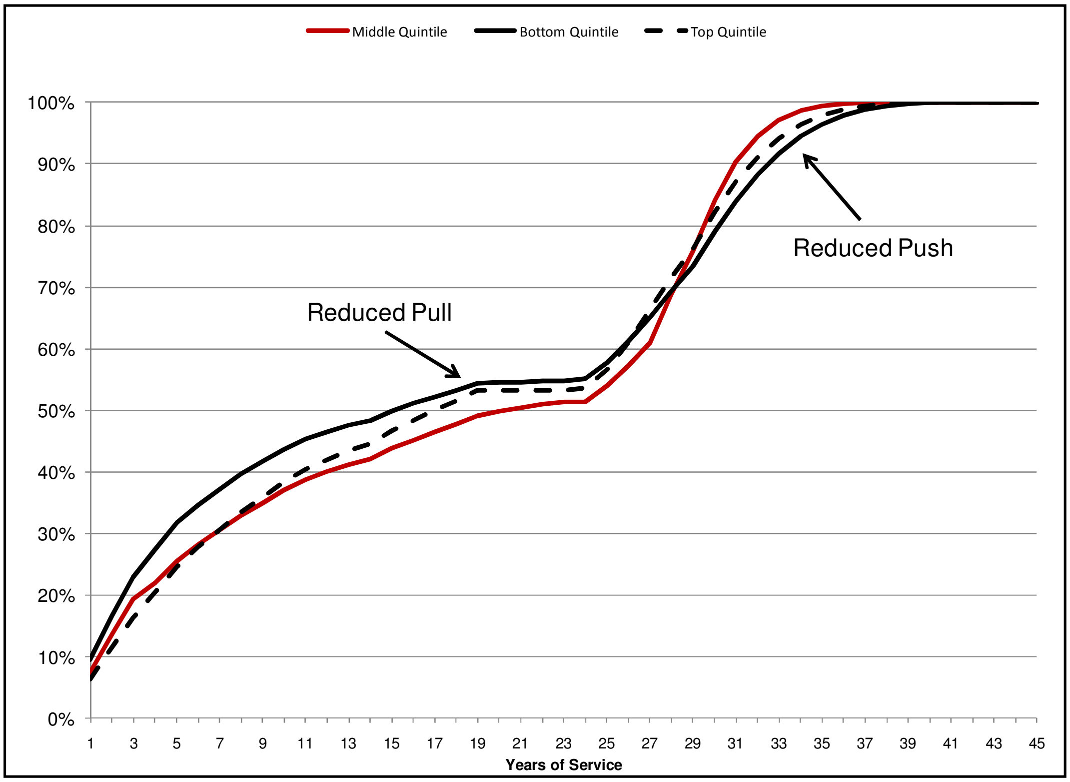


Figure 6 shows the differing separation rates using cumulative distributions. Again, analogous figures for school and district quality are included in the appendix. One can readily see that both the bottom and top quintiles have a flatter, less kinked cumulative distribution. Both cumulative distributions are above the distribution for the middle quintile before 28 YOS and below it after. This would indicate that those in the bottom and top quintiles are less affected by the both the pull and push effects.

Figure 6: Cumulative Distribution for School-by-Grade Quality Quintiles



9. Conclusions

In this paper we have analyzed the incentives embedded in the Arkansas teacher pension plan and provided empirical evidence on the behavioral response of teachers to those incentives. The evidence appears to be strong that teachers respond to pension incentives, but that those in the top and bottom quintiles of quality have a marginally weaker response.

We plan to extend this draft paper by further disaggregating quality by subject and possible matching teachers to students to get teacher value added. However, these preliminary results suggest that the incentive structure created by the pension system works as a fairly blunt instrument that affects teacher behaviour relatively equally across the quality distribution.

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Appendix

Table 4: School-by-Grade Model Value Added Coefficients

	Math Lag 1	Math Lag 2	ELA Lag 1	ELA Lag 2	Std. Dev. RE
Math Value Added					
2005	0.3929***	0.3303***	-0.0208	0.0761**	$7.11 * 10^{-12}$
2006	0.3937***	0.2786***	0.1109***	0.0557***	0.1744
2007	0.3633***	0.3312***	0.1384***	0.0670***	0.1836
2008	0.4197***	0.2968***	0.1406***	0.0705***	0.1726
English Language Arts Value Added					
2005	0.0820*	0.0322	0.4341***	0.3609***	0.1994
2006	0.1088***	0.1127***	0.4446***	0.2391***	0.1433
2007	0.0732***	0.0898***	0.4548***	0.2875***	0.1389
2008	0.0919***	0.0496***	0.4514***	0.3178***	0.1188

Table 5: School Model Value Added Coefficients

	Math Lag 1	Math Lag 2	ELA Lag 1	ELA Lag 2	Std. Dev. RE
Math Value Added					
2005	0.3929***	0.3303***	-0.0208	0.0761**	$7.76 * 10^{-11}$
2006	0.3954***	0.2741***	0.1126***	0.0559***	0.1632
2007	0.3611***	0.3285***	0.1388***	0.0691***	0.1623
2008	0.4141***	0.2965***	0.1410***	0.0736***	0.1619
English Language Arts Value Added					
2005	0.0791*	0.0344	0.4345***	0.3631***	0.2068
2006	0.1081***	0.1120***	0.4456***	0.2382***	0.1354
2007	0.0719***	0.0897***	0.4526***	0.2893***	0.1235
2008	0.0890***	0.0509***	0.4477***	0.3211***	0.1096

Table 6: District Model Value Added Coefficients

	Math Lag 1	Math Lag 2	ELA Lag 1	ELA Lag 2	Std. Dev. RE
Math Value Added					
2005	0.3892***	0.3290***	-0.0195	0.0746**	0.0548
2006	0.4010***	0.0047***	0.1163***	0.0556***	0.0995
2007	0.3646***	0.3253***	0.1422***	0.0677***	0.1017
2008	0.4186***	0.2937***	0.1434***	0.0718***	0.1052
English Language Arts Value Added					
2005	0.0749*	0.0408	0.4398***	0.3626***	0.0426
2006	0.1118***	0.1078***	0.4496***	0.2355***	0.0875
2007	0.0736***	0.0883***	0.4565***	0.2867***	0.0756
2008	0.0895***	0.0510***	0.4511***	0.3190***	0.0731

Figure 7: Separation Probabilities by School Quality

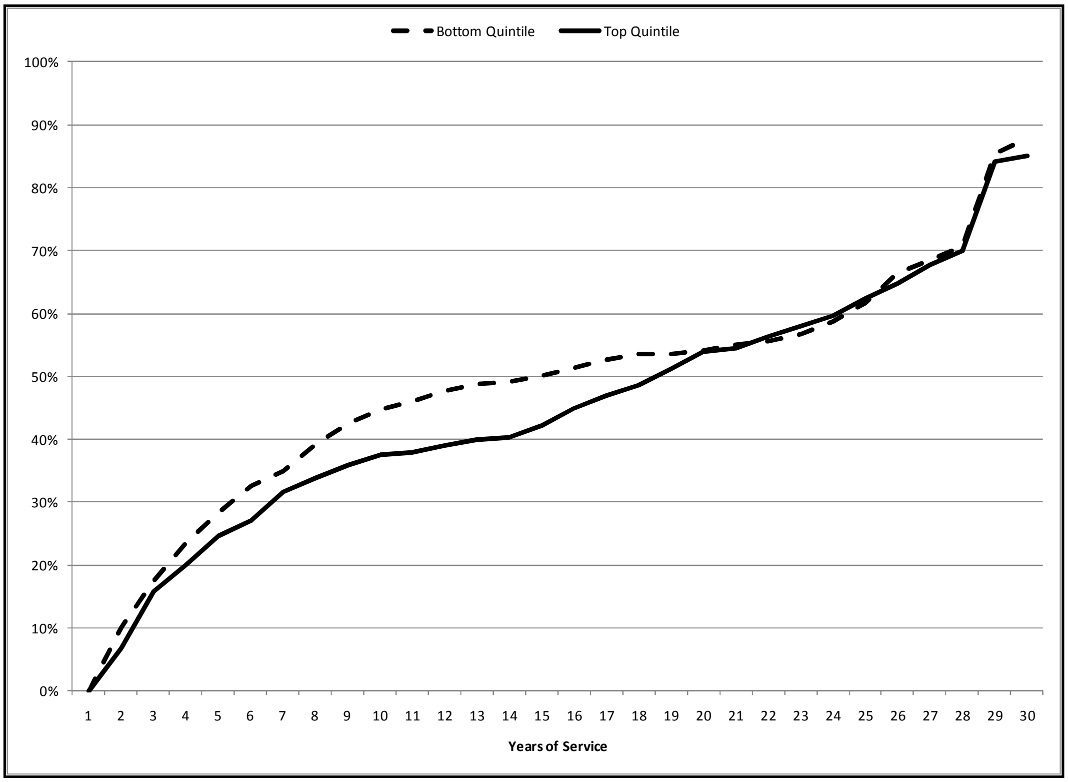

Figure 8: Separation Probabilities by District Quality

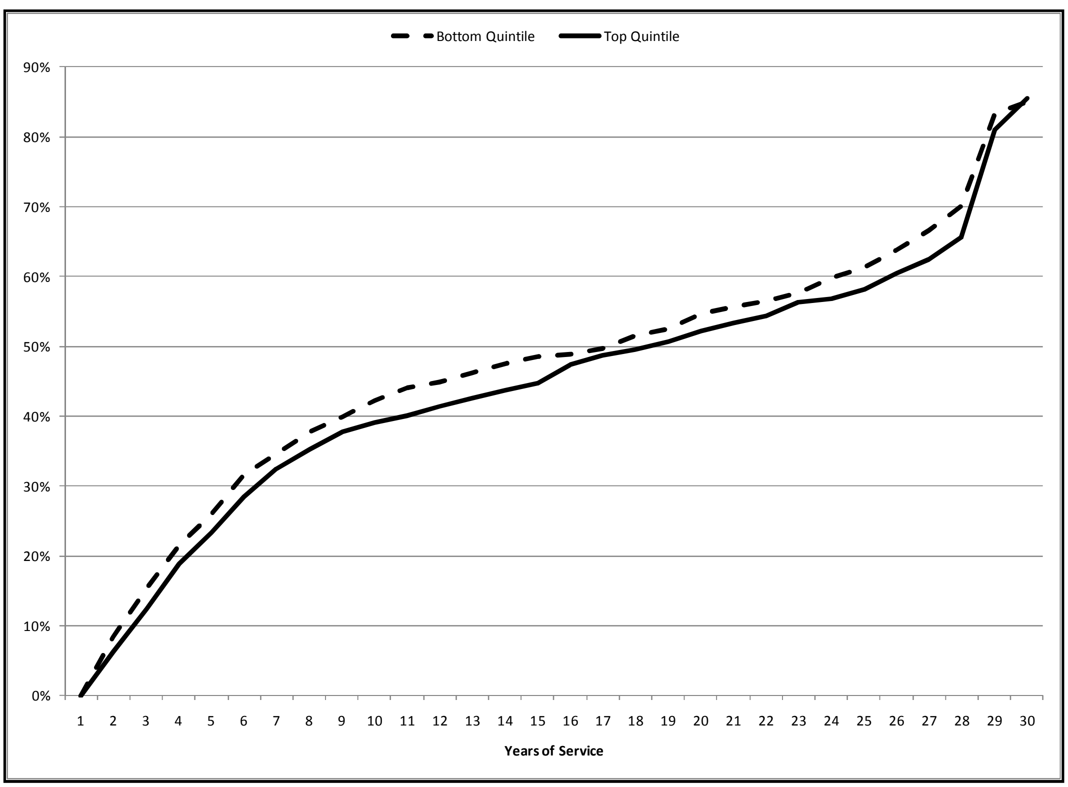

Figure 9: Estimated Separation Probabilities for School Quality Quintiles

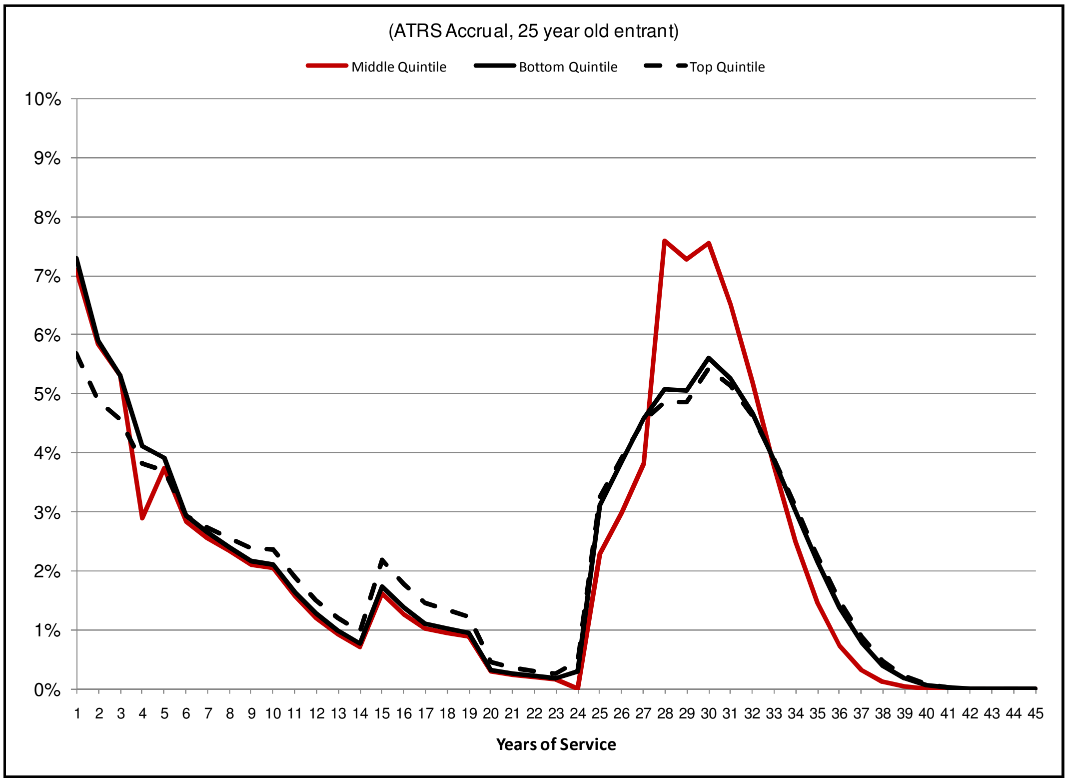

Figure 10: Estimated Separation Probabilities for District Quality Quintiles

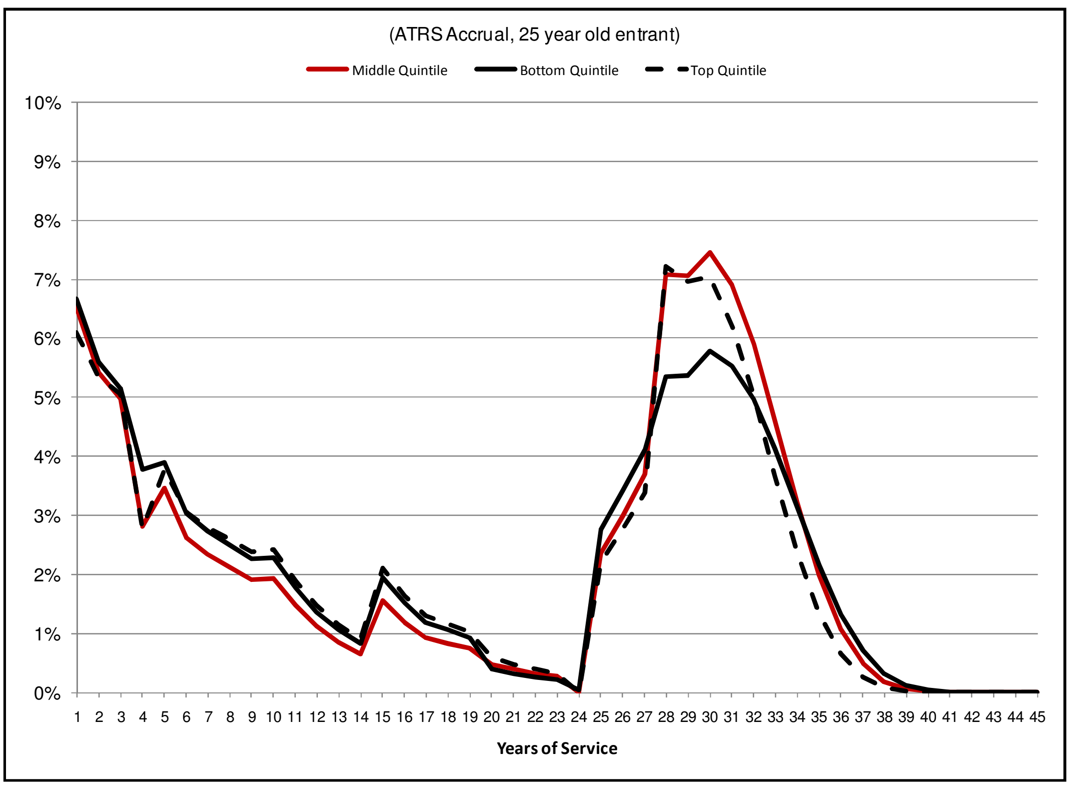

Figure 11: Cumulative Distribution for School Quality Quintiles

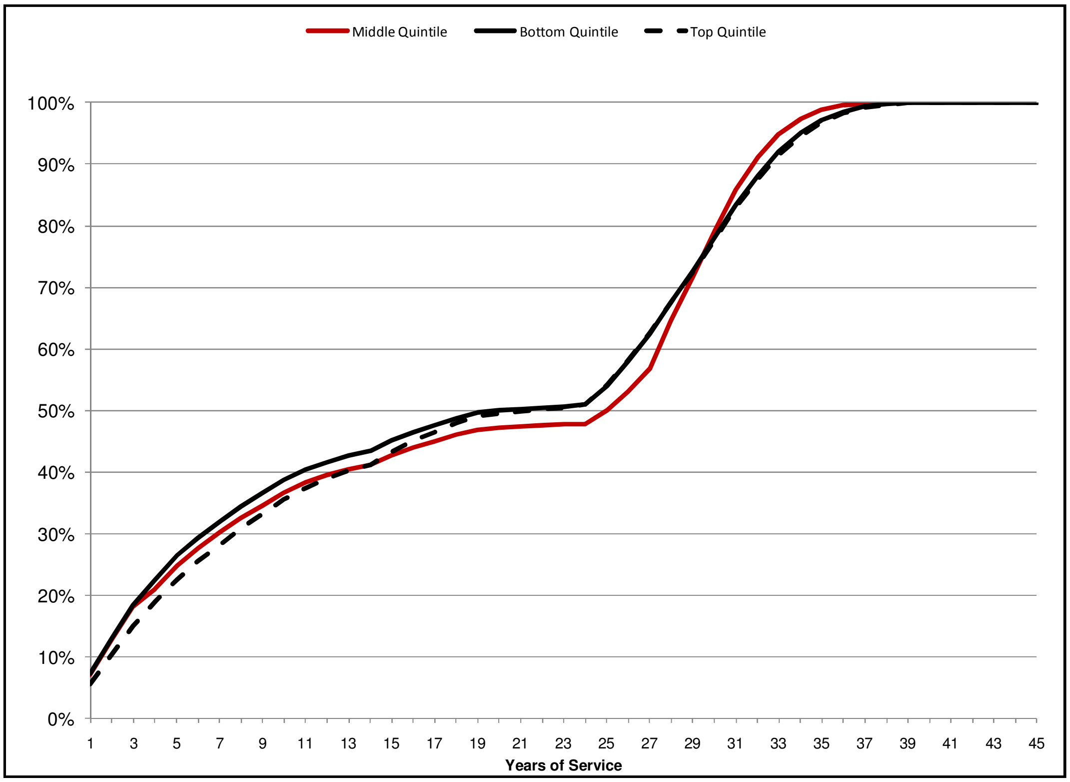

Figure 12: Cumulative Distribution for District Quality Quintiles